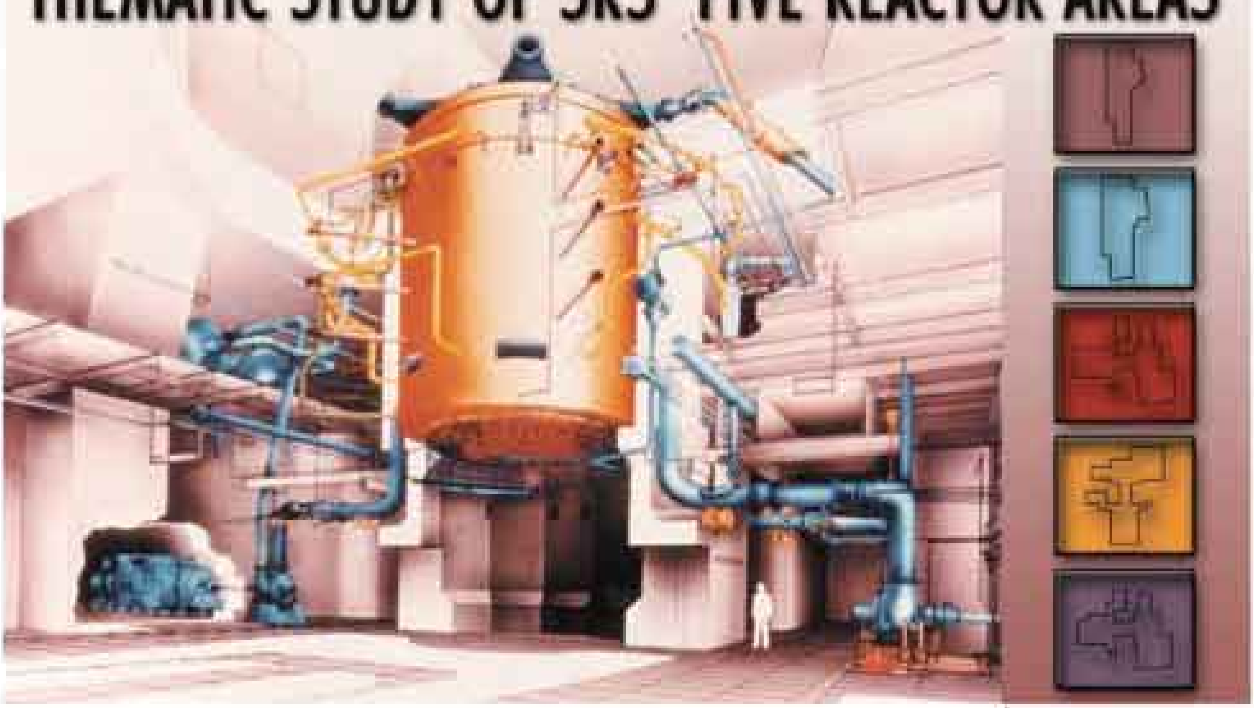
Volume 1

REACTOR ON

THEMATIC STUDY OF SRS' FIVE REACTOR AREAS



NEW SOUTH ASSOCIATES

PROVIDING PERSPECTIVES ON THE PAST

SAVANNAH RIVER SITE COLD WAR HISTORIC PROPERTY DOCUMENTATION

NARRATIVE AND PHOTOGRAPHY

REACTOR ON

THEMATIC STUDY OF SAVANNAH RIVER'S FIVE REACTOR AREAS

Aiken and Barnwell Counties, South Carolina

Report submitted to:

Savannah River Nuclear Solutions (LLC)• Aiken, SC

Report prepared by:

New South Associates • 6150 East Ponce de Leon Avenue • Stone Mountain, Georgia 30083

Principal Investigator:

Mary Beth Reed

Historians and Authors:

Mark T. Swanson

Terri Gillett

March 24, 2010 • Final Report

New South Associates Technical Report 1743

ABSTRACT

This documentation was prepared following the Consolidated Memorandum of Agreement (MOA) signed by the Department of Energy-Savannah River (DOE-SR) and the South Carolina Historic Preservation Office (SHPO) in August 2004 in response to the proposed deactivation and decommissioning (D&D) of numerous reactor area historic properties. While the Consolidated MOA was the catalyst for the study, a Cultural Resources Management Plan was later developed in 2004 that more fully defined how documentation studies were to be completed at the Site. Since 2004, other reactor area historic properties have undergone D&D with SHPO concurrence and in 2009, planning for the D&D of P and R reactors was begun with SHPO concurrence. These actions precipitated the development of a reactor thematic study containing documentation of reactor area building types that are considered eligible for listing in the National Register of Historic Places (NRHP). This documentation is based on field analysis, oral history, primary documentation, and research. New South Associates prepared the narrative and Savannah River Nuclear Solutions (SRNS) completed the photographic documentation.

ACKNOWLEDGEMENTS

Many people deserve to be thanked for a project of this size. First and foremost are the interviewees, who volunteered their time and energy to the project. These folks were: Harvey Allen, Robert Anderson, James Boswell, Fred Christensen, Mark Collins, Andy Cwalina, Bill Dallis, Woody Daspit, Peter Gray, Lawrence Heinrich, Walt Joseph, Gerald Merz, Frank Pagane, Daniel Pellarin, Linda Perry, and Al Peters. This report would not have been possible without their contributions. In addition, members of Reactor Technology were asked for input into the preservation process via a questionnaire and many responded. Their responses helped guide the documentation and established many of the themes in the context. We gratefully acknowledge their contribution.

Thanks must also be given to the managers of the different reactor areas, Bill Dallis, Peyton Northington and Marvin Ross, who took time from their busy schedules to orchestrate our access to the buildings, act as tour guides, and answer our many questions.

Photography was an essential element in documenting the reactor area buildings for this project and a number of people at Savannah River Site need to be thanked for their work in this area. Both Byron Williams and Steve Ashe from the SRS Photography Department contributed significantly to this report by photographing the reactor area buildings in their current condition. Historic photographs were used to document the buildings in their prime operating condition and Bruce Boulineau did a heroic job of scanning the hundreds of images pulled from the archives at SRS - a major contribution to the report. Tom Kotti kept the whole crew miraculously on schedule. We would also like to thank Denny Vanover for making available the architectural and engineering drawings of the reactor area buildings on file at SRS.

Chris Rodrigues provided editorial assistance that was much appreciated and helped improve the document. Last but certainly not least, we would like to thank Linda Perry and Caroline Bradford. Linda has been our liaison with Savannah River Site and has worked closely with New South in recent years to ensure the success of cultural resource management at SRS. Caroline Bradford, SRS Cold War Curator contributed her expertise working with the historians to identify and collect artifacts Without the assistance of those mentioned above, and countless unnamed others, this project would not be the success we think it is. All of their contributions are sincerely appreciated.

TABLE OF CONTENTS

ACRONYM LIST

ACHP	ADVISORY COUNCIL ON HISTORIC PRESERVATION
AMCP	ASSISTANT MANAGER FOR CLOSURE PROJECTS
AM&F	AMERICAN MACHINE AND FOUNDRY
AEC	ATOMIC ENERGY COMMISSION
AEC SROO	ATOMIC ENERGY COMMISSION SAVANNAH RIVER OPERATIONS OFFICE
AED	ATOMIC ENERGY DIVISION – DU PONT COMPANY
AOE	ASSESSMENT OF EFFECT
CAB	SAVANNAH RIVER SITE CITIZEN'S ADVISORY BOARD
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT
CFR	CODE OF FEDERAL REGULATIONS
CNTA	CITIZENS FOR NUCLEAR TECHNOLOGY AWARENESS
COE	U. S. ARMY CORPS OF ENGINEERS
CRM	CULTURAL RESOURCE MANAGEMENT
CRMP	CULTURAL RESOURCE MANAGEMENT PLAN
CSRA	CENTRAL SAVANNAH RIVER AREA
DECP	DECOMMISSIONING PROJECT (DOE-SR)
D&D	DEACTIVATION AND DECOMMISSIONING
DOD	DEPARTMENT OF DEFENSE
DOE	U. S. DEPARTMENT OF ENERGY
DOE	DETERMINATION OF ELIGIBILITY
DOE FPO	U. S. DEPARTMENT OF ENERGY FEDERAL PRESERVATION OFFICER
DOE-SR	U. S. DEPARTMENT OF ENERGY SAVANNAH RIVER
DWPF	DEFENSE WASTE PROCESSING FACILITY
ECS	EMERGENCY COOLING SYSTEMS
EM	ENVIRONMENTAL MANAGEMENT
EOC	EMERGENCY OPERATIONS CENTER – SRS
EPA	U. S. ENVIRONMENTAL PROTECTION AGENCY
ERDA	ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
FFA	FEDERAL FACILITIES AGREEMENT
FRA	FEDERAL RECORDS ACT
GS	GIRDLER SULFIDE
HABS	HISTORIC AMERICAN BUILDINGS SURVEY
HAER	HISTORIC AMERICAN ENGINEERING RECORD
HWCTR	HEAVY WATER COMPONENTS TEST REACTOR
INL	IDAHO NATIONAL LABORATORY
IRM	INFORMATION RESOURCE MANAGEMENT DEPARTMENT - SRS
JCAE	JOINT COMMITTEE ON ATOMIC ENERGY
LANL	LOS ALAMOS NATIONAL LABORATORY
LTBT	LIMITED TEST BAN TREATY
LTR	LATTICE TEST REACTOR
MED	MANHATTAN ENGINEERING DISTRICT
MOA	MEMORANDUM OF AGREEMENT
MPPF	MULTI-PURPOSE PROCESSING FACILITY
NARA	NATIONAL ARCHIVES RECORDS ADMINISTRATION
NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NEPA	NATIONAL ENVIRONMENTAL POLICY ACT

NHL	NATIONAL HISTORIC LANDMARK
NHPA	NATIONAL HISTORIC PRESERVATION ACT
NNSA	U. S. DEPARTMENT OF ENERGY NATIONAL NUCLEAR SECURITY ADMINISTRATION
NPS	NATIONAL PARK SERVICE
NPT	NON-PROLIFERATION TREATY
NRC	NUCLEAR REGULATORY COMMISSION
NRHP	NATIONAL REGISTER OF HISTORIC PLACES
NTG	NEUTRON TEST GAGE
NURE	NATIONAL URANIUM RESOURCES EVALUATION
NYX	NEW YORK SHIPBUILDING COMPANY
ORA	OPERATIONS RECREATION ASSOCIATION
ORNL	OAK RIDGE NATIONAL LABORATORY
PA	PROGRAMMATIC AGREEMENT
PDP	PROCESS DEVELOPMENT PILE
PSE	PRESSURIZED SUB-CRITICAL EXPERIMENT
RBOF	RECEIVING BASIN FOR OFFSITE FUEL
RTR	RESONANCE TEST REACTOR
SALT	STRATEGIC ARMS LIMITATION TREATY
SCDAH	SOUTH CAROLINA DEPARTMENT OF ARCHIVES AND HISTORY
SCDHEC	SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
SCIAA	SOUTH CAROLINA INSTITUTE OF ARCHAEOLOGY AND ANTHROPOLOGY
SDI	STRATEGIC DEFENSE INITIATIVE
SE	SUB-CRITICAL EXPERIMENT (EXPONENTIAL TANK)
SHPO	STATE HISTORIC PRESERVATION OFFICE/OFFICER
SHRINE	SAVANNAH RIVER INFORMATION NETWORK ENVIRONMENT
SP	STANDARD PILE
SRARP	SAVANNAH RIVER ARCHAEOLOGICAL RESEARCH PROGRAM
SRI	SAVANNAH RIVER NATURAL RESOURCE MANAGEMENT AND RESEARCH INSTITUTE
SRL	SAVANNAH RIVER LABORATORY
SREL	SAVANNAH RIVER ECOLOGY LABORATORY
SRNL	SAVANNAH RIVER NATIONAL LABORATORY
SROO	SAVANNAH RIVER OPERATIONS OFFICE
SRP	SAVANNAH RIVER PLANT
SRS	SAVANNAH RIVER SITE
SRSO	U. S. DEPARTMENT OF ENERGY-SAVANNAH RIVER SITE OFFICE
SRSOC	SAVANNAH RIVER SITE OPERATIONS CENTER
SRTC	SAVANNAH RIVER TECHNOLOGY CENTER
STI	SCIENTIFIC AND TECHNOLOGICAL INFORMATION
TC	TEMPORARY CONSTRUCTION
TCAP	THERMAL CYCLING ABSORPTION PROCESS
TRAC	TRACKING ATMOSPHERIC RADIOACTIVE CONTAMINANTS
TTBT	THRESHOLD TEST BAN TREATY
UCNI	UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION
UGA	UNIVERSITY OF GEORGIA
USC	UNIVERSITY OF SOUTH CAROLINA
USFS	U. S. FOREST SERVICE
USH	UNIVERSAL SLEEVE HOUSING
VWF&S	VOORHEES, WALKER, FOLEY AND SMITH
WIND	WEATHER INFORMATION AND DISPLAY SYSTEM
WSRC	WESTINGHOUSE SAVANNAH RIVER COMPANY

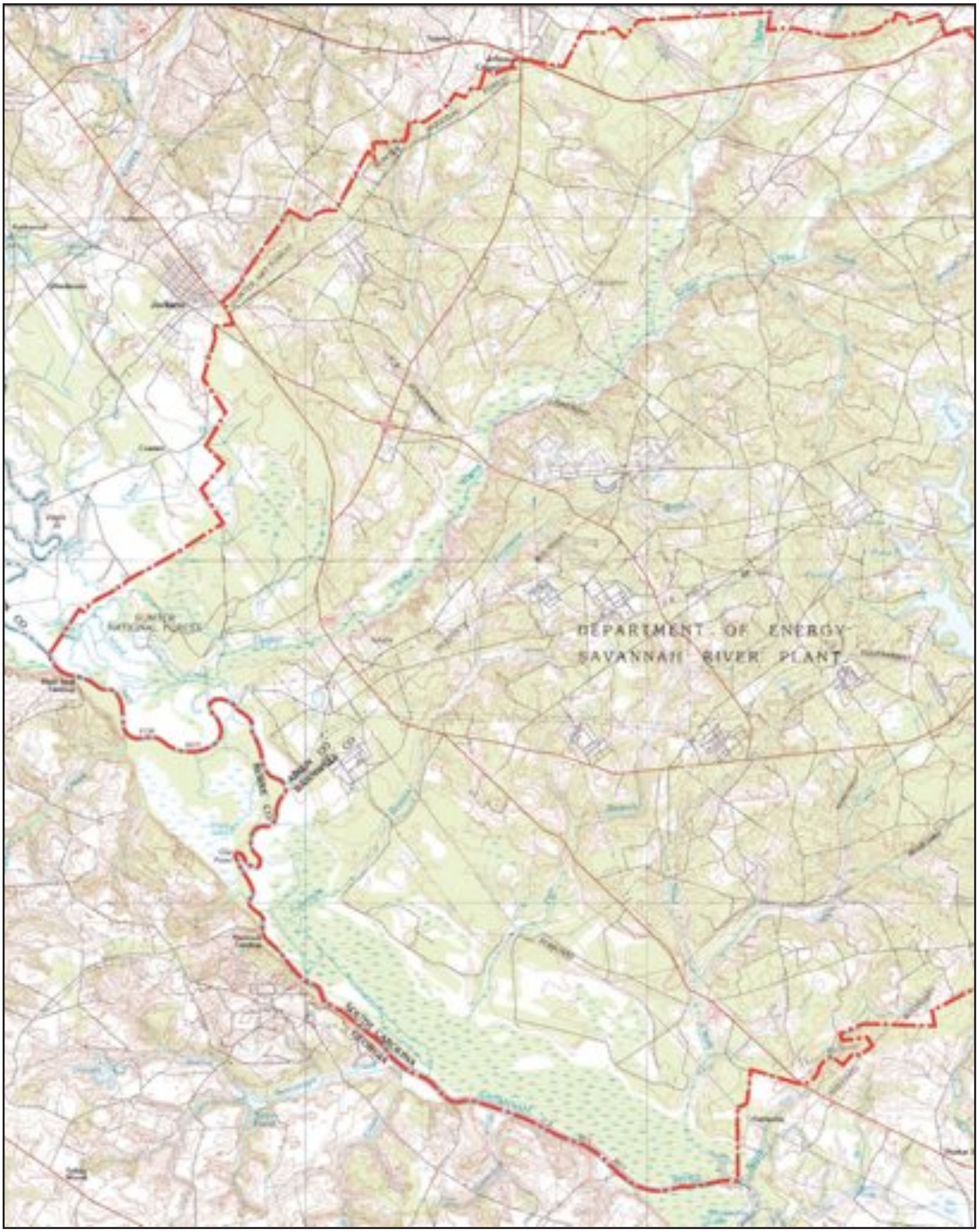
I. INTRODUCTION

This document is a thematic study of five production reactors and their associated support structures at Savannah River Site (SRS), formerly known as Savannah River Plant (SRP), located south of Aiken, South Carolina, within Aiken, Barnwell and Allendale counties. These reactors collectively played an important role in our nation's defense during the Cold War. The Department of Energy Savannah River (DOE-SR) recognized their historic significance in 2004 in a Programmatic Agreement that specified the development of a Cultural Resource Management Plan (CRMP) for their future treatment. The CRMP was subsequently developed and it outlined how historically significant buildings, that were considered eligible for nomination to the National Register of Historic Places, would be documented, should a Federal undertaking occur that would affect the qualities that made them eligible for nomination. This reactor thematic study, precipitated by proposed deactivation activities in P Area that will affect the reactor building and its associated support structures, 108-1P and 108-2P, reflects the documentation objectives in the CRMP.

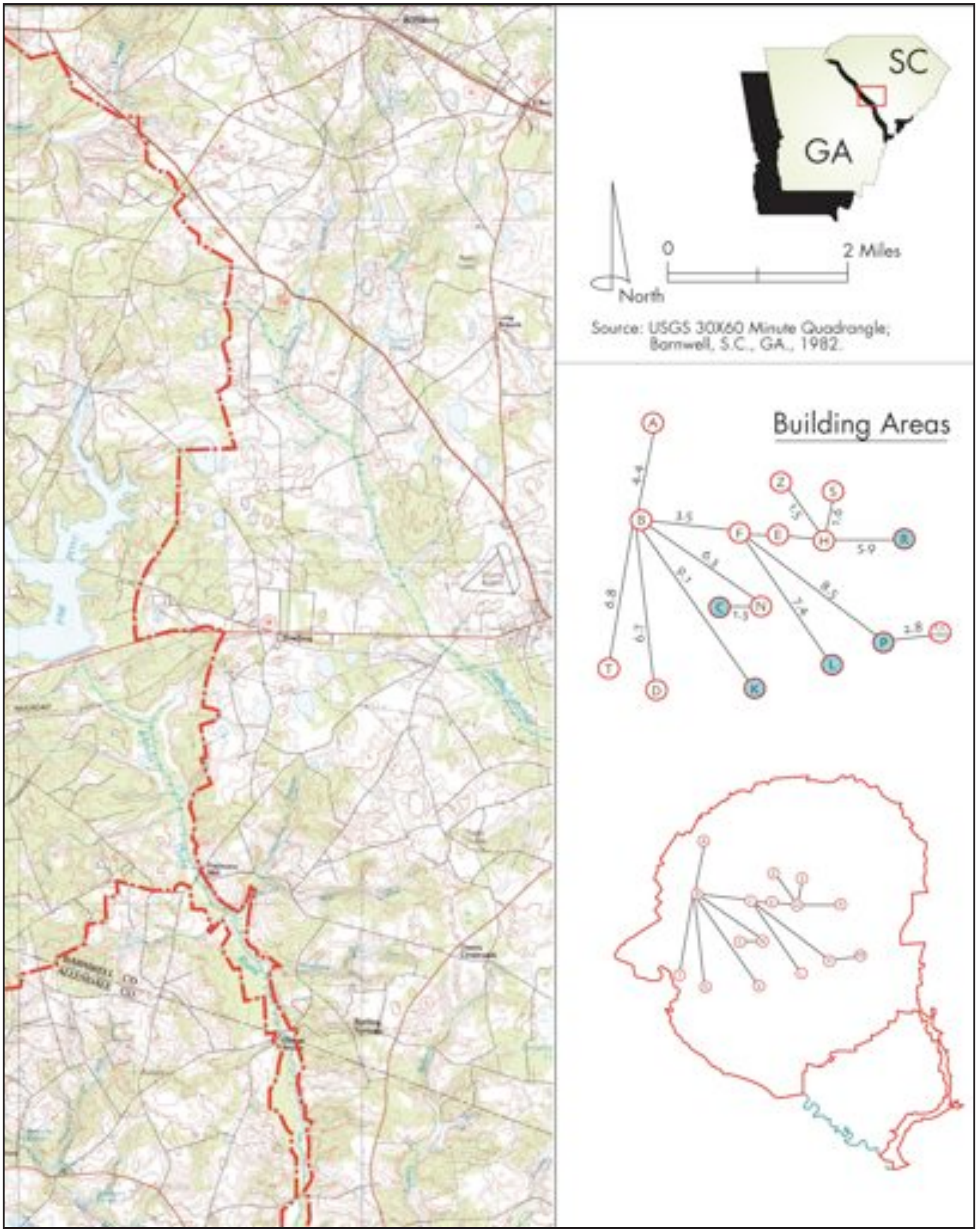
Between 1950 and 1955, Du Pont was provided an unprecedented opportunity in reactor design and engineering that produced five heavy-water moderated and cooled production reactors at the SRS. These reactors were built as part of the 1950s Atomic Energy Commission (AEC) expansion program at the onset of the Cold War and they featured design differences that set them apart from the early AEC reactors at Hanford that dated to the Manhattan Project. Each SRS reactor is a massive, multistory, irregularly shaped building primarily constructed of reinforced concrete with stacks reaching approximately 200' in height, substructures reaching 40' below grade, and featuring different configurations at grade level. They are processually alike but different in their size and layout. The five reactors are identified by letter designations, and in the order of construction, they are R, P, L, K, and C. R and P reactors are most similar and can be considered a replicated "type" within the Savannah River reactor group. L and K reactors form the next generation type while C reactor, the last to be constructed, represents a third type.

Each also had its list of achievements. R Reactor was the first of the five to be constructed and to go on-line, achieving that distinction on December 28, 1953. As such, it was the first large heavy water-moderated and cooled reactor, outside of the small and experimental reactors at Argonne National Laboratory. P Reactor, the next to go on-line, was the site of ground-breaking neutrino research later in the 1950s, and in the years that followed. L Reactor was the first to be controlled by computer, possibly the first anywhere in the world; it was also the first to be re-started after a closure period of over 10 years. C Reactor was the site of record-breaking high flux work in the 1960s.[1] It also played a unique role in the Transplutonium Programs championed by Glenn Seaborg, chairman of the AEC in the 1960s and early 1970s.

Each of the five reactor areas (Areas R, P, K, L and C) share a complement of like buildings and structures, with few exceptions, which allowed each area to operate independently. The building types are known numerically as: Reactor Building, 106, 107, 108, 109, 110, 122, 151, 152, 183, 184, 185, 186, 188, 190, and 701, 704, 706 and 711. A suffix of R, P, K, L and C follows each building number to denote the area in which the building type was located.


DEPARTMENT OF ENERGY
SAVANNAH RIVER PLANT

SRS Location Map



The reactor areas (R, P, L, K and C) are centrally located within the SRS in Barnwell County although the Site is located on a 198,344-acre tract spread over a three county area. Other manufacturing and administrative areas required to sustain the SRS's Cold War mission were also established within the Site that features the Savannah River as its western border. The Site comprises roughly one percent of the state and contains approximately 310 square miles within South Carolina's upper coastal plain. Historically the area that became the Site was mostly agricultural and its current physical setting remains fairly rural. The county seat of Aiken County, the city of Aiken, lies 12 miles to the north; the Augusta, Georgia metropolitan area lies 15 miles to the northwest. The cities of Jackson and New Ellenton are located on the site's northern perimeter. SRS is considered part of the 18-county Central Savannah River Area (CSRA) adjoining the Savannah River in both South Carolina and Georgia.

THEMATIC STUDY APPROACH

Reactor operations from the Site's construction to the close of the Cold War is considered a major theme in the Site's history and this is the period of significance this study covers. As defined in the CRMP, a thematic study approach is warranted where there are replicated historic building types that are functionally related, as is the case with SRS' five reactor areas. If an undertaking were determined to pose an adverse effect on any of the significant building/building types within a replicated group, this would initiate the development of a full thematic study of the group. Thus the onset of the P Area undertaking was the catalyst for this study.

Despite differences in the reactor buildings, each of the five reactor areas consisted of a complement of service buildings that were almost identical. These buildings are listed in a number of sources dating to the early to middle 1950s.[2] Between 1950 and 1956, a total of 114 permanent facilities were constructed to support reactor operations overall; 21 building/structure types were constructed in each building area. R Area had two additional building types that were not replicated at the other reactor areas, raising the building types to 23 in number for reactor-associated facilities. Table 1 provides the building number, formal name, and building area for each of the support buildings and structures at the close of construction in 1956.

Table 1. Reactor Building Types, Building Numbers, and Names

Building Number	Name	Building Area
	Reactor	R, P, L, K, and C
106	Emergency Process Water Storage Tank	R, P, L, K, and C
107	Cooling Water Effluent Sump	R, P, L, K, and C
108 -1&2	Engine Houses	R, P, L, K, and C
108 -3	Fuel Unloading Facilities	R, P, L, K, and C
109	Purge Water Storage Basin	R, P, L, K, and C
110	Gas Storage	R, P, L, K, and C

Building Number	Name	Building Area
122	Process Storage Building	R
151-1&2	Primary Substations	R, P, L, K, and C
152	Secondary Substation	R, P, L, K, and C
183-1	Clarification Plant	R
183-2	Filter and Softener Plant	R, P, L, K, and C
183-4	Clarification Plant	P, L, K, and C
184	Powerhouse	R, P, L, K, and C
185	Cooling Towers	R, P, L, and K
186	Cooling Water Reservoir	R, P, L, K, and C
188	Ash Disposal Bain	R, P, L, and K
190	Cooling Water Pump House	R, P, L, K, and C
701-1	Area Gate House and Patrol Headquarters	R, P, L, K, and C
701-2	Gate House	R, P, L, K, and C
701-3	Gate House	R, P, L, K, and C
704	Office and Shops Building, Change House, and Stores	R, P, L, K, and C
706	Reactor Tech	C
711	Steel and Pipe Storage	R, P, L, K, and C

Over time, reactor areas lost some buildings while other areas, such as C Area, experienced expansion and the construction of new buildings particularly during the 1980s. Notably, only C Area would receive a historic building after the construction period, 706-C, a construction-era Butler Building that became the focus of "Reactor Tech" activities. R Area, shutdown in 1964, had few buildings intact in 2007 while the other areas had lost their powerhouses, cooling towers, as well as other support buildings. In addition, after shutdown, parts of R Reactor were harvested for use at the remaining reactors. Production, not preservation, was the mission within a highly technical environment propelled by our nation's need to supply the nuclear arsenal during the Cold War. Plus much of this loss occurred prior to the recognition of the historic significance of these facilities and their value in telling the Cold War history of the site. This document addresses that story.

As defined in the CRMP, a thematic study involves the development of 1) an illustrated narrative history based on extensive primary and secondary research; and 2) photographic documentation. The goal of the narrative was to describe the reactor process showing how nuclear materials were delivered to the reactor, how irradiation occurred, and how the irradiated materials were handled and then shipped to the Separations areas. In addition each reactor building area, its buildings and the reactor process equipment were to be described so the information gathered could be used later for interpretation and to help guide future evaluations of significance for any artifacts found or associated process equipment. The narrative was based to the fullest extent possible on primary sources. Records kept by both Du Pont and the Department of Energy and its predecessor agencies were researched.


Reactor Building

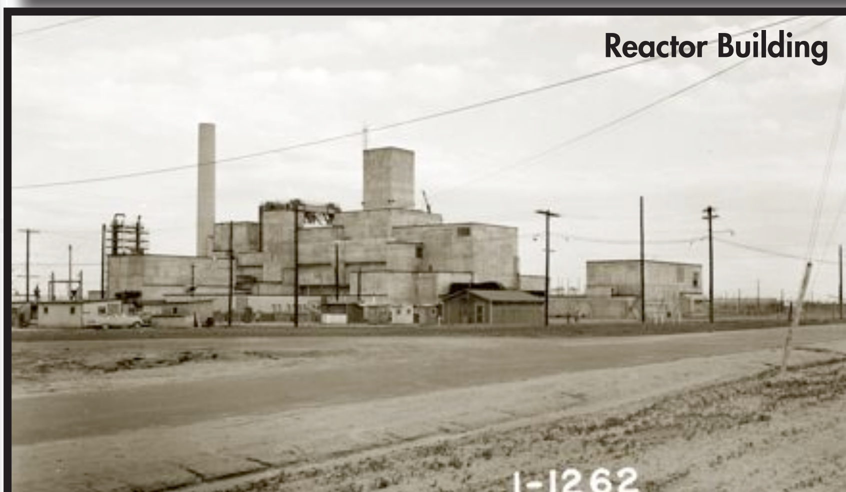

106


107


108-1&2


108-3


Reactor Building



Reactor Building


109

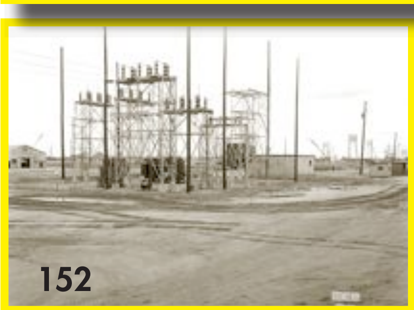

110


122


151-1&2

Reactor Area Building Types

- Types Covered in this Study
- Types Covered Under Separate Thematic Study


152


183-1

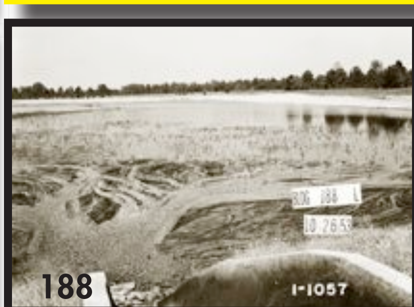

183-2


183-4


184


185


186

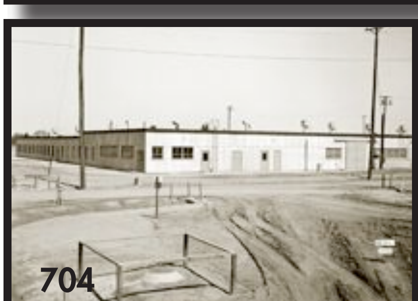

188


190

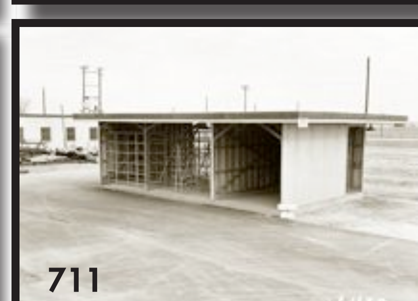

701-1


701-2


701-3


704


706


711

Engineering drawings or "as builts" for each of the building types were gathered for the study and extensive research through the Site's Photographic Archives was completed. Many of these historic views were selected for illustration.

An essential part of the primary research was the gathering of oral history from knowledgeable SRS retires and current employees that were part of reactor operations. Their recollections contributed greatly to the narrative. Fifteen oral history interviews were completed. Excerpts are given in Chapter 12 and full transcriptions are included in Appendix B.

Photographic documentation is a critical mitigation tool and an essential component of this study but specific challenges posed by the type and condition of the historic facilities to be documented had to be addressed. Specifically, the reactors contain contaminated areas that were not personnel accessible, including the process area's reactor room, which is the most significant part of the building. R, P and C reactors are unlit, power is limited, and all have been "cleaned out" to the walls. Another documentation challenge was the presence of lead-based paint peeling from walls and equipment throughout the reactor buildings with the exception of those in use. Traditionally, this resource type, given its significance, would be extensively documented with large format photography. However, the presence of historically significant but inaccessible areas, the lack of lighting and power and the loss of integrity made the visual capture of each reactor's interior end state difficult and non-productive in terms of information potential.

Given the above, a photographic documentation work plan was developed that moved away from documenting a reactor's interior solely through mitigation photography of the building's end state. Instead, historic photography, complemented by end state photography where needed, was selected and compiled into a photographic portfolio. SRS maintains a photographic archive that contains an extensive collection of historic views that range in content from pre-construction, to construction, to showing the reactors in use. SRS has always employed onsite professional photographers and large format photography was consistently used to record the site's buildings and activities through the 1970s. The portfolio of large format historic views was supplemented by end state photography when the historical record had an omission or when a historic property had an intact and significant interior that needs to be documented. Current photography was completed with a digital camera capable of high-resolution images that will be developed to meet archival standards.

DOE-SR developed the thematic study approach and the photographic documentation plan in concert with the SC State Historic Preservation Office, the SRS Heritage Foundation, and the Savannah River National Laboratory. Appendix C contains the P Reactor undertaking notification that provided the specific work plan for this study. In addition, a questionnaire was circulated among the members of the SRS Reactor Technology group to get input on what they felt were the most important historical values should be captured in the documentation and preservation of the reactors. The completed questionnaires are presented in Appendix D.

SRS COLD WAR HISTORIC DISTRICT AND ITS SIGNIFICANCE

The reactors and their associated buildings and structures are considered to be part of a Cold War Historic District that meets the criteria for nomination to the National Register of Historic Places (NRHP). DOE-SR under Section 110 of the National Historic Preservation Act inventoried its Cold War associated cultural resources in 2004 and identified 220 historic properties that met the NRHP criteria. A discussion of the district and its significance follows.

The Savannah River Site is an exceptionally important historic resource containing information about our nation's twentieth-century Cold War history. It contains a well-preserved group of buildings and structures placed within a carefully defined site plan that are historically linked, sharing a common designer and aesthetic. The site layout, predicated on environmental safety best practice in 1950 and a functional industrial approach, is intact. The site, its buildings, structures and its layout, constitute a unique cultural landscape that possesses historical significance on a national, state and local level in the areas of engineering, military, industry, and social history. The Site is directly associated with the Cold War, a defining national historical event of the twentieth century that lasted over four decades. This association satisfies National Register Criteria A or the association of a property with events that have made a significant contribution to the broad patterns of our history. The Site's process and research facilities were also used to further research in pursuit of peaceful uses of atomic energy. The Transplutonium Programs, the discovery of the free neutrino, the production of plutonium-238 for heat sources, and the production of heavy water for research were all notable achievements. The Cold War and the development of atomic energy for weapons and for peaceful purposes have received considerable scholarly attention as definitive forces within twentieth-century American history.

The proposed Cold War district also satisfies National Register Criteria C as it embodies best practice principles of nuclear design and safety when constructed. It represents the work of a master in that Du Pont was the designer of the unique and unprecedented complex that required the simultaneous construction of five nuclear production reactors, two separation plants, an industrial size heavy water plant, and a fuel and target manufacturing plant. Du Pont was considered the single American firm with the capability to handle the enormous job entailed in the Site's construction and operation. While this facet of Criteria C is usually applied to an architect or architectural firm, it is appropriate here. Du Pont brought its unique corporate culture, management skills, adherence to flexible design and its deep atomic energy experience to the job. A letter from President Truman to Du Pont requesting they take on the project underscores the fact that Du Pont was considered uniquely qualified to build and operate the Savannah River Site.

The historic district is also considered eligible under Criteria C for the methods of construction used that involved flexible design, an innovative approach that was characteristic of Du Pont and its management style and that directly contributed to the Site's success. The proposed district's buildings and structures reflect unique architectural and engineering attributes that were consonant with their mission. These include unique construction materials, functional design, and special design criteria for radiological shielding, personnel safety, and the ability to sustain a military attack. The engineering required to bring the nine Savannah River plants online was innovative and was successfully completed under rigorous schedules unparalleled in our nation's twentieth-century history. For all the above reasons, the proposed Cold War District amply satisfies National Register Criteria C.

Savannah River Site's historic district may also fulfill National Register Criteria D, the potential to yield information in history. While this criteria is usually reserved for archaeological resources it is applicable here. Much of the historical data that elucidates Savannah River's full Cold War history is held as classified information. When these records are declassified and open to the American public, new information disclosed might yield important information about the Site's Cold War past that is unknown or imprudent to publicly release at this time.

While its national importance to the Cold War is evident, SRS also gains National Register standing for its impact on South Carolina as a whole and on the Central Savannah River Area (CSRA) as a region. The selection of the site along the Savannah River for the construction of what would be known as the Savannah River Plant had a profound impact on the state, although one less readily quantified. It shifted the image of South Carolina from that of a rural agrarian state to one that was more progressive and industrialized. The training and inclusion of locals within the SRS' workforce demonstrated the ability of southerners to work within modern industrial highly technical facilities. Du Pont's management of this labor force, and the harmonious relations between races at the Site, further diminished northern concerns about establishing factories in the South. SRS' existence, and the efforts of local politicians, would result in additional nuclear facilities coming to the region. Interstate and regional pacts on nuclear topics were developed that would become models for interstate cooperation. The presence of SRS would begin to shift state University curriculums from solely an agricultural focus to a new emphasis on engineering, raised the hopes and self esteem of its citizens, and placed the state at the forefront of the march to a New Age. No other single construction, site or event would so affect South Carolina's history in the Cold War era, and the SRS derives National Register standing at the state level from this influence as well.

No other construction would so dramatically alter a region. By its very construction, the SRS rewrote the history of the CSRA. Communities, like Ellenton and Dunbarton, vanished in its wake, as did the rural areas that surrounded them. Other communities, like Aiken, changed almost overnight. As the first "open" nuclear site, the SRS brought an immigration of scientists and engineers the likes of which few regions in the nation would ever experience, changed the housing stock and appearance of the towns these atomic immigrants would move to, changed the make-up of their schools, political parties, and other social organizations, and rewrote local history. It is difficult to imagine anyone within the CSRA, if asked about the history of their region, not mentioning the SRS within their first thoughts and words. The SRS was extremely significant regionally as well as nationally and at the state level.

DOCUMENT ORGANIZATION

The Reactor Notification's mitigation plan laid out the organization for the thematic study. After this introduction, a context for the Site and its Cold War mission is presented to anchor the reactor discussions and to provide the reader with some general background on the Site's history. Chapter 3 provides a primer on basic atomic information and a brief history of reactor design prior to the Savannah River reactors. Construction of the reactor areas is treated in Chapter 4. The following chapters, 5, 6, 7, and 8 describe the reactor building and its processes using the five areas in a reactor as an organizational framework. Chapter 5 describes the overall building type and its assembly area. The Process Area (includes Personnel Area) discussion follows in Chapter 6; Chapter 7 handles the Disassembly Area. The Purification Area is discussed in Chapter 8. The next chapter deals with the differences between each reactor and what made them unique. Chapter 10 provides an operational history of reactor operations and Chapter 11 details the shutdown of the reactors to the present. The document closes with excerpts from oral history interviews with individuals associated with the reactors over time. After the Endnotes, Appendix A contains the Photographic Documentation arranged by building number. Appendix B includes oral history transcripts, Appendix C holds the P Reactor Notification letter, which defines the scope of this reactor thematic study and Appendix D contains the questionnaires provided by individuals within Reactor Technology.

II. SAVANNAH RIVER SITE COLD WAR CONTEXT

The SRS, built by E. I. Du Pont de Nemours and Company for the U.S. Atomic Energy Commission, had its origins in the early years of the Cold War as a facility for the production of plutonium and tritium, materials essential to the nation's nuclear arsenal. From the beginning, its mission was military. It was designed primarily to produce tritium, and secondarily to produce plutonium and other special materials as directed by the Department of Energy (DOE) and its precursor organizations, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA). Because of this mission, SRS has been an integral part of the nuclear weapons production complex. The production goal of the complex was to transform natural elements into explosive fissile materials, and to bring together fissile and non-fissile components in ways that would best meet the goal of Cold War deterrence. SRS provided most of the tritium and a large percentage of the plutonium needed for the production of fissile components from 1953 through 1988.

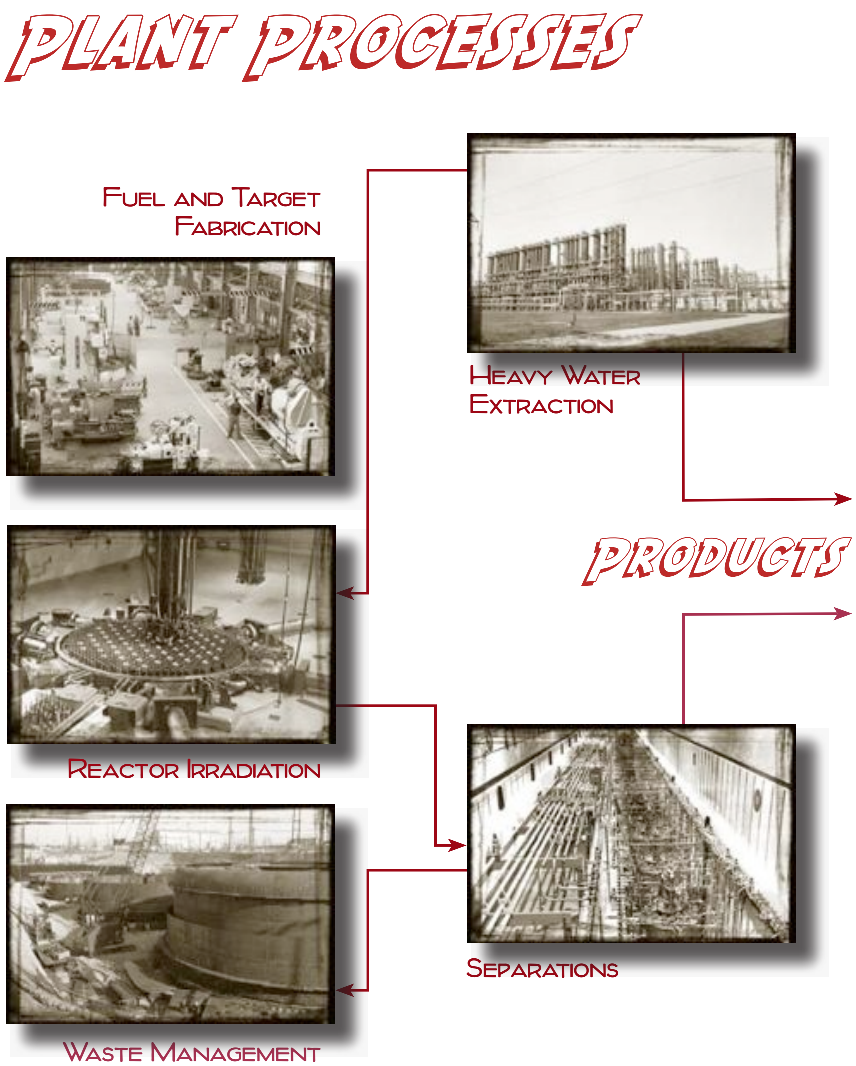
In addition to the Cold War defense mission, there was another, almost parallel, story of research and development using Site technologies and products for peaceful uses of atomic energy. Such government-sponsored research was strongly supported by the AEC, which was a civilian organization independent of military control. Although many of the non-defense programs conducted at SRS did not develop with the promise hoped for in the 1950s and 1960s, this was not for want of effort on the part of the AEC, Du Pont, or the scientists who helped operate SRS.

The two basic missions at SRS, nuclear materials production for defense, and production for non-defense programs, are explored in greater detail below. Both were considerable achievements. The defense mission produced much of the material required for the nuclear bombs and warheads constructed during the height of the Cold War. The non-defense programs generated new materials and increased the general knowledge of nuclear science.

COLD WAR DEFENSE MISSION

The defense mission of the SRP, as it was known prior to 1988, was an integral part of the AEC program to create weapons-grade plutonium and tritium for incorporation into fission and fusion bombs, known respectively as atomic and hydrogen bombs. The defense mission of SRP, and for that matter, the AEC, had its origins in the Manhattan Project, the World War II program that manufactured the world's first fission bombs, using both uranium and plutonium. It was the use of these devices against Japan in August 1945 that ended World War II, and ushered in the Atomic Age. The Manhattan Project, a vast and secret enterprise, set the tone for its successor, the AEC, even though the two were organized in different ways.

We don't dig Uranium out of the ground, and we don't make bombs, but we do nearly everything in between.



Plutonium-238

Produced by neutron irradiation of neptunium-237, a byproduct of uranium irradiation. Valuable for its heat generating capacity.

Curium-244

Properties and applications similar to plutonium-238.

Plutonium-239

Used as a nuclear explosive, a breeder reactor fuel, or as the starting target material for production of heavier radioisotopes.

Tritium *(Hydrogen-3)*

A radioactive isotope of hydrogen, component of thermonuclear explosives, and a potential fuel for thermonuclear fusion power generation.

Cobalt-60

Known radiation source and has long been used for radiotherapy.

Californium-252

One of the rarest man-made isotopes, has great potential value in medicine, industry, research, and education.

Heavy Water *(D_2O)*

Important nonradioactive product of the Savannah River Plant. It occurs at a concentration of 0.015% in natural water and must be concentrated to 99+% to be useful in reactors as a neutron moderator.

And Other Radioactive Isotopes

Depiction of Plant Processes and Products Compiled from Savannah River Laboratory's Nucleonics of Tomorrow in the Making Here Today (Aiken, South Carolina: E. I. Du Pont de Nemours and Company, not dated).

The Manhattan Project

The Manhattan Project, formally known as the Manhattan Engineer District (MED), was established in August of 1942, more than half a year after Pearl Harbor.[1] Its mission was to beat the Germans in what was widely assumed to be a race for the atom bomb.[2] Unlike other Army Corps of Engineers districts, the MED had no specific geographical boundaries and virtually no budget limitations. General Leslie Groves was put in charge of the operation, and he was allowed enormous leeway. As Groves himself would state after the war, he had the role of an impresario in "a two billion dollar grand opera with thousands of temperamental stars in all walks of life."[3] In organizing the MED, Groves established a precedent that would carry over to the AEC: scientific personnel and resources would be culled from the major universities, but production techniques would be obtained from corporations familiar with the assembly line.[4] The Manhattan Project could not have succeeded without a willing army of brilliant physicists (many of whom were refugees from Hitler's Europe), the nation's huge industrial base of capital and personnel skills, and the leadership and construction skills provided by the Army Corps of Engineers.[5]

Commemorative Manhattan Project Button "A" Bomb Button. Courtesy of Oak Ridge National Laboratory.

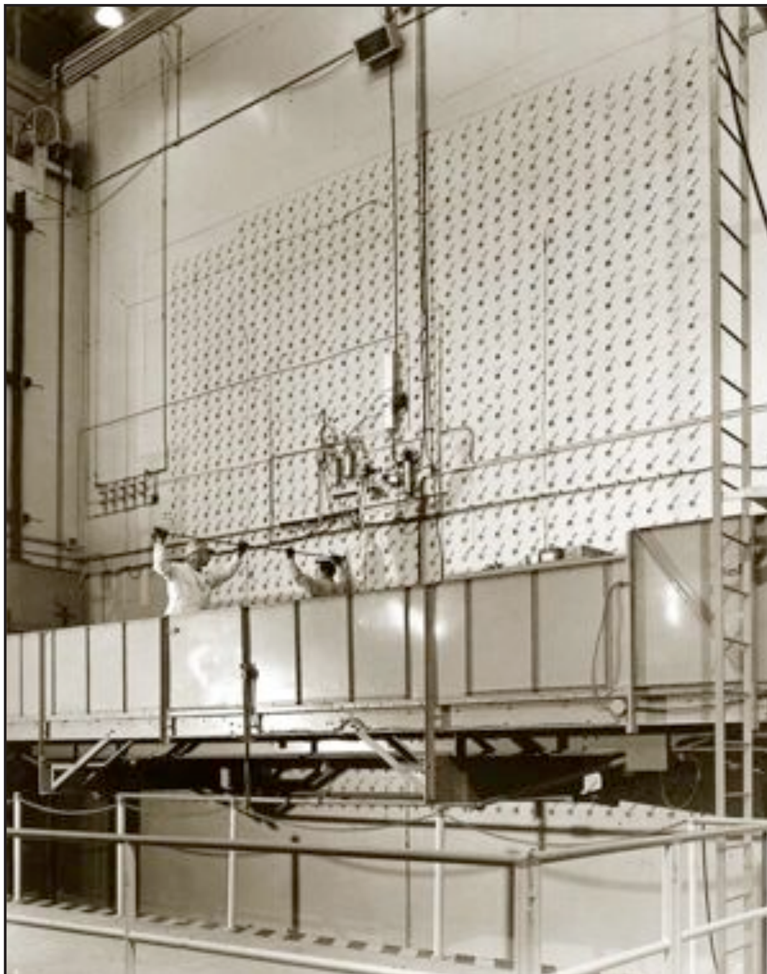
The last half of 1942 saw the groundwork laid for the development of the Manhattan Project. Groves and others selected the methods and sites to be used to produce the bomb. For both speed and economy, Groves wanted to concentrate on one single method for bomb production, but science would not oblige.[6] In the fall of 1942, there were a number of equally valid and equally untried methods for obtaining the fission material for an atomic bomb. There was even a choice of materials: uranium-235 and plutonium.

General Leslie Groves (left), Manhattan Engineer District Leader and Robert Oppenheimer (right), Scientist, Los Alamos.

The methods best known to the scientific community at the start of the Manhattan Project dealt with the collection of isotope uranium-235, which comprises only a very small percentage of natural uranium. There were at least four possible methods for removing uranium-235 from the matrix of natural uranium: the centrifuge method; thermal diffusion; gaseous diffusion; and electromagnetic separation.

To complicate matters, there was also a new method based on the production of a man-made element, plutonium, discovered and named by Glenn Seaborg and others in 1941. Plutonium could be produced by irradiating natural uranium in a pile or reactor, after which it could be separated from uranium chemically, something not possible with isotopes like uranium-235.[7]

By the end of 1942, the field was narrowed to three main methods in the race to produce nuclear materials: gaseous diffusion, electromagnetic separation, and plutonium production. In December 1942, when President Roosevelt gave his final approval for the all-out push, it was decided to proceed with all three.[8] The last of these methods certainly got a boost on December 2, 1942, when Italian refugee Enrico Fermi, working at the University of Chicago, created the world's first self-sustaining chain reaction in a graphite reactor.[9]



X-10 Pile Constructed by E. I. Du Pont de Nemours & Co. at Oak Ridge, Tennessee, now designated as a National Historic Landmark. Courtesy of Oak Ridge National Laboratory

By this time, three huge test and production sites had been selected for MED's work. The first was Oak Ridge in Tennessee, then known as "Clinton Engineer Works," selected as the site for a full-scale electromagnetic plant (Y-12), a gaseous diffusion plant (K-25), and a plutonium pile semi-works (X-10).[10] Constructed in 1943, X-10 became the world's first production reactor when it went critical on November 4, 1943.[11] Hanford, in Washington State, was selected as the main plutonium production site, while Los Alamos in New Mexico, under the direction of Robert Oppenheimer, was chosen to be the nerve center of the project and the bomb assembly site.[12]

While Los Alamos may have been the center of the MED, Hanford was the key to the plutonium bomb, which required the new element in quantities unimaginable before the war. For the construction of the X-10 at Oak Ridge and the full-scale reactors to be built and operated at Hanford, Groves picked Du Pont. This was done not only because of Du Pont's history of explosives manufacture and its association with the U.S. military, but also because it was a large chemical firm that had the personnel, organization, and design capabilities required to do the job.[13] Most importantly, it had a tradition of translating scientific ideas and laboratory techniques into assembly line production.[14]

To do so in a field of endeavor in which they were not expert, Du Pont was to depend heavily upon the Metallurgical Laboratory of the University of Chicago for nuclear physics and radiochemistry experience. Du Pont's key technical employees were sent to Chicago and to Clinton to learn from the research scientists about problems that would bear on the design and operation of the semi-works and the full-scale production plants. This dialogue between the industrial engineers and the academic scientists would be the basis for the selection of processes, and the design of the equipment needed to carry them out, at both the semi-works and at Hanford.[15]

Hanford's three reactors (B, D, and F) and two separations buildings were constructed in 1943-1944. The reactors, water-cooled and graphite-moderated, went on line between September 1944 and February 1945.[16] One of the first crises in the plutonium program occurred shortly after the Hanford B reactor went critical in September 1944. The reactor would go critical and then shut down in a totally unexpected series of oscillations that threatened to ruin the production schedule. After frantic research, it was determined that the reaction had been killed by a periodic build-up of xenon that proved to be a huge neutron absorber with a nine-hour half-life.[17] An engineering feature added by Du Pont was instrumental in solving the problem of xenon poisoning. When scientists at the University of Chicago's Metallurgy Laboratory insisted that only 1500 tube openings were needed in the reactor face, Du Pont added an additional 500 openings as a precaution. This spare capacity, built into every Hanford reactor, made it possible to load the extra openings and simply overpower the effect of the xenon.[18]

By early 1945, Hanford was shipping plutonium to Los Alamos for bomb assembly work.[19] With a detonation device based on implosion, which was more complicated than that required for the uranium bomb, the plutonium bomb had to be tested near Alamogordo, New Mexico, in July 1945. One month later, a similar device was dropped on Nagasaki, only three days after the uranium bomb was dropped on Hiroshima.

The Manhattan Project had been a purely military undertaking, conceived and successfully concluded as a top-secret operation of the Second World War. In the year that followed the war, the project began to unravel as top scientists and others left the project to return to civilian life, and the government considered different proposals for dealing with the awesome power that had ended the war.

Onset of the Cold War

Relations between the United States and the Soviet Union, guarded during WWII, began to chill in the aftermath. The Cold War had its "official" beginnings in February and March of 1946, with three critical events. The first was Stalin's speech (February 9) to Communist Party stalwarts, reaffirming the Party's control over the Soviet Union, and promising more five-year plans and an arms race to overtake the capitalist powers. This was followed on February 22 by George Kennan's famous telegram describing the expansionist worldview of the Soviet leadership, and suggesting "containment" as the best solution. Last but certainly not least, on March 5, was Churchill's "Iron Curtain" speech at Fulton, Missouri.[20]

The beginnings of the Cold War in early 1946 quickly derailed initial talk of international control of atomic energy. By the time the AEC was created by Congress in the summer of 1946, atomic energy had become the cornerstone of the nation's defense against the Soviet Union's preponderance in conventional land forces. For this reason, President Truman was shocked to discover that when the AEC took over Los Alamos in early 1947, the United States did not possess a single assembled working bomb.[21]

Between 1947 and 1950, during the chairmanship of David Lilienthal, the main mission of the AEC was the re-establishment of the nation's nuclear arsenal. The AEC was created as an umbrella agency to control all of the nation's nuclear research and materials production. In this capacity, by early 1950 the AEC oversaw a virtual nuclear empire that not only included old MED facilities at Oak Ridge, Hanford, and Los Alamos, but also encompassed offices in Washington, D.C. and facilities at Argonne National Laboratory (Chicago); Schenectady, New York; Brookhaven National Laboratory, New York; and the University of California Radiation Laboratory at Berkeley, in addition to other small facilities around the country.[22]

During this same period, international events conspired to make the AEC's defense mission even more critical, as international relations slid further into the deep freeze. Concerned that a devastated postwar Europe might drift into the Communist camp, the U.S. government introduced the "European Recovery Program," first espoused by George Marshall in June of 1947. The "Marshall Plan," as it was commonly known, was worked out between the U.S. and various European nations months before it passed Congress in April of 1948. Although offered to all European nations, Stalin saw to it that his side refused to participate. When middle-of-the-road Czechoslovakia expressed interest in the plan, the local Communists, aided by the Red Army, staged a coup in February 1948. This move also gave the Soviets direct access to the rich Joachimstahl uranium mines, desperately needed by Stalin's nuclear program.[23]

Senator and Brigadier General in the U.S. Army Reserve Strom Thurmond, Representative Leroy Anderson and Captain Harry Peters, 1957. "Along the Iron Curtain, Looking into Communist East Germany from 11th Armored Cavalry Regiment Observation Post." Courtesy of the Special Collections, Clemson University Libraries, Clemson, South Carolina.

Unwilling to cooperate with the Western allies in the postwar reorganization of Germany, Stalin initiated the Berlin Blockade, which began in the summer of 1948 and lasted almost a year. It was the first direct confrontation between the United States and the Soviet Union, and it led to the creation of the North Atlantic Treaty Organization (NATO) in 1949.[24] Other crises soon followed. In May of 1949, the Chinese Nationalists, still devastated from the Japanese invasion during World War II, collapsed before Mao's Communist insurgents. Even more ominous, on August 29, 1949, the Soviet Union detonated its first atomic bomb (a plutonium device), an achievement that Truman and most of the U.S. nuclear establishment thought would elude the Soviets for years to come.[25] At the end of 1949 and beginning of 1950, in the wake of the Soviet bomb, Truman and the AEC made plans for the development of the hydrogen bomb, the so-called "Super."[26] Almost simultaneously, Klaus Fuchs, a German émigré who had served in the British Mission to the Manhattan Project at the highest levels of plutonium bomb research, confessed to spying for the Soviets. This revelation in February 1950 sent shock waves through the nuclear community in both Britain and the United States, and seemed to reinforce the decision for both the Super and tighter security. Senator Joseph McCarthy began his accusations just days after news of Fuchs' confession, and four months later, on June 25, 1950, North Korea invaded South Korea.

During the Korean War (1950-1953), the AEC's defense mission was paramount, as witnessed by the explosion of the first H-Bomb in November 1952, and the growth of the nation's nuclear arsenal from 300 to 1000 bombs. The military mission remained strong long after the war, with the official U.S. policy of "massive retaliation" announced by Secretary of State John Foster Dulles in January 1954.[27] The centerpiece of the nation's nuclear arsenal was the H-Bomb, a thermonuclear device that relied on a complex combination of fission and fusion, with fission required to heat and fuse atoms of hydrogen isotopes like tritium to release the high-energy neutrons required for the blast. During the 1950s, a number of thermonuclear devices were detonated, first by the United States and quickly followed by the Soviet Union. These new bombs required increased supplies of plutonium as well as tritium, which had a half-life of 12 to 13 years. The push for the hydrogen bomb led to the expansion or establishment of new AEC facilities, beginning in 1950. Foremost among these new or improved facilities were the Los Alamos Scientific Laboratory, the Lawrence Livermore Laboratory in California, and the SRP in South Carolina.[28] The SRP was first conceived to produce tritium, but was designed to be versatile in its production capacity, accommodating the production of both tritium and plutonium, in addition to other nuclear materials.

The first U.S. thermonuclear device, Mike I, was detonated in November 1952, before the completion of SRP. However, for at least a decade after the first SRP reactor went critical in December 1953, the main, if not overwhelming, mission of the Plant was the production of plutonium and tritium, in the percentages required by annual AEC quotas. SRP played a crucial role in the production of nuclear materials for both fission and fusion bombs, first for Air Force bombers, and finally for the long-range missiles that became prevalent in the late 1950s and early 1960s. During the period when the Cold War was at its peak, between the Korean War (1950-1953) and the Cuban Missile Crisis (1962), SRP was a main contributor to the AEC's defense mission.

Mike Shot. Courtesy of the Los Alamos National Laboratory

Savannah River Plant as Part of the Big Picture

Cold War nuclear weapons production in the United States can be divided into four phases: (1) a research phase, (2) a growth and production phase, (3) a stabilization phase, and (4) a second growth and production phase. The first research phase lasted from the end of World War II until 1955. The second phase witnessed a period of growth and production that lasted from about 1955 through approximately 1967. It was in preparation for this production that the Savannah River Plant was constructed, and this period approximates the more productive era of reactor operations at the site. The primary mission of the Savannah River Plant has been first to produce tritium, and second to produce plutonium and other special materials as directed by the Department of Energy and its precursor organizations.

Complex-wide, plutonium production reached its peak in the early 1960s. The third period was one of stability, during which the concentration of effort was on the improvement of performance and operations of the nuclear arsenal; this phase lasted from about 1967 until 1980. During this period, eight of the nine Hanford reactors were closed down, and the ninth reactor that remained in operation was used to produce fuel-grade plutonium. This left Savannah River as the primary source of weapons-grade plutonium during the period. The fourth phase was a second period of growth, which began in 1980 and saw the restart of L reactor at SRP and the return of Hanford's N reactor to weapons-grade plutonium production. In addition, SRP's C, K, and P reactors were used to produce super-grade plutonium that could be blended with excess fuel-grade plutonium that had been produced in the Hanford N reactor. This phase ended in 1988, when all plutonium production was halted.[29]

The following context, which is specific to Savannah River Site, is based generally on this chronological framework. The plant's construction (1950-1956) is treated as a separate phase in the Site's history, followed by a stable period of production and performance improvement that lasts through 1979. Between 1980 and 1989, SRS experienced dramatic change. The decade began with expansion but this was soon sharply curtailed by shifts in the public's perception of nuclear technology and the abbreviation of the Site's defense mission with the fall of the Iron Curtain.

SAVANNAH RIVER PROJECT, 1950-1955

The Soviet Union detonated its first atomic bomb on August 29, 1949. Labeled "Little Joe" by American journalists, the bomb's unpublicized detonation was confirmed through the AEC's program of sampling rainwater. As a consequence, production needs were increased by the Joint Chiefs of Staff who established new minimum requirements for the atomic stockpile. Programs that had been stalled were now begun with vigor. To accommodate the perceived production needs, new "production piles" were required and the Joint Committee on Atomic Energy (JCAE) decided to build new reactors rather than upgrade those at Hanford.

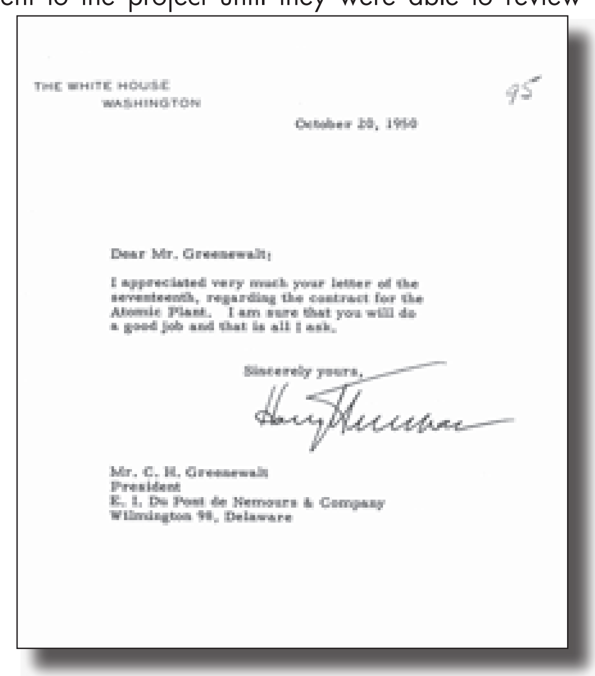
Enlarging the stockpile was the first response to the Soviet bomb. The second was the decision to produce a hydrogen bomb, a weapon many times more powerful than the uranium and plutonium devices dropped on Japan at the end of World War II. On January 31, 1950, Truman signed a presidential directive that directed the AEC to continue work on all forms of nuclear activity, including the development of the thermonuclear bomb, stating, "We have no other course."[30] A program jointly recommended by the AEC and the Department of Defense to produce materials for thermonuclear weapons in large quantities received presidential approval in June. The AEC had already estimated the construction costs for a new production center at approximately $250,000,000 and Sumner T. Pike, Acting Head of the AEC, immediately began negotiations with Crawford H. Greenewalt, president of E. I. Du Pont de Nemours & Co.[31] Truman requested funds from Congress for the construction of two heavy water reactors for the production of thermonuclear weapons on July 7 and shortly after the AEC drafted a letter contract framed in anticipation of Du Pont's acceptance of the project.[32]

Du Pont Signs On

With the passage of the appropriations bill in early 1950, the AEC opened negotiations with Du Pont to build and operate the new plant. Du Pont had built the X-10 reactor and semi-works for the separation of plutonium from irradiated fuel slug facility at Oak Ridge and had built and operated Hanford during World War II through 1946. Both ventures left an indelible print on the corporation headquartered in Wilmington, Delaware, and the success of both Du Pont efforts had left an equally indelible print in the minds of the MED's Leslie Groves and the AEC. In the field of atomic energy industry, they were seasoned players with a pennant under their belts. Crawford Greenewalt and his staff had participated in a period of intense creativity in which the labors of atomic scientists in their laboratories were duplicated on the production line under wartime conditions. Between 1942 and 1946, Du Pont's engineers and scientists had become experts within the atomic energy field. No other American firm could match Du Pont's expertise in the design and construction of production reactors and chemical processing facilities.[33]

AEC representatives visited Greenewalt formally in May of 1950 to apprise him of the proposed project and on June 8th the Wilmington firm was asked to complete the following: finish the site survey; design, construct, and operate a new reactor installation; and act in a review capacity for the technical aspects of the reactors and the processes for the production of heavy water.[34] The Commission also asked Du Pont to find a location that would not warrant the construction and management of a "company" town, a significant departure from previous military atomic energy plants established by the government.

Du Pont replied that it would consider the project if it had full responsibility for reactor design, construction, and initial operation. The "flexible" reactor design specified by the Commission called for a heavy water moderated and cooled reactor and Du Pont wanted to delay commitment to the project until they were able to review initial plans, particularly for heavy water production, and get a sense of proposed schedule. Greenewalt added a final proviso - that Truman himself request Du Pont's involvement in the project because of its urgency and its importance to the nation's security - which was done in a letter dated July 25, 1950.[35] Greenewalt's request was aimed at squelching any associations with the "merchants of death" label that lawyer Alger Hiss had leveled at the corporation in the 1934 U.S. Senate investigation of the munitions industry. Truman's letter, briefly written and to the point, would become an industrial icon for Du Pont. On July 26, Du Pont's Executive Committee adopted a resolution to undertake the project. The internal resolution also established the Atomic Energy Division (AED) within Du Pont's Explosives Department. The AED would be responsible for the new project.[36]



THE WHITE HOUSE
WASHINGTON

95

October 20, 1950

Dear Mr. Greenewalt:

I appreciated very much your letter of the seventeenth, regarding the contract for the Atomic Plant. I am sure that you will do a good job and that is all I ask.

Sincerely yours,

Harry Truman

Mr. C. H. Greenewalt
President
E. I. Du Pont de Nemours & Company
Wilmington 98, Delaware

A letter contract, backdated to August 1, 1950, was signed between Du Pont and the AEC.[37] The letter, which would be superceded by a formal contract three years later, specified that there would be no "facility village" associated with the project and that Du Pont would not be held liable for any lawsuits that might result.[38] On October 18, Greenewalt wrote the company's stockholders that Du Pont would assume responsibility for the construction and operation of the new facility. As at Hanford, the government would pay all costs and receive any patents that might develop out of the work; Du Pont would get an annual fee of just one dollar.[39] Some of the contractual clauses that were first written into the Hanford contract and were duplicated in the SRP contract would become standard in operating contracts undertaken in the modern nuclear industry.[40]

At the time of the letter agreement, the AEC wanted Du Pont to build a tritium plant with two reactors, each to operate at an energy level of around 300 megawatts (MW). The AEC had selected the reactor type advanced by Argonne National Laboratory that was cooled and moderated with heavy water and Du Pont after review accepted the design. By 1950, heavy water reactors were considered more versatile than the graphite reactors Du Pont had built at Hanford and had better neutron economy.[41] As early as August of 1950, Du Pont's Atomic Energy Division had made preliminary improvements to the basic heavy water design proposed by Argonne and was on a pathway to construction.[42]

Site Selection

The proposed site, referred to as "Plant 124," was selected after a six-month investigation launched by Du Pont's Engineering Department and aided by the U.S. Army Corps of Engineers (COE). Truman had advised AEC's Gordon Dean not to brook any political pressure in the decision-making process and the selection process began on June 19, 1950.[43]

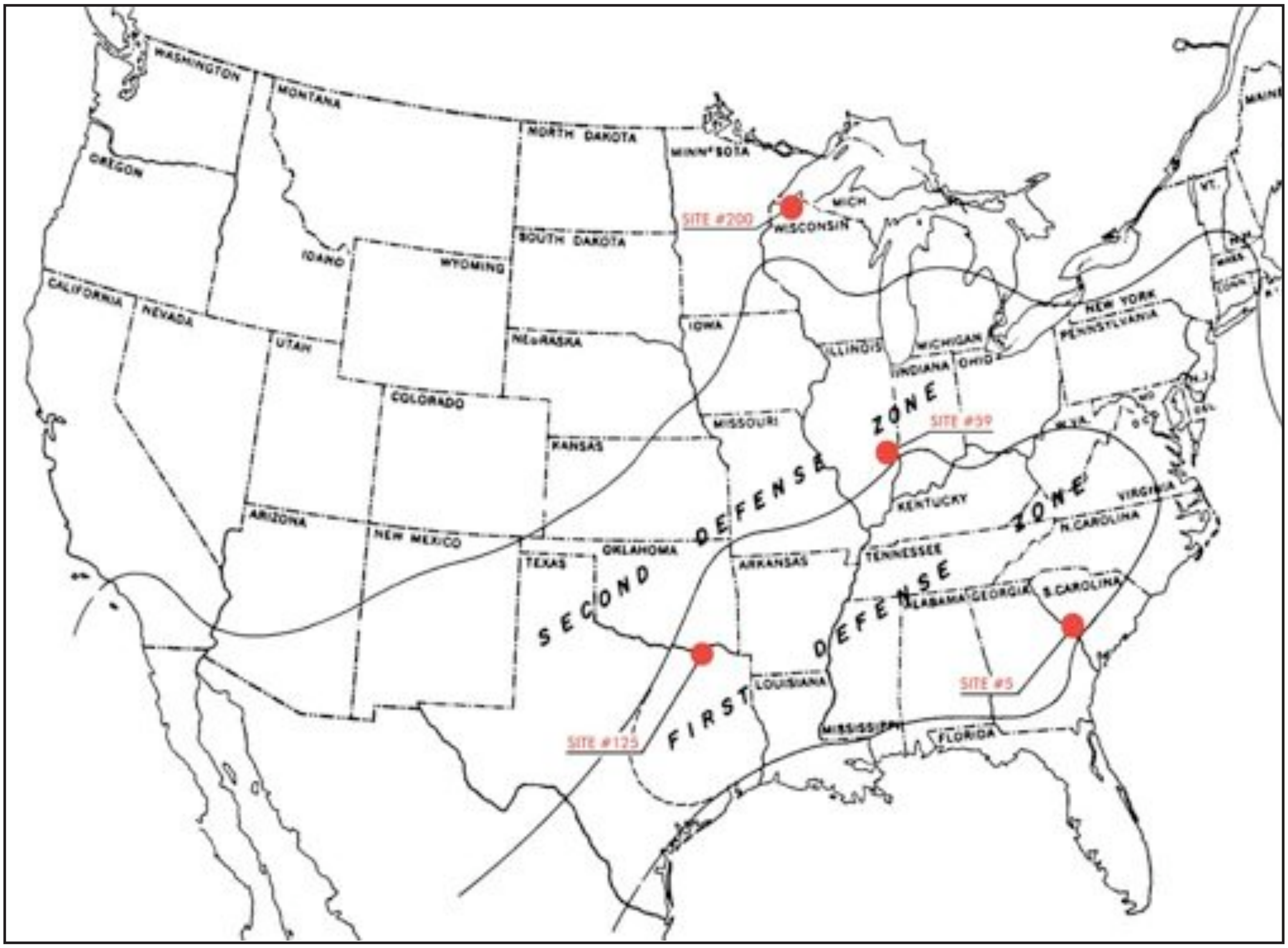
The AEC had first contacted the COE and asked them to prepare a list of sites including government-owned lands that might be suitable. This preliminary data was reviewed in the Cincinnati Corps Office of the Great Lakes Division but was found lacking in definition. The following methodology was agreed upon: all rivers with a recorded minimum flow of 200 cubic feet per second (c.f.s.) were marked on sectional maps prepared by the Corps and locations within 20 miles to a river were considered. Bands were drawn along selected rivers and potential sites were located within these bands. The preferred site would also be located in the "The First Defense Zone" for strategic reasons imposed by the Department of Defense. This zone encompassed area that stretched from Texas to Virginia and north to Illinois. Embracing the central portion of the Southeast, it included 84 candidate sites. A second band of area that stretched from Arizona to New Hampshire was considered the "Second Defense Zone." The latter had six candidate sites. C. H. Topping, Principal Architect and Civil Engineer within Du Pont's Design Division, further described the selection process that was guided by "basic site requirements" that were jointly arrived at by Du Pont and the AEC. The requirements were: a one-square mile manufacturing area; a 5.6-mile buffer zone enclosing the manufacturing area; a 10-mile distance to neighboring communities of 500 individuals and a 20-mile distance from communities with 10,000 individuals; presence of supporting populations to absorb the incoming workforce; ample water and power supplies; accessibility by rail and highways; favorable meteorology and geology; and positive conditions for construction and operating costs.[44]

Sixty-five sites were eliminated when progress in reactor design studies established that the minimum acceptable water supply was 400 c.f.s. By August 2, the list was pared down to seven sites. Members of the AEC, Army Corps of Engineers staff, and the Du Pont team, between August 6 and 17, chose these as candidates for a field inspection. Three local sites made it to this shortlist: two in South Carolina and one in Georgia. The site in Georgia was eliminated when it was learned that the Clark Hill reservoir would put a portion of the desired site under water and a site in northwestern South Carolina was considered too isolated. Site #5 in Aiken and Barnwell counties stayed in the running.

Changing water requirements also led to searches in colder climate areas both within and outside of the Second Defense Zone. These sites were put into the selection mix and similarly eliminated as the selection criteria were applied. In mid August, the requirement for the minimum water supply was increased to 600 c.f.s.[45] The Special Committee of the National Security Council on Atomic Energy had called for the construction of three additional reactors.[46]

A final evaluation of sites using the original and expanded criteria focused on four locations. These were Site #125, which was located along the Texas and Oklahoma border on the Red River; Site #59 which was located on the border of Illinois and Indiana on the Wabash River; Site #205 which was located on the shores of Lake Superior in Wisconsin; and Site #5 located in Aiken, Barnwell and Allendale counties on the Savannah River in South Carolina. Essentially, three factors were compared. The first was the availability of large quantities of reasonably pure water for process capability, the second was the presence of towns of sufficient population that could absorb the proposed labor force but were at a sufficient distance to minimize any impacts, and third, the presence of sufficient land that was suitable to the construction of production areas. During the week of August 24th, these sites were field checked by the AEC's Site Review Committee composed of five experts drawn from American engineering firms such as Black and Veatch, Sverdrup, etc., that were authorities on site selection.

Site #5, a rural site along the Savannah River in South Carolina, was recommended to the Site Review Committee on November 13, 1950 as the final selection. In the words of Du Pont Engineer, C. H. Topping, it "more nearly meets the requirements than do the others."[47] The Site Review Committee concurred with the recommendation and Site #5 was selected. The AEC formally confirmed the decision on November 28 and the public was notified by an AEC press release on the same day. AEC's Curtis A. Nelson was named as the plant first local manager in August. Nelson, a Nebraska born civil engineer and colonel in the Manhattan Project, was familiar with heavy water technology through his work as a liaison with Canada's Chalk River Plant. He also brought strong construction experience to the new project from his years in the Civilian Conservation Corps and as engineer in the Corps of Engineers where he had supervised the construction of the Joliet Illinois Ordnance Plants.[48] He was charged, along with Bob Mason, Du Pont's Field Manager for Construction, with moving the project off the Du Pont Company's and their subcontractor's drawing boards and placing nine industrial plants into the rural South Carolina landscape. Mason, a Hanford veteran, was assigned to the project on September 25.



Site Selection Map Showing Military Defense Zones and the Location of Candidate Sites. Site No. 5 is the future Savannah River Plant.

Announcement

The swiftness and military execution of the site selection announcement attests to the months of planning involved in its preparation. At 11 o'clock on Tuesday morning, November 28, 1950, the announcement was made simultaneously at press conferences held in Atlanta and Augusta in Georgia; at Columbia, Charleston, and Barnwell, in South Carolina; and to mayors, presidents of chambers of commerce, state, city, and county officials. During the day, teams representing both AEC and Du Pont called on city, county, and state officials in Atlanta, Columbia, Augusta, Aiken, Barnwell, Ellenton, Jackson, Dunbarton, Snelling, Williston, White Pond, Windsor, and Blackville. Later in the day further details were released concerning the project by the AEC in Washington, D.C. Teams gathered that evening in the office of the Du Pont Field Project Manager at the Richmond Hotel to compare notes.[49]

AEC Field Manager Curtis Nelson and Du Pont's Chief Engineer formally delivered the news to Governor Strom Thurmond and Governor-elect James F. Byrnes in Charleston, South Carolina, where they were attending the Southern Governors Conference. Governor Thurmond invited Georgia's Governor Herman Talmadge to join in the press conference prepared for the journalists covering the conference. The timing of the announcement for what could only be forecasted as a regional economic success story was excellent for both Thurmond and Talmadge. Byrnes was well versed in atomic energy development for military purposes. He had acted as Franklin Roosevelt's "Assistant President," running the country while FDR fought the war and he was Truman's Secretary of State.[50] All three men were major figures in national and Southern politics and it is unlikely they watched the site selection process unfold without knowledge or interest.


The Augusta Chronicle
$260,000,000 H-bomb material facilities will be constructed in S. C. near Augusta
Allies facing 'new war'
Grim note is voiced by Gen. MacArthur
Aiken-Barnwell site is selected for plant
Shocked officials seek urgent steps
Plant means big boom for Augusta
Ellenton's residents stunned, but accept news patriotically

Front page of *The Augusta Chronicle*, November 29, 1950, reported on the announcement from several angles reflecting the many meanings the new plant would have for the country, the CRSA, and for those displaced by the proposed land acquisition.

The public announcement of the project signaled a new era in which the American public's right to know was at least partially fulfilled. Previous military atomic energy undertakings had been done in total secrecy as part of a wartime defensive effort. The Savannah River Project was complex and atypical as it was to be constructed during peacetime, its mission still required secrecy, and a government town was not to be constructed. The latter meant that the surrounding communities, which were fairly settled, were to absorb the new workforce estimated in the thousands and to create the infrastructure and services needed for this population increase. Public disclosure was warranted and unavoidable. A straightforward approach was chosen in which public outreach and partnership initiatives were advocated. Public meetings, lectures, project managers working with community development and business leaders, and the airing of a movie called *The Du Pont Story* in Augusta for business leaders and new employees were just some parts of the AEC and Du Pont's well-orchestrated strategy for strong and positive public relations.

Site Description

With the site survey behind them, Du Pont moved forward with site definition and acquisition strategies. When acquired, the site would contain about 200,646 acres or 310 square miles within Aiken, Barnwell, and Allendale counties situated within two sub-divisions of the Atlantic Coastal plain: the Aiken Plateau and the Alluvial terraces that lie along the river. Eighty percent of the site was situated within the Aiken Plateau, where elevations ranged between 300 and 385 feet. The terraces are composed of three tiers of varying widths banding the river. From north to south, six streams dissected the tract: Upper Three Runs Creek, Four Mile Creek, Pen Creek, Steel Creek, Hattie Creek, and Lower Three Runs Creek. Five streams empty into the river in a southwesterly direction, the sixth, Lower Three Runs, flows to the southeast and drains the eastern portion of the proposed site. Although irregular in shape, the site measured roughly 22 miles in width and 22 miles in length.

The proposed site was rural but not isolated. The nearest large urban centers in Georgia were Augusta (20 miles northwest), Atlanta (155 miles west and north), Savannah (85 miles to the southeast) and in South Carolina, Columbia (65 miles northeast). In addition, data was gathered on towns with populations of over 1,000 individuals

Meeting at Ellenton Auditorium, December 6, 1950. The U.S. Corps of Engineers real estate officers responsible for the land acquisition called a public meeting in Ellenton. A representative from each family was asked to attend the question and answer session. Reportedly, over 500 individuals attended what appears to have been a segregated meeting with attendees, both black and white, spilling out of the main hall into the building entries and lobby. Courtesy of SRS Archives, negative 1221-1.

within a 50-mile radius to the site. The project area contained seven communities: Ellenton and Hawthorne in Aiken County, and Dunbarton, Meyers Mill, Robbins, Leigh, and Hattieville in Barnwell County. Ellenton, a post-Civil War railroad community and local trading center, was the largest with a population of 600. Dunbarton, also a railroad town, had a population of 231 individuals. The remaining communities were smaller. Meyers Mill possessed some stores and a cotton gin while Leigh was synonymous with a box and crate manufactory, the Leigh Banana Case Company, that operated at that site between 1904 and 1954, employing about 300 people in 1950.[51]

Camp Gordon, Oliver General Hospital and its annex, Daniel Field, and the Augusta Arsenal were military installations less than 26 miles from the proposed site and six airports, five municipal fields on which there was a recapture clause in case of war and one USAF inactive airfield, that were within 40 miles.[52] The existing road system was composed of state highways that intersected with U.S. highways and in addition, there was a well-defined network of unpaved "farm to market" dirt roads. Rail service was already in place. The Charleston and Western Carolina (CWC) Railroad paralleled the river, providing service from Savannah to Augusta and the Atlantic Coast Line Railroad ran from Barnwell to Robbins where it joined the CWC line. The CWC ran through Ellenton and Dunbarton and the smaller communities were railroad stops on the line.

The acquisition process was handled over an 18-month period by the South Atlantic Real Estate Division of the U.S. Army Corps of Engineers on behalf of the AEC. The process formally began the day after the announcement so that the government would have the necessary lands either by declaration of taking or through actual purchase by June 30, 1952. The acquisition process was staged to accommodate construction requirements. Priority zones were established, rights of entry obtained, and property transfers swiftly occurred. Ultimately, 123,100 acres situated in Barnwell County, 73,462 acres in Aiken County, and 4,084 acres in Allendale County were acquired. Boundary realignments occurred as the acquisition process progressed, eliminating two of the four communities (Jackson and Snelling) that were originally within the project area and adding on a 4,453 acre corridor of land on both sides of Lower Three Runs Creek in Barnwell and Allendale counties.

Six thousand individuals were evacuated from their homes and homesteads. Some displaced owners moved their homes, joined neighboring communities, and worked at the plant. Business owners relocated and new businesses were spawned by the influx of plant employees, particularly during construction. Others sold their properties and left the area viewing the change as an opportunity. While a sense of patriotism motivated most of the project area residents, it was difficult for all involved as government appraisals were guaranteed to fall short when values were attached to land that had generations of farming and family life invested in its soil.

Site Layout

Some residents preferred to move their homes to locations outside the new federal site. Du Pont designated a House Moving Coordinator to handle the moves. All land was acquired by June 30, 1952. Courtesy, SRS Archives.

SRP was originally organized into nine manufacturing areas, a central administration area, and two "service" building areas known as the Temporary Construction Area (TC Area) and Central Shops. Between building areas, buffer areas were forested, masking the earlier landscape and providing a sense of distance and isolation. The areas were linked by a well-designed transportation system that included 210 miles of surfaced highways, a cloverleaf that was the first constructed in the state, and 58 miles of railroad track. Previous road names were erased and letter designations, such as Road A, Road B, etc., were assigned.

Each area was given a number and a unique letter designation (Table 2). Function was reflected in the area numbers; letters identified site geography. This code-like system, used first at Hanford for the identification of building areas and their associated facilities, and the road lettering system heightened the anonymous and utilitarian character that evolved at the site.

1956 Basic Information Map- General Areas.

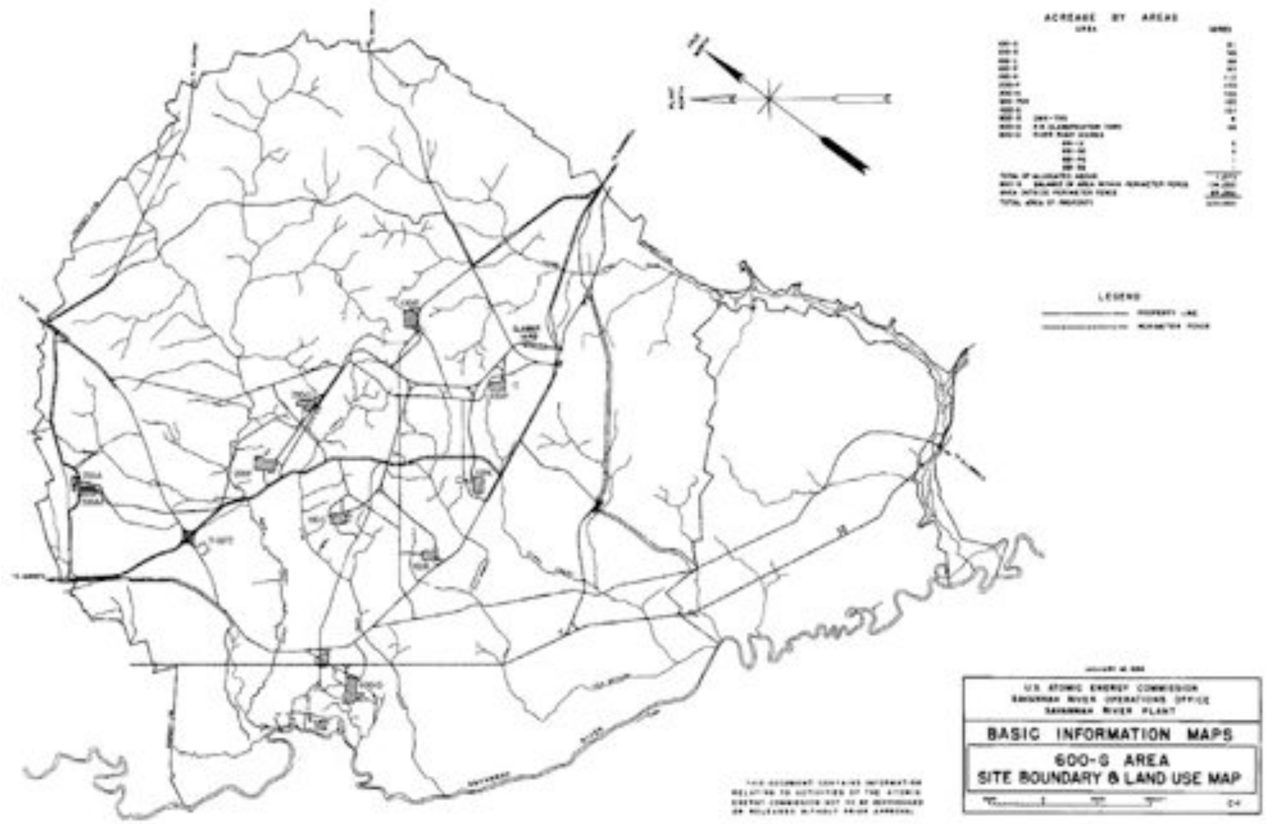


Table 2. Area Nomenclature

100 - Reactor Area	100-R, P, L, K, and C
200 - Separations Areas	200-F, H
300 - Fuel and Target Fabrication Area	300-M
400 - Heavy Water Production Area	400-D
500 - General (lighting, transmission lines, substations, etc)	500-G
600 - General	600-G
700 - Administration Area	700-A

Each 100 area, 100-R, 100-P, 100-L, 100-K, and 100-C, was situated in the central part of the site, aligned in an arc. The reactor areas were purposely dispersed at 2.5-mile intervals from each other and 6 miles from the site boundary to minimize the impact of an "atomic blast." Early maps show the site layout process and the reservation of space or alternative sites for future expansion. The *Engineering and Design History* notes that much discussion occurred between Du Pont and AEC consultants on where the process buildings should be located, however it was the U.S. Air Force that had the final word on their dispersal, suggesting that the pattern chosen had military ramifications.[53] Two river water pump houses, one at the mouth of Upper Three Runs Creek and a second two miles upstream from the first, supplied water to the 100 areas, primarily for cooling the heavy water coolant.

The 200 Areas, 200-F and 200-H, were also centrally located within the site's core area, approximately 2.5 miles from the closest reactor area and about 6 miles from the project area perimeter. The canyon buildings, massive concrete buildings, would dominate each separations area. F area contained four process buildings originally and was built to be self-sufficient. H Area did not contain the same process buildings but space was allotted for future expansion. Water to both 200 areas was supplied from deep wells.

The 400-D Area, located near the site's southwest perimeter approximately one mile from the river, housed heavy water production units and support buildings. Resembling an oil refinery, the 400 Area was characterized by three steel tall tower units, a flaretower, a finishing facility and other support buildings including a powerhouse. After SRP was closed to the public, this area was viewable from outside the site boundaries and the GS towers and flare tower was the visual image most area residents connected with SRP. A third river pump house supplied water to 400 Area.

The 300-M Area was situated near the northwest perimeter of the project area where it was laid out in a rectangle that adjoins the 700 Area. It contained testing and fabrication facilities for reactor fuel and targets. Two buildings, 305-M (now 305-A) and 777-M (now 777-10A), contained test reactors that were used to test the components manufactured in the 300 Area and to aid development and testing for SRP reactor design.

The 700-A Area was SRP's administrative and "service" center. It contained the main administration building noted in the excerpt above, the medical facility, communications facilities, patrol headquarters as well as a variety of maintenance and storage buildings. A Area also contained the Main Technical Laboratory, now Savannah River National Laboratory, in which plant processes were researched, designed, and tested, and other research facilities.

Finally, two pilot plant facilities, CMX and TNX, were located near the 400 Area. The former was designed to run corrosion tests on heat exchanger equipment installed in the reactors and to investigate what types of water treatment processes were needed for plant operations. A small pump house accompanied it. The latter was a pilot plant for processes completed in the 200 area canyons.

Nine coal-burning powerhouses located in the building areas supplied steam to the process areas and the overall site. The large pipes that carried the steam are above ground, arching over roadways where necessary and paralleling the road system. Outside the manufacturing and service building areas, general facilities needed for either process support or general site support included three-river water pump houses, a pilot plant, railroad classification yard, and burial ground for solid wastes.

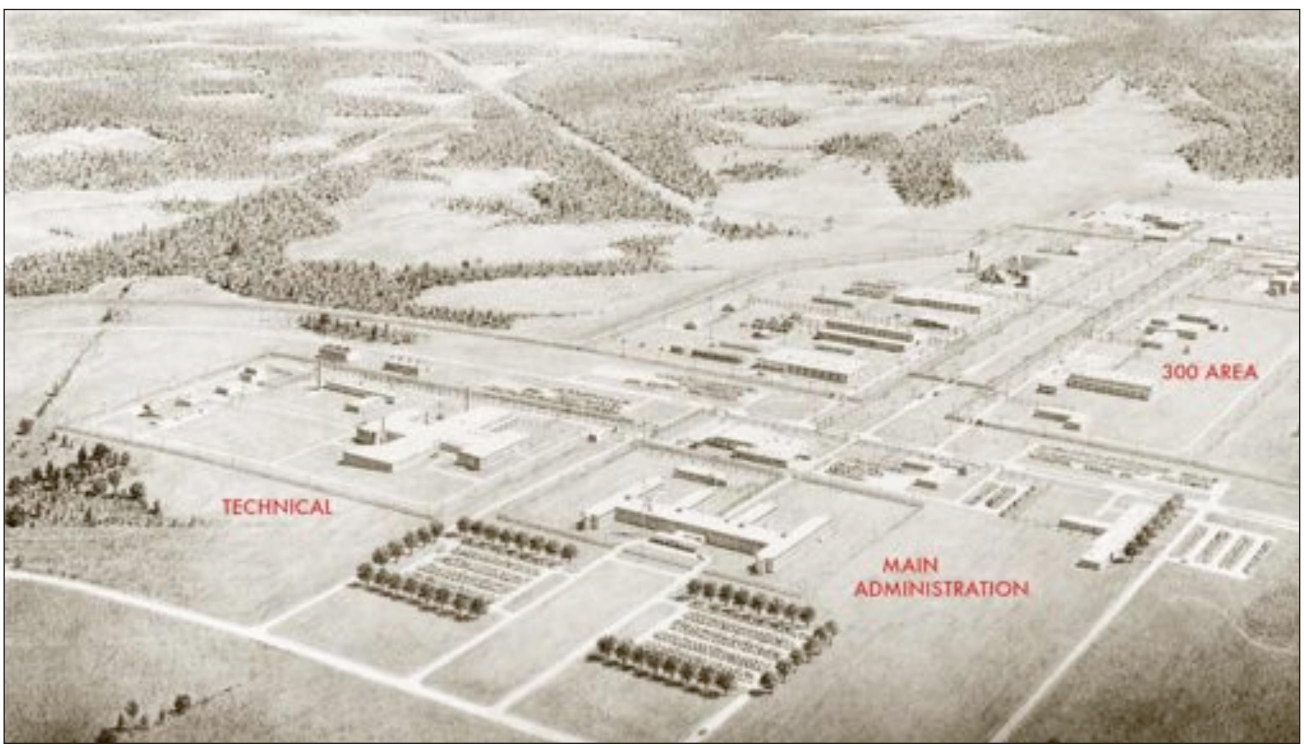
The first generation of buildings at SRP was simply designed using a functional ethic. The AEC's specification that the project's buildings be spartan in their design was a done deal given the climate of American post-war industrial architecture. The choice of building materials, reinforced concrete and transite paneling, were mandated by the building code. Articulated in reinforced concrete or steel frame with transite panels, the majority were beige or gray boxes built for maximum flexibility and for government service. Their uniformity in color, their number and size, and their geometric forms create a harmonious grouping of buildings within an ordered industrial landscape where form reverberates function. This functional perspective is further emphasized by the placing of the Site utilities aboveground so that massive pipes parallel roads or arch over them. Economically motivated, this design feature has strong visual impact.

Subcontractors

It was recognized from the start that Du Pont Engineering Department would need supporting organizations to complete the project given its size and schedule. Temporary use was made of the Bush House located on Highway 19 as the Field Construction Office and a tenant farmer's dwelling was adapted for use as the Field Cost Office. The need for immediate construction buildings while Du Pont was organizing called for the hiring of a local architectural and engineering firm, Patchen and Zimmerman of Columbia, SC, to get things off the ground.[55] This firm's design work at the TC Area with its two massive cartwheel buildings and the adjacent cloverleaf created one of the most visually appealing layouts on site.

Engineering and design assistance to Du Pont was provided by the following subcontractors: American Machine and Foundry Company, Blaw-Knox, the Lummus Company, Gibbs & Hill, Inc, and Voorhees, Walker, Foley & Smith. Each of these firms had demonstrated experience in their respective areas and each made significant contributions to the equipment and SRP building stock.

Table 2. Subcontractors for Du Pont Project 8980.



Architectural Rendering of the Main Administrative Area (700-A) and the Fuel and Target Fabrication Area by Architects Voorhees, Walker, Foley & Smith, ca. 1951

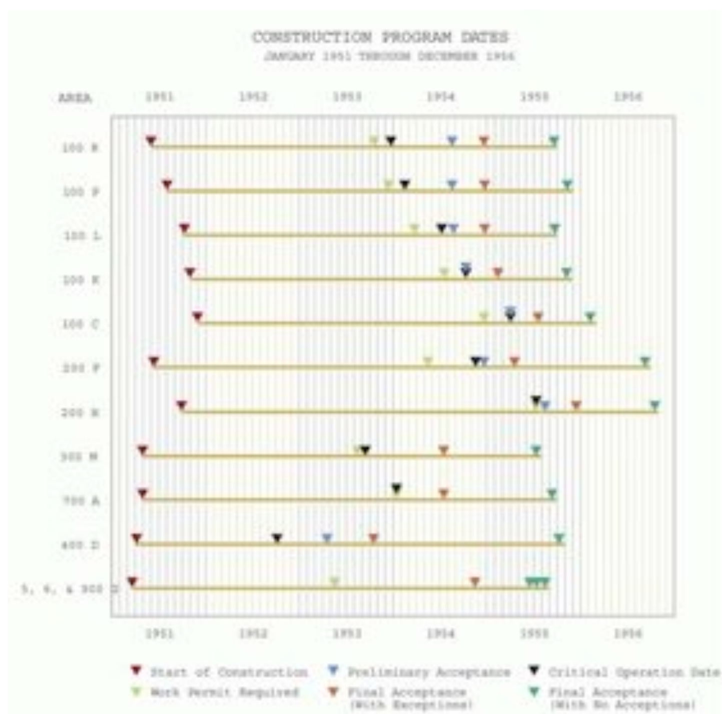
American Machine and Foundry (AM&F) - This firm was charged with the design and fabrication of special mechanical equipment for use in the 100, 200, 300, and 400 area process facilities. AM&F described their firm as manufacturers of machines for industry. In 1950 they were considered the world's largest manufacturer of cigarette and cigar making equipment.[56]
The Lummus Company - This firm was requested to design and partially procure six "GS" units (towers 116' in height) including the DW and finishing plants for the 400 area heavy water production facilities. The firm brought strong petroleum, petrochemical, and chemical experience to the project. Self described as a network of men, minds, and machines that were dedicated to transforming ideas and capital into profit earning processes and equipment, the Lummus Company, international in scope and headquartered in New York, were expert in the design of distillation processes.[57] The 400-area design benefited from an agreement between the Girdler Corporation, which had designed the Dana Plant, and the Lummus Company for the exchange of technological information gained from the Dana Plant that could be applied at SRP.[58]
Blaw-Knox Company - Design of process buildings and equipment required in 200 area facilities, general area facilities (600 area) related to 200 area processes.
Gibbs & Hill, Inc. - Design of steam, water, and electrical facilities for process areas and overall plant. This engineering firm based in New York was subsumed by Dravo Corp of Pittsburgh in 1965 then later sold to Hill International, a New Jersey based firm.
Voorhees, Walker, Foley & Smith - This New York architectural/engineering firm was responsible for the design for all "service" buildings including laboratories and general facilities including roads, walks, fences, and parking areas; the manufacturing buildings in the 300 area; laboratories; some design work for 200 areas and overall site clearance at SRP. It was also responsible for Du Pont's Experimental Station in Wilmington, the MED laboratories at Columbia University and Argonne National Laboratory.[59]
New York Shipbuilding - This firm was responsible for fabricating the five reactor vessels that were transported by barge to the South Carolina site. Known as the NYX Program, this effort produced the cover plate of the reactor vessels known as the "plenum" (a laminated steel plate 19 feet in diameter, four feet thick, weighing about 100 tons, and drilled with 500-4-inch tubes), the reactor vessels, and the primary piping.[60] Organized in 1899, New York Shipbuilding was located on the banks of the Delaware River in South Camden, New Jersey. The firm brought its experience in the fabrication of heavy industrial equipment and machinery to the task. A company history notes that the firm had taken on projects as "a public service where the facilities of the Yard provided the only available means for constructing unusual items. Its location on tidal waters, with weight handling equipment up to 300 tons, makes it possible to load assemblies which may be beyond the size or weight limitations for shipment by rail."[61] These qualities were probably well known to Du Pont who also had a plant in the Camden area.

Unfolding Scope of Work and Flexible Design

By Hanford standards, the 38 months from start of construction to operation for C reactor at Savannah River was quite slow. However, by later standards, such a pace would appear incredibly rapid. The placing of R reactor in operation in December 1953, when the conceptual design had only been sketched out in December 1950, seemed to later nuclear specialists a remarkable achievement in engineering and management.[62]

The scale, shape, and funding of the Savannah River Project and the mix of plutonium, tritium, and other radioisotopes to be produced in its reactors was determined by the AEC. The schedule was set by world events. Du Pont's design team, in association with their primary subcontractors, was responsible for translating the larger conceptual design outline by the AEC into reality within an atmosphere of "urgency and commitment."[63] Du Pont designers accomplished their goals using a "flexible design" approach. This approach operated at two levels: the first entailed postponing design decisions until the best design could be determined by research or through consultation, and the second was to build in the potential for future design options should AEC policy change.

In the first scenario, Du Pont designers based some design decisions on their experience from previous atomic energy plant construction projects and from scientific research completed at the AEC's national laboratories. This allowed them to move forward with production in some areas while alternative design choices were researched for others. In the second scenario, postponement of design was necessary as part of the current and future client-contractor relationship. AEC directives, based on Department of Defense guidance on what product or product mix was needed for its weapons program, directly translated into design decisions. Du Pont recognized this as an integral feature of their contract and responded with aplomb to an evolving scope of work. Their ability to do so was characteristic of the firm's management that had an internal set of departmental checks and balances and well-honed procurement strategies.[64]



Bar Graph showing the construction schedule and the milestones reached. Source: Engineering Department, E. I. Du Pont de Nemours & Co., Savannah River Plant Construction History, Volume I, DPES 1403, 1957.

SRP Operations, 1955 - 1989

As an integral part of the nuclear weapons production complex, SRP's primary mission has been first to produce tritium, and second to produce plutonium and other special materials as directed by DOE and its precursor organizations.[65] Its role was not one that can be described as one step along a linear process, but rather as one of the hubs of material movement through the complex. Table

3 shows how the site was integrated into the overall nuclear weapons complex and the direction of material flow that established the relationship.

Table 3. Direction of Flow of Materials into and from the Savannah River Site to other Sites Within the National Nuclear Weapons Production Complex

Other Sites Within Complex	Direction of material flow	SRP Area	Type of Material
FMPC and Weldon	To	300 Area	**Raw Materials:** natural and low enriched uranium for fuel and target manufacture
Oak Ridge Site Y-12 Plant	To	300 Area	**Isotope enrichment:** highly enriched uranium for fuel and target manufacture
Oak Ridge Site Y-12 Plant	To	300 Area	**Isotope enrichment:** Lithium for target manufacture
Oak Ridge Site Y-12 Plant	From	400 Area	**Isotope enrichment:** Heavy Water for deuterium production and deuterium gas
Dana Plant	To	100 Area	**Isotope enrichment:** Heavy Water for moderator and coolant
FMPC and Reactive Metals, Inc.	From	300 Area	**Fuel and Target Fabrication:** depleted uranium for fuel
Weldon Spring Plant, FMPC, Oak Ridge Site K-25 Plant, and Paducah Gaseous Diffusion Plant	From	200 Areas	**Separations** (for raw materials recycle): low enriched uranium for recycle
Oak Ridge Site Y-12 Plant	From	200 Areas	**Separations** (for raw materials recycle): highly enriched uranium for recycle
Rocky Flats	From	200 Areas	**Separations:** plutonium metal buttons for pit production
Mound Plant	To	200 H Area	**Separations/component manufacture:** recovered tritium for purification and reuse
Pantex Plant and Iowa Army Ammunition Plant	From	200 H Area	**Separations/component manufacture:** filled tritium reservoirs ready for assembly

Source: USDOE Office of Environmental Management, *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to their Environmental Consequences* (Washington, DC: USDOE Office of Strategic Planning and Analysis, 1997), 18-19, 154-155.

Heavy Water Production and Rework

The Heavy Water plant at SRP (the D Area) used the Girdler Sulfide (GS) process of hydrogen sulfide-water exchange. This portion of the plant, completed in 1952, included 144 process towers ranging from 6.5 to 12 feet in diameter, each 120 feet tall.[66] Between 1952 and 1957, the D Area plant and the heavy water plant at Dana, Indiana, supplied most of the heavy water for the nuclear weapons production complex. A sufficient stockpile of heavy water had been accumulated by 1957 to allow the closure of Dana and of two-thirds of the Savannah River units. The remaining units continued to operate until 1982, primarily to reconcentrate heavy water that became diluted during reactor operations. During its 30 years of operation, D Area produced over 6,000 tons of heavy water.[67]

In the spring of 1953 a small plant was constructed in D Area to produce deuterium gas from heavy water by electrolysis. Some of this deuterium was used at Savannah River in the Tritium facility (tritium reservoirs were actually filled with a mixture of tritium and deuterium), and some was sent to the Oak Ridge Site to be converted to the lithium deuteride used in the secondary assemblies of thermonuclear weapons. A second, larger deuterium plant was constructed in D Area in 1954.[68]

Fuel and Target Fabrication

The manufacture of early reactor fuel elements, or slugs, was fairly straightforward. Although there had been problems in the early fabrication process at Hanford, the lessons learned there allowed SRP production in the M Area to proceed with relatively few problems. The slugs were solid natural uranium rods about one inch in diameter and eight inches long, clad in aluminum. The uranium rods were fabricated by Femald (FMPC) and shipped to Savannah River. The metallurgical structure of the uranium rods was adjusted (first at Savannah River, later at FMPC prior to shipment); the slugs were then sealed in aluminum.

Lithium target slugs were also needed for the production of tritium, and for use as control rods in the reactors. Lithium was sent from the Oak Ridge Site to Savannah River Building 320-M, where it was alloyed with aluminum, cast into billets, extruded to the proper diameter, cut to the required length, and canned in aluminum. The lithium-aluminum slugs were also encased in aluminum sheaths, called raincoats. At Savannah River, tritium was initially produced as a reactor byproduct in the lithium-aluminum control rods. As AEC requirements for tritium increased, reactor elements specifically designed for tritium production were needed. Driver, or fuel, elements of highly enriched uranium were used to provide the neutrons for irradiating the lithium-aluminum target elements. Enriched uranium drivers were extruded in 320-M until 1957, after which they were produced in the newly constructed 321-M, built specifically for this process.[69]

The M Area at Savannah River continued to produce most of its own fuel and target assemblies until the end of the Cold War. Revisions and upgrades were made to the facilities, as needed, one of the most important being the change from solid slugs to tubular elements. The production of solid slugs ended late in 1957. Production in the M Area increased and decreased with the needs of the reactors. The last large increase was in 1983, when the operations in 321-M went to 24 hours a day. Operations fell off as the reactors closed, and for the most part have ceased altogether since 1989, when the last reactor was taken off line.[70]

Reactor Operations

There were five production reactors operating at the Savannah River Plant during the Cold War, identified as C, K, L, P, and R reactors. The first SRP reactor to go online was the R reactor, which was tested for integrity and operability during the fall of 1953, and brought to criticality in December. The first few months of operation were problematic because instruments triggered frequent automatic power reductions and "scrams," or unscheduled emergency shutdowns. Improvements to the instrumentation and signal systems mitigated these problems, and the number of scrams, one a day in February 1954, fell to an average of one in three days by May. P reactor was the second to go critical, the event occurring on February 20, 1954. The first irradiated fuel was discharged from R reactor the following June, and all five reactors were operating by the end of March 1955.[71]

Changes were quickly made to both the reactors and reactor operations. Although Savannah River was originally intended as a tritium production site, the lithium-aluminum slugs from which tritium was produced were at first used only as control rods. As a result the first tritium was produced as essentially a byproduct of plutonium production. However, AEC requirements for tritium production had increased by 1955, and that year the reactors were loaded in configurations specifically meant to produce tritium. As operators found they could increase the power levels at which the reactors operated, they began adding extra heat exchangers to eliminate the increased heat. C reactor had 12 heat exchangers, but the other four reactors only had six, a necessary shortcoming due to limited supplies of heavy water and vender production capabilities during the construction period. The number of heat exchangers was increased to 12 on all reactors in 1956, and the original power output of 378 megawatts was increased to 2,250 megawatts.[72] A megawatt, as used in reference to production reactors, is not a measure of electrical generation but of thermal output, a convenient measure of the operation of a reactor.

To further increase the capabilities of the cooling system, a large retention lake was created. Heavy water was used to remove heat from the reactors, and light water from the Savannah River was used to remove heat from the heavy water. The increase in the amount of heat being removed via the heavy water meant a concurrent increase needed to be made in the amount of heat being removed by the light water. Unlike the heavy water, the light water was returned to the river, so a means of dissipating its heat before returning the light water to the environment was necessary. The 2,600-acre P and R (PAR) Pond was constructed for this purpose, and was integrated into the cooling system in 1958. All the cooling water from R reactor then was routed to Par Pond, and a portion of P reactor water was sent out via Par Pond. The new reservoir not only served as a means of cooling water, it also created an additional source of cooling water for P and R reactors, which produced savings in pumping costs. Since they would then be drawing less water from the Savannah River, more would be available for the other three reactors. This and further improvements in the light water circulating system allowed C reactor to be brought to a power level of 2,575 megawatts in 1960, and to eventually reach its all-time peak of 2,915 in 1967.[73]

Another major change in reactor operations came with the use of computers. Computers were first used to monitor the 3,600 reactor process sensors on an experimental basis in K reactor beginning in 1964. The experiment was successful, and the system was added to the three other then-operating reactors (R reactor had been placed on standby in 1964) by the end of 1966. In 1970, a closed loop control system began trial operation at K reactor. Computers were used to assess information from the sensors, and to make adjustments to groups of control rods based on that information. Using computers to do this was another means of optimizing reactor performance. In the late 1970s, new computer systems were installed to provide safety functions and to monitor and add additional control over reactor operations.[74]

By 1970, the heyday of reactor operations had passed. R reactor was shut down in 1964 due to a lack of demand for reactor-produced products, and L reactor was placed on standby status in 1968 for the same reason. C, K, and P reactors continued to produce tritium, plutonium, and other isotopic elements as directed by the AEC in pursuit of both military and non-military programs. All of these events in reactor operations will be discussed more specifically in the body of this document.

Separations

Operations at the Savannah River Plant included two main types of separations: combined plutonium and uranium extraction, and tritium extraction. The former was conducted primarily in the canyons in F and H areas. The F Canyon went into operation in November 1954, and the H Canyon was online the following July. In these two buildings, the fuel elements that came from the reactors were dissolved in acid to separate the uranium and plutonium from waste fission products by chemical extraction in solution. Tritium separations took place in two much smaller areas. Slugs irradiated to produce tritium were initially sent to a building in the F Area, which started operating in October 1955, where the slugs were melted, instead of dissolved, to release the gaseous tritium. After melting, the tritium was purified by a process known as thermal diffusion. Tritium extraction was moved to its current location in H Area a few years later.[75]

The two canyons were originally designed to operate using the Purex process by remote operation and maintenance—which meant that the process areas were not designed to be entered by personnel on a routine basis. During the first year of operation, the F Canyon attained its designed throughput level of three metric tons of uranium per day. Lessons learned from early operations in F Canyon allowed H Area operations to achieve a throughput of seven tons per day.[76]

In early 1957, the F Area canyon was closed down so that substantially larger equipment could be installed to increase throughput, and so that a new facility to convert the plutonium to metal could be built on the canyon roof. This would more than double the capacity of the canyon. The modifications took two years to complete, and the F Canyon went back into operations in March 1959, with a capacity to process 14 tons of uranium each day.[77] As soon as F Area was back in operation, H Area was shut down for conversion to a modified Purex process designed to safely recover enriched uranium from target elements then beginning to be used in the SRP reactors, a change that took only three months. H Canyon was back in operation by June.[78] Many more minor modifications of the canyons followed over the years to allow products other than uranium and plutonium to be recovered, but the fundamental processes for extracting plutonium and uranium remained essentially the same throughout the Cold War.

The first tritium facility was located in Building 232-F. A 232 building was also constructed in the H Area, but it was not completed during the initial phase of construction. The H Area tritium building was outfitted for production in 1956, and by the end of the year two lines were operating. Tritium was originally shipped elsewhere for placement in the reservoirs, but by 1957 this was completed. In August of the following year, tritium began being recycled in this facility as well. Tritium processing capacity in the H Area facilities was doubled in 1958, and the F area 232 facility was closed that autumn. A new facility, the Replacement Tritium Facility, went into operation in 1993, and it continues to perform the tritium mission today.[79]

Waste Management

In general, the waste facilities at Savannah River were modeled on those at Hanford but modified somewhat since the radioactivity of the high-level wastes would be greater than those at Hanford. The original tanks each had a capacity of 750,000 gallons, were supported by internal columns, set on top of a steel pan to catch any leaks, and encased in concrete. Separate tanks were provided for high- and low-level wastes, and the high-level units were provided with cooling coils to remove heat generated during the decay of the wastes (cooling coils were added to all these tanks in 1955). Waste evaporation facilities were also provided as a means of reducing waste volume.[80]

Eight such tanks were originally built in F Area, and four in H Area (with space for four additional tanks set aside), each buried under at least 9 feet of soil. Four more tanks were approved for H Area in 1954, due to expected increases in the throughput of H Canyon. These four tanks were larger, each having a capacity of 1.07 million gallons, but other details of design were essentially the same as that of the original 12 tanks. They were constructed in 1955 and 1956. By June 1955, the first high-level waste tank was already full, prompting efforts to reduce the volume of waste sent to storage.[81]

Four single-wall tanks for low-heat high-level wastes were constructed in F Area in 1958, and four in the H Area in 1962. These tanks have caused numerous problems due to leakage through fine cracks caused by the reactions of the solutions stored there. However, only one of the original 12 tanks has leaked substantially. Four others have deposits on the outside of the tank walls that may indicate leakage, but no leaks have been found. An additional 27 tanks, each with a capacity of 1.3 million gallons, have been constructed since 1962. These are all similar in design to the initial tanks, except the catch pans extend the full height of the tanks, rather than only five feet, as with the initial design.[82]

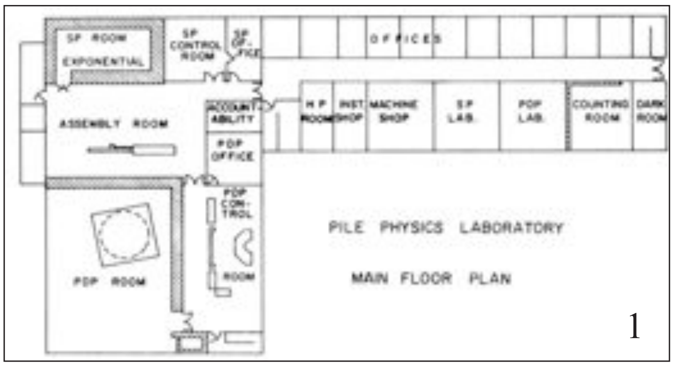
Two burial grounds serve as the disposal site for solid wastes. The original burial ground occupied about 76 acres and was used from 1953 until 1972. The second, larger burial ground has been used since 1972; it covers approximately 119 acres. Solid low-level waste from all plant areas were buried there, with special areas set aside for items with higher levels of radiation or with plutonium fission products. The TRU solid wastes were buried in designated sections of the burial ground but, by the early 1980s, they were being stored on concrete pads in containers that allowed for later retrieval.[83]

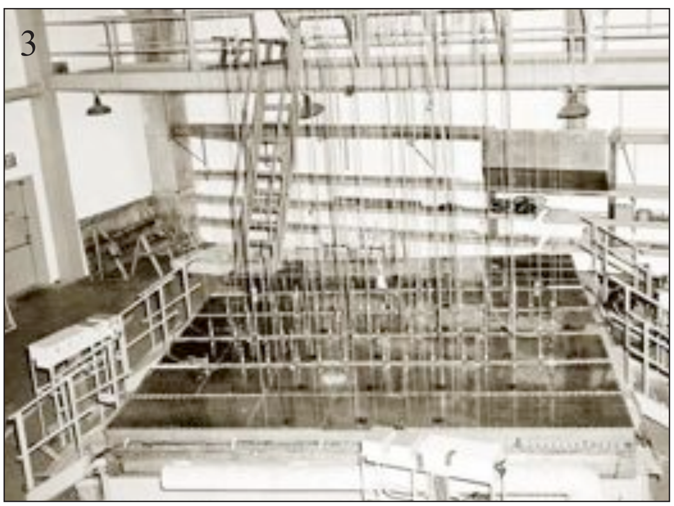
Research, Development, and Testing

The scientists and researchers at the Savannah River Laboratory (SRL) were responsible for research and improvements in process design in support of SRP's operations. From the beginning, it was noted that neither heavy-water moderated reactors, nor the Purex process, had ever been operated on an industrial scale.[84] Also,

Savannah River's Test Reactors

1. Pile Physics Laboratory floor plan. This facility housed three test reactors used by SRL researchers. The reactors were placed under the high-hat area of the building. Courtesy of SRS Archives, negative DPSTF-83. 2. Pressurized Subcritical Experiment (PSE) test reactor in Pile Physics Laboratory that was used to measure nuclear parameters at high pressures and high temperatures. When built, it was the first of its kind. Courtesy of SRS Archives. The Standard Pile (SP) was designed and constructed by the General Electric Company and was similar to the Thermal Test Reactor at Knolls Atomic Power Laboratory. (Not shown). 3. Fuel elements were placed in the Process Development Pile (PDP), a zero-power test reactor used for physics research. Courtesy of SRS Archives, negatives DPSTF 1-2613, 1-2536. 4. PDP control room. Courtesy of SRS Archives, negative DPSPF-8929-13.



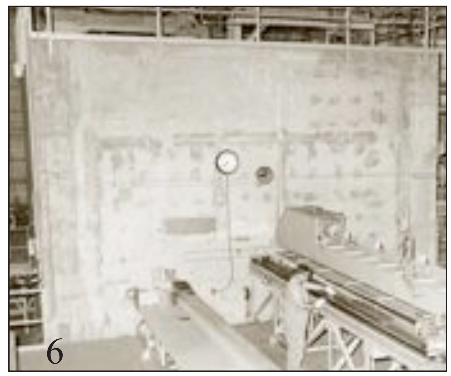


People, Research and Development

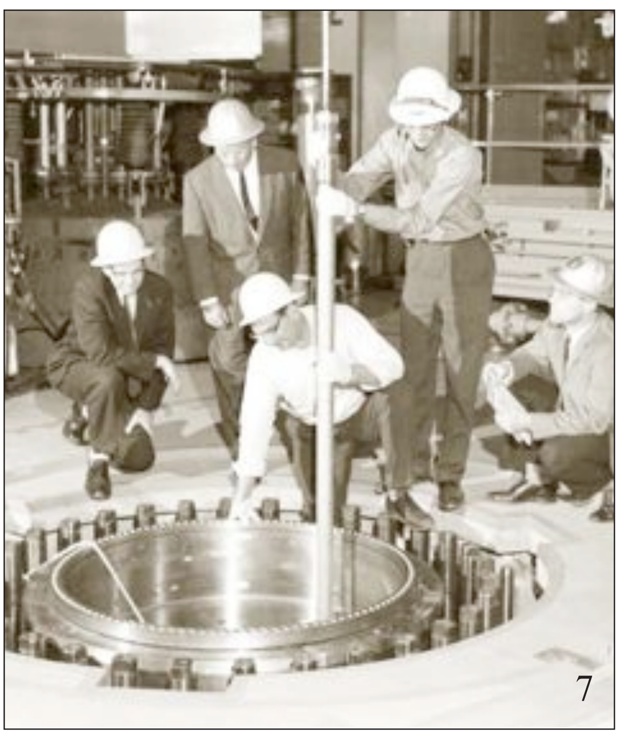
5. Graphite Test Pile control room in 305-M. Courtesy of SRS Archives, negative 2023. 6. Face of Graphite Test Pile, Courtesy of SRS Archives, negative 38887-1. 7. Interior of Heavy Water Components Test Reactor. Courtesy of SRS Archives, negative DPSTF-6027. 8. Aerial of Heavy Water Components Test Reactor (HWCTR). This test reactor facility was decommissioned in 1997. Courtesy of SRS Archives, negative 7885-G.

5

6



7



8

the versatility of the reactors called for the development of new fuel and target elements. The need to explore the safety and process issues involved called for the installation of laboratory facilities that were fully equipped to allow research and experimentation on a laboratory or micro scale of the processes that were writ large in the process buildings. Consequently, the general laboratory area that was established in A Area was fitted out with sand filter systems and waste treatment facilities. The main research facilities were: the main laboratory; 777-M (later 777-10A), an experimental physics laboratory; process pilot plant facilities CMX and TNX (also referred to as semiworks); 735-A, the Health Physics Laboratory; and 723-A, the Equipment Engineering laboratory.

SRL, the main laboratory, was the focus of separations technology studies, metallurgical research and development, heat transfer studies, and radiation monitoring. Its “High Level Caves” allowed chemical and metallurgical equipment studies on highly radioactive materials behind heavy shielding windows and the Isotopes Process Development Laboratory allowed radionuclides to be encapsulated for use as targets.[85] After 1983, the testing of new fuel and target elements was moved from CMX to SRL. The TNX Semiworks Facility, a pilot plant, was equipped with instrumentation and stainless steel equipment for “cold” processing for chemical engineering studies on a larger scale afforded by the main laboratory facilities.

777-M, later designated 777-10A, the Physics Laboratory, contained three test reactors: the Process Development Pile, the Standard Pile, and the Subcritical Experiment. These test reactors allowed scientists to provide experimental measurements needed to test reactor charge design. While computers would eliminate the need for these test reactors in the 1980s, they were integral to the safe and successful operation of SRP’s five reactors, as reactor charges were first tried out in the laboratory environment prior to their use in reactor operation. The reactor designers who used the test reactors in 777-10A used slide rules, mathematical tables, and desk top calculators to make the calculations that would later be generated by computers.

In addition to the central mission of supporting plant operations, a second laboratory system was established at SRP devoted to environmental studies. Savannah River Ecology Laboratory (SREL) was first housed in the Forest Service area but was given a new building in 1977 in A Area where it is surrounded by a complement of environmental laboratory facilities that range from duck pens to greenhouses. SREL and a consortium of other research programs conducted by the Savannah River Forest Station (SRFS), Savannah River Archaeological Research Program (SRARP) and Du Pont feature research on disparate ecological topics that range from reptile studies, aquatic insects, restoration of degraded habitats, reintroduction of endangered species, and investigations into the Site’s cultural history. SRS was designated as the first National Environmental Research Park (NERP) in 1972 as a result of the National Environmental Policy Act (NEPA), the Energy Reorganization Act and the Non-Nuclear Energy Research and Development Act. Under these acts, the Site area became an outdoor laboratory set aside for national environmental goals in ecological research, research into the effects of nuclear energy on the environment, and finally, the disposition of this area is reportable to the public.

DEVELOPMENT OF PEACEFUL USE OF ATOMIC ENERGY, AND ITS IMPACT ON SRP

The tug-of-war between military and non-military applications of atomic energy was present at the inception of the AEC. Senator Brien McMahon of Connecticut championed civilian control over atomic power, and his bill, which became the Atomic Energy Act of 1946, barely beat out others that championed direct Army control.[86] Congress passed the McMahon Bill in July, and Truman signed it into law the following month. According to this act, the AEC was to become effective December 31, 1946/January 1, 1947.

After advice or directives had filtered through the Commission, the Office of the General Manager carried out the directives, with work divided into various divisions, such as Production, Raw Materials, Military Application, Research, Engineering, Biology and Medicine, and Administrative Operations.[87] Even though the AEC's main mission was defense-related (peaceful use of the atom was not even a formal part of the Atomic Energy Act of 1946), civilian control meant that there was always a push at the AEC to justify atomic energy use for non-military purposes.

The early leadership of the AEC certainly demonstrated this interest in the non-defense mission. David Lilienthal, appointed as the first chairman of the AEC by Truman in October 1946, was himself a strong proponent of the peaceful use of atomic energy, taking his case to the public in a number of articles that tried to correct the popular perception that nuclear energy was just for bombs.[88] Among the peaceful uses of the atom listed by Lilienthal were the control of disease, new knowledge of plants and the workings of the natural world, and even incredibly cheap electricity provided by nuclear power plants.[89]

During the Korean War, 1950-1953, little was heard about the peaceful use of the atom. With the close of that conflict, however, President Eisenhower reopened this potential with his "Atoms for Peace" address at the United Nations on December 8, 1953.[90] In direct response to this initiative, Congress passed a new Atomic Energy Act in 1954 that essentially amended the original act to allow for international cooperation in the development of atomic energy and in the civilian use of atomic energy. This allowed domestic utility companies to build and operate nuclear power plants.[91] The 1954 Atomic Energy Act not only broadened the scope of the AEC, but also allowed nuclear energy to be used outside of its purview. While peaceful uses of the atom had always been an interest of the AEC, it was now an official part of its charter.[92]

Purely scientific studies, like the neutrino research conducted at SRP in 1955-1956, were just the beginning of the non-defense mission conducted at AEC facilities. In addition to the Oak Ridge School of Reactor Technology, established in 1950, the AEC sponsored a five-year reactor development program in the mid-1950s, designed to test five experimental reactors for potential use.[93] Out of this work came two broad agendas: the breeder reactor program, which was largely for the Navy, which was keenly interested in nuclear power for ships and submarines; and power reactor research for civilian use.

The use of nuclear power for the production of electricity was first done in December 1951 at the National Reactor Testing Station (later, the Idaho National Engineering Laboratory). In 1955, this capability was expanded to Arco, Idaho, the first U.S. town to be powered by nuclear energy.[94] The development of commercial power reactors soon spread to selected spots throughout the country, using reactor types that varied from the heavy-water cooled and moderated variety found at SRP and favored by the AEC, to the light-water reactors favored by the Navy. Other reactors, like Hanford's N-Reactor, were dual purpose, capable of both nuclear materials production and power.

The AEC favored the development of heavy-water power reactors, and the SRP was closely involved in the AEC plans to provide this technology to commercial utilities throughout the country. By the late 1950s, heavy-water power reactor studies were commonly produced at the Savannah River Laboratory, and these studies culminated in the design and construction of the Heavy Water Components Test Reactor (HWCTR), built and operated at SRP in the early 1960s.[95] During this same period, and drawing on technical data obtained from HWCTR, the Carolinas-Virginia Tube Reactor, near Columbia, South Carolina, became the first heavy-water moderated power reactor in the U.S.[96]

Despite AEC efforts to push heavy-water power reactors, the example of HWCTR and the Carolinas-Virginia Tube Reactor was not generally emulated in the United States (HWCTR itself was closed down in 1964).[97] As early as 1962 U.S. utility companies showed a clear preference for light-water reactors.[98] These reactors, using pressurized light water, were based on research that came out of the U.S. Navy's reactors program, especially the Navy's light-water reactor at Shippingport. Ironically, the AEC "Atoms for Peace" program, which provided partially enriched uranium to commercial reactors, worked against the AEC heavy-water reactor program: heavy-water reactors might have been more popular if utility companies had been forced to use natural uranium.[99]

Speaking in 1963, Lilienthal described Eisenhower's "Atoms for Peace" initiative as "still alive, but in a wheelchair."[100] While almost surely in reference to the international aspect of that initiative, Lilienthal's comment could be said to apply to the AEC's program to spread heavy-water power reactor technology to U.S. utility companies. Despite considerable research and achievements, the program simply did not progress in the direction intended.

With the reduction of the AEC's military mission in 1964, the stage was set for another series of programs to further develop the peaceful use of the atom. These new initiatives were two-fold: provide isotopic heat sources for the U.S. space program, then becoming a major national concern; and contribute to the transplutonium programs that were pushed by Glenn Seaborg, one of the discoverers of plutonium and chairman of the AEC from 1961 to 1971.

Among the isotopic heat sources produced for the space program was cobalt-60, desirable because it did not produce a decay gas.[101] Another isotopic heat source requested of the AEC was curium, and the production of this material dovetailed with the transplutonium program.[102]

The heavy-water reactors at SRP were pivotal to the transplutonium campaigns, which began with the production of curium during the Curium I program (May-December 1964). The successful attempts to produce curium and other heavier nuclides led to a succession of programs conducted at SRP and coordinated throughout AEC facilities nationwide. These programs included the High Neutron Flux program, both at SRP and at Oak Ridge, where the High Flux Isotope Reactor (HFIR) began operation in 1965.[103] Curium II (1965-1967) completed the required production of curium, and provided a start for the most ambitious of the transplutonium campaigns: the production of californium. The Californium I program (1969-1970) was designed to produce enough californium to make the isotope available to industry and private sector interests.

The production of californium went hand-in-hand with the Californium Loan Program, sponsored by the AEC to help create a potential industrial and medical market for this powerful neutron source.[104] Despite the best of intentions, however, most of this work was in vain. Even though samples of californium were distributed to willing participants throughout the country and elsewhere in the 1970s, no viable market developed for what was still an expensive isotope with a relatively limited application.

The problems inherent in the Californium Loan Program were ones that plagued other potential applications of atomic energy for non-military use: the expense was simply more than the limited market would bear. The transplutonium programs, while wildly successful as scientific endeavors, failed to take up the slack left by the reduction in the defense mission. In the case of SRP, the production reactors were just too expensive to maintain and operate for the production of non-defense nuclear materials.

When the defense mission went into eclipse in the late 1980s, the non-defense mission, especially that for production reactors, went into decline as well. The close of the Cold War in 1989 solidified the forecast for Savannah River and the other production sites. The rise of environmentalism in the 1970s had already made inroads into nuclear progress, changing American attitudes about the safety of nuclear production plants and nuclear power plants. The promise of nuclear energy was increasingly called into question and new regulators and environmental regulations were placed into effect. While the ramp up of military might under Reagan characterized the start of the decade, by its close, world affairs and changing public opinion created new missions related to environmental clean-up and restoration rather than nuclear materials production.

ENVIRONMENTALISM, EXPANSION, AND CHANGE AT SAVANNAH RIVER

At the end of the Carter Administration and throughout the Reagan years (1980-1988), there was a resurgence in the production of nuclear weapons materials. This reaffirmation of the nuclear weapons complex was opposed by the environmental movement and then halted by the end of the Cold War. All of this led to conflicting changes at Savannah River Plant, especially in the 1980s. The decade opened with new requirements set by the Department of Defense for plutonium and tritium that directly translated into physical change for the plant. New construction occurred in the process and administration areas to house new programs and personnel, worn facilities were repaired, and technical upgrades were made to operating systems and equipment. Updated security provisions and other physical changes were made with the installation of Wackenhut Services Inc. as the on-site security force.

While SRP expansion was gaining momentum, the environmental movement was also becoming a force that ultimately changed the nature of how the expansion would take place. The accident at Three Mile Island in 1979 drew national attention to the nuclear power industry and reactor safety. The environmental movement hastened change but it was the end of the Cold War in 1989 that shaped new missions for the Savannah River Site.

Rise of Environmentalism

In December of 1974, the Environmental Protection Agency issued the first sanitary NPDES permit for the Savannah River.[105] While this was largely pro forma, it was a harbinger of things to come. In subsequent years, there would be an increase in environmental regulation on federal lands, and Savannah River was not exempt from this trend. In 1976, the Resource Conservation and Recovery Act (RCRA) gave the EPA authority to enforce environmental laws on all Department of Energy weapons-production sites. As a result, regulatory agencies began to weigh in on the previously "closed" controversy over the relative merits of confinement and containment at nuclear reactors, as well as the need for towers to cool reactor effluent water, a feature that was already standard for commercial power reactors.

Despite a promising collaboration in the early 1970s, environmental regulation and the nuclear community did not have the same agenda, and this became clear during the mid- to late-1970s. Environmental regulators soon moved beyond a balanced concern for the environment and the search for new energy sources, and began to micromanage commercial and DOE facilities solely for the benefit of the environment. The nuclear community, long sustained by public awe of atomic power, now began to find itself under attack by a public that increasingly feared the atom and its residual effects. By the late 1970s, the average environmentalist was antinuclear and environmental regulators were responsive to that shift.

Carter, an "environmental president," was the first to promote alternative sources of energy, such as solar and wind power. The exploration of such avenues was in fact one of the main reasons for the establishment of the Department of Energy in 1977. This exploration did not extend to the nuclear industry. In addition to banning the reprocessing of spent nuclear fuels for commercial reactors, Carter put a stop to the breeder-reactor demonstration program started by Nixon.

In the early 1980s, President Reagan would attempt to revive both the commercial reprocessing of spent fuels and the breeder reactor program, but by this time interest had flagged both in Congress and within the U.S. commercial nuclear industry. The demonstrated abundance of natural uranium certainly played a role in this shift of opinion, but the biggest change would be the accident at Three Mile Island. Even though it was the worst accident to befall the U.S. nuclear industry, its most disastrous impact was in public relations.[106]

The impact within the industry was great. Many of the energy concerns and conservation programs conceived in the early 1970s were simply abandoned by the late 1970s and early 1980s. Due to environmental regulations and a lessening demand for nuclear energy that was apparent even in 1979, there was less concern about the uranium supply or the discovery of new uranium sources. This spelled the end of projects like NURE, and effectively put an end to any real demand for the reprocessing of spent nuclear fuels for commercial reactors.

Three Mile Island also had an impact on the nation's production reactors. Up to that point, reactor safety had concentrated on the prevention of major accidents, with an acceptance of certain low-level risks as a requirement of the job. In the wake of Three Mile Island, however, more thought was given to low-probability accidents, and to ways of reducing reactor power levels as well as levels of radioactivity. With this new emphasis, "Loss of Coolant Accidents" (LOCA) became a major concern of the 1980s.[107] With LOCA raised to greater significance, there was a corresponding rise in the importance of Emergency Cooling Systems or ECS. The idea behind the Emergency Cooling System was that even after shutdown, the ECS could still supply cooling water to a reactor in the event of an emergency. Throughout the nuclear industry, and certainly at Savannah River, Emergency Cooling Systems were added to reactors or were augmented in the years after 1979.[108]

At the other end of the nuclear process, Three Mile Island also focused attention on the problem of radioactive waste, a dilemma that had never been permanently resolved. There were two types of radioactive waste, low-level and high-level, and both had their unique problems and potential solutions. The Low-Level Radioactive Waste Policy Act of 1980 made every state responsible for the low-level waste produced within its borders. Even though the solution to most low-level waste involved burial, progress in implementing this law was so slow that Congress was forced to amend the act to give several states more time to comply.[109]

The problems associated with high-level waste, especially those of the defense industry, were greater and more intractable. Here, simple burial was not adequate, even though the idea of "geological disposal" of high-level waste had been proposed in underground salt deposits and at Yucca Mountain, Nevada, since at least 1957. Storage in high-level radioactive waste tanks was the preferred method of disposal, but this was recognized to be a temporary solution, and never more so than when the first serious leaks began to compromise the tanks in the early 1970s.[110] By the end of the decade, it was acknowledged that there would have to be some sort of "Defense Waste Processing Facility" to provide a more permanent solution to the problems of storage.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as the "Superfund" legislation, helped provide the resources to clean up radioactive waste sites around the country. The money came with strings attached. The EPA and the states under authority delegated by the EPA, were given more authority to regulate DOE weapons production sites. The Nuclear Waste Policy Act of 1982, which President Reagan signed into law in January 1983, followed this law two years later. Robert Morgan, manager of Savannah River Operations Office (SROO) between 1980 and 1988, played a significant role in carrying out this act, which required the Department of Energy to establish a long-term site for the permanent disposal of the waste generated by nuclear power plants.

Reactor Upgrades, L-Restart, 700 Area Expansion, and Close of Heavy Water Facilities

Only four of the nation's production reactors were in operation in 1980: SRP's P, K, and C and Hanford's N reactor. Plutonium irradiated in N reactor had a high concentration of plutonium-240 that was unsuitable for weapons grade material. This shortcoming could be corrected by blending it with plutonium that had a lower concentration of plutonium-240 and SRP was directed to produce the proper plutonium for blending. A program to recover scrap plutonium at Rocky Flats in particular also had ramifications for SRP Operations. In order to comply with the change in product needs, SRP was compelled to upgrade and modernize its three operating reactors to allow them to attain higher power levels within shorter cycles. In 1980, one assessment cited the following problems: one-quarter of the reactor heat exchangers were irreparable due to wear and aging; plant facilities had obsolete and worn out instruments and controls, not only in the reactors but in other plant areas as well; that the needed parts could seldom be replaced in kind; and finally there were too few engineers available to design modern equivalents.

To begin to refurbish the Site's facilities, a five-year Restoration Program was established and funded at $350 million dollars, which was to be dovetailed with a $300 million dollar Productivity Retention Program by Du Pont. The Restoration Program did not include capital funds needed for new construction such as the Defense Waste Processing Facility (DWPF) discussed below but was the source of funding for L-restart and other upgrades.

The L Reactor Startup Team was the first management group to be placed under Du Pont's "program management" organizational philosophy. The program management structure was applied plant-wide in 1982. Courtesy of SRS Archives, negative 34872-3.

By 1983, SRP's engineers were successful in this endeavor as the reactors reached the needed power levels, exceeding expectations. In addition, Du Pont was directed in 1981 to reactivate L reactor, a project that, when completed in 1984, brought L reactor to a safety and dependability level comparable to that of the three reactors that had remained in operation and had been continually upgraded. Employees in the 300 Area worked a seven-day workweek to keep up with the pace the higher power level in the reactors warranted and in anticipation of L reactor startup.[111] This was a major initiative budgeted at $214 million, employing a peak workforce of 800 for the renovation efforts, and projected to employ an operating workforce of 400 to run the reactor. It was also the first time that a reactor on standby had ever been refurbished and restarted after being out of service for more than a decade. The reactor was refurbished with new heat exchangers, replacement piping, removal of aluminum-nitrate from the reactor tank and nozzles, and the addition of safety upgrades. The challenges for the Restart Program stemmed from environmental rather than technological challenges.

DOE had completed an internal study of all associated environmental issues involved with the restart program, but chose not to follow the Environmental Impact Statement (EIS) procedure that provides for public hearings. This choice, characteristic of an agency committed to the "need to know" ethic, led to great controversy as local and national environmental groups called for action. Senator Strom Thurmond held local hearings in response as part of the Armed Service Committee's responsibilities that demonstrated the controversy production reactors could evoke by the 1980s.[112] By the close of 1983, it was recognized a lake would have to be constructed, not to impound cooling water, but to cool effluent water leaving the reactor before it would enter the Savannah River Swamp. L Reactor was finally re-started in 1985. It operated less than three years before it was shut down again. During its period of operation, its output was often constrained by the environmental requirement to limit the temperature in L Lake to 90 degrees F in the summer months.

The process areas were not the only focus of upgrades and new construction in the 1980s. The main Administration area was expanded under a long-range building program that aimed at replacing trailers with administrative facilities.[113] Between 1980 and 1989, nine buildings were added to the Upper 700 Area to ameliorate working conditions. Others were also added to F and H areas. The design and building materials used in this construction was based on obtaining the most space for the available money. The buildings were considered "Local Practice Commercial Standard Office Buildings" and were let to bid as "Design-Build" projects.

Another change in the 1980s was the closure of the last of the Heavy Water production units in 1982. The area was in operation for slightly over 29 years, and had produced a sufficient amount for the needs of the Site's three operating reactors. Heavy water produced at SRP was sold to foreign countries and domestic consumers for a variety of uses and it, along with timber, was a revenue producer for SRP. For example, the AEC negotiated the sale of 450 tons of heavy water valued at $42 million dollars in 1969.[114] Over 6,000 tons were produced during D Area's years of operation.[115]

Defense Waste Processing Facility (DWPF) and Naval Fuels Program

Two additional programs were also started in the 1980s concurrent with the restoration program further exacerbating financial and manpower deficiencies. The DWPF got underway as did the Naval Fuels Program.

Aerial View of DWPF Building 1977. Courtesy of SRS Archives, Negative 97-1527-1.

The long term problem of defense wastes was tackled in the early 1970s when scientists began to research for a solid waste form and a process by which defense wastes could be converted and stored in that form. Glass was selected after much research. The converted waste once vitrified would be encased in stainless steel canisters for permanent storage. Radioactive materials in the waste tanks were separated from nonradioactive materials through chemical separation processes that allowed the remaining sludge of radioactive materials to be sent to the DWPF Building, a monumental reinforced concrete building about 360 feet in length, 115 feet in width and 90 feet in height, for vitrification. Modeled after the canyons, most of the process work that occurs in this facility is conducted remotely behind heavy shielding. The salt that remains after the separation process is dissolved in water, cesium-137 and strontium-90 are precipitated and filtered then sent over to DWPF as a slurry for vitrification. The remainder, a salt solution, is hardened into a cement-like substance by mixing it with fly ash, furnace slag, and Portland cement. The final product called "saltstone" is placed in long concrete enclosures in Z Area. Construction began in 1984 but would be hampered by a lack of funding. The facility was complete in 1989 and actual vitrification began in 1996.[116]

The Naval Fuels program was aimed at converting uranium feedstock into usable fuel in support of the Navy's nuclear propulsion program. Facility 247-F housed the processes involved in this conversion; it was constructed and operated for a short while before it was deactivated.

The scale of the needed repairs and the new construction engendered by the Naval Fuels and the DWPF facilities was prodigious. Moreover, the timing was awkward. In historian Bebbington's words, all of these programs were coincident with the first generation of SRP employees reaching retirement age, compelling Du Pont to hire and train a new workforce that was in size and in scope comparable to that of 1950. The major departure in the 1980s from the 1950s was the hiring of outside contractors to fill the needed gaps in the Du Pont team.

A second large change in staffing came about in 1984 when DOE requested that a specialized security force be designated for plant protection that would be able to respond to the changing world order. Prior to 1984, Du Pont handled site security. The Du Pont security force was disbanded and security of the plant was transferred to Wackenhut Services, Inc. in 1984. At this time, physical barriers protecting restricted areas were enhanced and security measures were updated.[117]

Reactor Shutdowns and Du Pont's Departure

In 1986, a coolant system assessment indicated a situation could arise in which insufficient amounts of cooling water would be available to the reactors in an emergency situation. The power levels of the reactors were decreased by 25 percent in November of that year. Then, in early 1987, a special panel of the National Academy of Science set maximum reactor power levels to about 50 percent of normal full-power operations.

By this time, Du Pont was clearly interested in pulling out of the atomic energy business. In October 1987, Du Pont formally announced that it would not seek to renew its contract with the Department of Energy, scheduled to expire in early 1989. The rationale for their departure was first that the government no longer appeared willing to guarantee the work and that Du Pont was no longer uniquely qualified to do it. Following almost immediately, there were safety hearings before a House subcommittee.[118] Since the mid 1980s, DOE and its contractors had been under examination in Congress for allegations of poor safety practices at federal nuclear facilities. In hearings before the Subcommittee on Oversight and Investigations of the House Committee on Energy and Commerce, Savannah River was noted for its poor fire prevention procedures. Congress wanted sprinkler systems installed in the reactor buildings, and this was a government expenditure that SROO and Du Pont management had resisted for the simple reason that the all-concrete reactor buildings could not burn.

The concern over fire prevention was eclipsed by a news story reported on the front page of *The New York Times* in 1988. A report, "SRP Reactor Incidents of Greatest Significance" compiled three years before, which detailed and categorized 30 significant incidents in the history of the five Savannah River reactors, was released to the public. Most of the incidents in the 1985 report had been summarized in an earlier ERDA document. An internal memorandum initially, the report's purpose was to show that the serious reactor incidents at the Savannah River Plant were largely confined to the early years of operation, and that the safety precautions of later decades had greatly reduced the incidence of error. The 1988 report was released in an effort to show that nuclear work was in fact becoming safer. This was not how the information was received, and the national media immediately interpreted 30 "incidents" as "accidents." The outcry over the disclosure led to further congressional hearings over perceived problems at Savannah River. Media attention reached a peak in late 1988.

Responding to ever-tougher safety regulations and a relatively large stockpile of nuclear materials, the Department of Energy shutdown the three remaining reactors, P, K, and L in 1988. The fact that the Savannah River reactors had all been shut down was almost lost in the public debate. Although this shut down was initially intended to be temporary, it soon became permanent. In March 1987, administrative limits were placed on the power levels at K, L, and P reactors due to lingering uncertainties over the Emergency Cooling System (ECS). The following year, all three were shut down due to continuing concerns over the ECS, as well as the possibility of a "loss of pumping accident" or a "loss of coolant accident." K reactor was the first to go, in April 1988, followed in rapid succession by L in June and P in August. The ripple effect of these shutdowns passed through other areas of Savannah River as well. The production of fuel tubes ceased in Building 321-M that same year.

When Westinghouse assumed Du Pont's mantle in April 1989, all the reactors were shut down, and the U.S. had ceased the production of weapons-grade fissionable material altogether. The Site was officially included on the National Priority List and became regulated by the Environmental Protection Agency. In the same year, the Department of Energy formally announced that its primary mission had changed from weapons production to a comprehensive program of environmental compliance and cleanup. In a signal that it was making a break with the past, the facility's name was changed from the Savannah River Plant to the Savannah River Site.

Later attempts to use the reactors for further production were half-hearted. Even though L Reactor was selected as a backup for tritium production (1990), and K Reactor was restarted for power ascension tests (1992), the Department of Energy ordered both reactors shutdown with no capacity for restart in 1993.[119] While the work of nuclear processing continues in the Separations Areas and other places on-site, the SRS reactors themselves are now used to warehouse discarded radioactive materials.

End of Cold War

The controversy over "Star Wars," not to mention conflicts in Afghanistan and Nicaragua, kept the Cold War fairly warm in the early 1980s. There was also a confrontation over missile deployment in Europe. It was in this context that the L Reactor Restart program was initiated and completed. By the mid-1980s, however, Soviet society was beginning what would turn out to be a permanent thaw. Yury Andropov, Brezhnev's successor, died in 1984 after only a couple of years in power, and was eventually succeeded by Mikhail Gorbachev in 1985. Within a year, Gorbachev became the first Soviet leader to openly admit the weakness of his country's planned economy. More remarkably, he was the first Soviet leader to admit that elements of the old Communist doctrine were wrong or, at the best, outdated.[120] By the late 1980s, Gorbachev was well into the programs now associated with his name: *glasnost* (openness) and *perestroika* (economic and political restructuring of the old Soviet system).

The nuclear accident at Chernobyl played a role in this development. After first denying the accident, Soviet authorities soon made a complete turn-around, with relatively open disclosure of the problem and solicitations for foreign assistance. The approach to Chernobyl paved the way for new approaches to other problems. In December of 1987, the U.S. and Soviet authorities signed an agreement to eliminate all land-based intermediate range nuclear missiles from Europe. More was to follow in almost dizzying succession. In the fall of 1989, the Berlin Wall, symbol of the Cold War in Europe, was dismantled, permitting a rapid reunification of Germany. Communist regimes collapsed throughout Eastern Europe. Within two years, in 1991, the Soviet Union itself would collapse, leaving the former giant split into its various constituent republics. Gorbachev, now jobless, was forced to bow out to Boris Yeltsin, the president of Russia.

In the decade that followed, there would be additional problems with Russia as its economy continued downward, but there would no longer be the threat of an ideologically fueled nuclear war between the two great superpowers of the Second World War. Now it was the time to take stock of the vast nuclear arsenals in both countries, and initiate a general clean up of forty years of nuclear production. Savannah River Site, under the aegis of the Westinghouse Savannah River Company, was already poised to head in that direction.

This chapter has provided a context for Savannah River's Cold War history from a national and complex-wide perspective to provide background for the narrative that follows. The next chapters deal specifically with the history of Savannah River's reactors and their operation.

III. REACTOR DESIGN

The reactors at Hanford, in Washington State, constructed for the Manhattan Project, were the first production reactors anywhere in the world. The Hanford complex was in operation at the time of the design and construction of Savannah River, but these reactors were moderated with graphite blocks piled into what looked like a structure. The earliest name for a nuclear reactor, the word "pile," came from this, and was actually the preferred term for a reactor until the mid-1950s.

One of the legacies of the Manhattan Project was the use of graphite reactors for the production of fissionable material. Graphite, however, was not the best material for the moderation of thermal neutrons. Even in the days of the Manhattan Project, it was known that heavy water (deuterium oxide) had better moderation properties. It slowed neutrons quicker than graphite, and it absorbed fewer, leaving more to serve production needs. Unlike graphite, it could simultaneously serve as both moderator and coolant. During World War II, however, the problem with heavy water was supply. There was not enough to do the job.[1]

Even in the years that followed, heavy water was difficult to produce or harvest. Heavy water, or deuterium oxide, is found naturally in regular "light" water only at the rate of 1 per 5,000 atoms. Much of the heavy water used at Savannah River was produced at the Dana Plant, and on site, in the 400-D Area, by means of the hydrogen-sulfide dual temperature exchange process known as the "GS process"or Girdler Sulfide process. It has been estimated that the heavy water within just one of the SRP reactor systems cost many millions of dollars.

REACTOR WORK AT ARGONNE

Because Savannah River reactors were to be moderated with heavy water, nuclear engineers with the AEC and Du Pont did not draw direct inspiration from the Hanford reactors, but rather from the smaller heavy water-moderated reactors at Argonne National Laboratory, the AEC's center for reactor research, then located near Chicago, Illinois. It was for this reason that a number of Du Pont employees were sent to Argonne for heavy water reactor training. The first contingent of 66 was sent as early as August of 1951; by 1953, there were over 300.[2] Many of these would go on to work at Savannah River. Among those that did were Milton Wahl, Charles Wende, William Mackey, Peter Gray, Woody Daspit, Larry Heinrich, and Daniel Pellarin. Tom Gorrell recalled that many of the people he worked with at 777-M, had first gone to Argonne for heavy water experience.[3] Woody Daspit, Larry Heinrich, and Daniel Pellarin could be counted among that number.

By the early 1950s, graphite reactors and their operation posed no mysteries. In fact, the very first nuclear reactor to operate at Savannah River was the graphite test pile in 305-M, which went critical in September of 1952 and was in operation testing fuel metals before the end of the year.[4] Relatively little fanfare accompanied this achievement.

Crash Course on Atomic Energy

There are 92 elements found in nature, ranging from hydrogen, the lightest, to uranium, the heaviest. The smallest part of an element, that still has the chemical characteristics of that element, is an atom. With the exception of the very lightest element, all atoms consist of three types of particles: protons, neutrons, and electrons. Protons and neutrons comprise the core of an atom, called the nucleus, while the much smaller electrons are typically depicted as orbiting around the core. Protons and electrons are positively and negatively charged, respectively. Neutrons have no charge.

Atoms are identified by two numbers. The "atomic number" is the total number of protons within the atom, while "mass number" consists of the total number of protons and neutrons within the core (electrons have virtually no mass). An isotope is an atom of the same element with the same number of protons and electrons as a regular atom, but with a different number of neutrons. Isotopes are found in nature, but they are rare. The purpose of a reactor is to provide the neutrons needed to create isotopes of existing elements, or to create man-made elements heavier than uranium. Some of these emit neutrons and are capable of sustaining a nuclear chain reaction, where neutrons enter a nucleus, which then splits, emitting more neutrons, splitting more nuclei. Such materials are said to be "fissionable," and can be used to make an explosive nuclear device.[i]

A nuclear transformation is usually done with neutrons, simply because the neutron has no electrical charge and therefore can penetrate an atom relatively easily. The slower the neutron, the easier it is to penetrate the atom's core. Neutrons are slowed down by bouncing off other atoms, until they are absorbed into a nucleus. This sort of neutron absorption can create isotopes, form a different element, or create fissionable material. An unwanted but unavoidable byproduct of any of these transformations is a certain amount of radioactivity, given off by transformed atoms as alpha and beta particles, and gamma rays.[ii]

A regular atomic bomb, the kind dropped on Japan at the end of World War II, is comprised solely of fissionable material, i.e., an isotope of uranium, U-235 (mass number 235), or a man-made element, plutonium (mass number 239). By the end of the war, it was clear that it was easier to make plutonium in a reactor than to harvest U-235 through electromagnetic means or through gaseous diffusion. A hydrogen bomb, which had not even been made in 1950 but was known in theory, required both fissionable material, namely plutonium, to trigger the explosion, followed by an immediate reaction with isotopes of hydrogen to produce an explosion much more powerful than the first atomic bombs. It was planned that the reactors at Savannah River Plant would be able to make both materials: plutonium, a heavy man-made element; and tritium, a radioactive isotope of the lightest element, hydrogen.

From the beginning, the SRP reactors were designed to produce both plutonium and tritium, the two essential materials for "hydrogen" bombs. In the beginning, plutonium was made by taking natural uranium (U-238) and subjecting it to the neutrons put out by U-235, a fissionable material. All of this was done within natural uranium itself, since the isotope U-235 occurs naturally as a very small percentage of natural uranium. For this fission to happen, however, there has to be a "moderator" present to moderate or slow down the speed of the extra neutrons, which can then enter the U-238 nucleus. U-238 absorbed a neutron to become the radioactive isotope U-239, which then decays by beta emissions to Neptunium-239, which in turn decays further to form the final product, plutonium-239. In the course of the life of the reactors at SRP, there were basically four "reactor fuels," or materials used in reactors to support chain reactions. These were: natural uranium (U-238), enriched uranium (natural uranium with more than the normal amount of the isotope U-235), plutonium-239, and the isotope uranium-233. In the first days of the reactors at SRP, the material most commonly used was natural uranium.[iii]

Tritium was made in a totally different fashion. Here, lithium was exposed to neutrons, which would split each lithium atom into two atoms of tritium. The first reactor control rods were made of lithium-aluminum, and tritium was produced in this fashion from the beginning. Later, tritium was manufactured directly from target elements fashioned of lithium-aluminum.

[i] Reactor Certification Training Manual, Reactor Operator and Supervisor, Study Guide, Principles of Reactor Operation (Revised March 1982, on file, SRS Archival Records), 6-13.

[ii] Ibid., 9-10.

[iii] Ibid., 17-20.

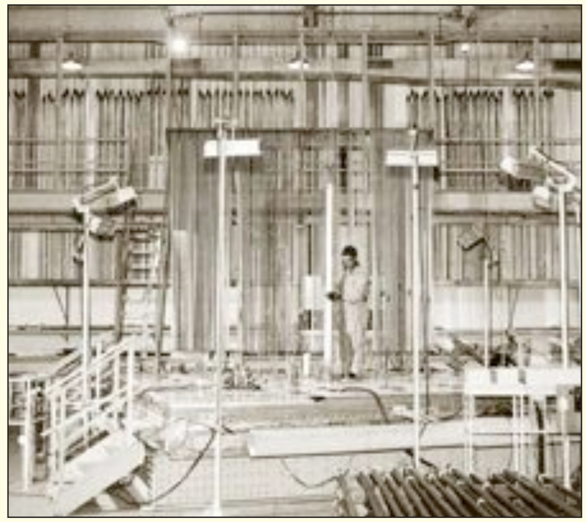
Anatomy of a Heavy Water Reactor

A reactor is a means for producing plutonium and tritium. Much of the discussion above represents what happens at the atomic level. Consider that to be the scale of a test tube. What will be described below is on a much larger industrial scale, something the size of a large manufacturing plant, which is in fact what a reactor is. It is basically a gigantic furnace, with things going in and out of it all the time. These things determined what was made and guaranteed that they were made safely.

There were three basic things that went into a reactor tank. The first was the heavy water moderator, which served as the nuclear matrix. Because heavy water was also used as the reactor coolant, it had to move rapidly through the tank in order to remove the thermal heat generated by the nuclear reaction. The second were the vertical elements that contained fission or other nuclear materials that would be transformed into plutonium or some other nuclear material. The third were the control rods and the safety rods that regulated or stopped the reaction process. All three were crucial to the operation of the reactor tank.

The heavy water moderator, which also served as the cooling agent, had to circulate in and out of the reactor at high speeds. Because it was so costly, heavy water had to circulate within a closed system. It could not be mixed directly with regular or "light" water. Light water, however, was needed to remove heat from the heavy water before it returned to the reactor tank, and this was done in "heat exchangers." These were large cylindrical tanks the size of railroad cars. The hot heavy water entered these tanks through thousands of tubes, which were surrounded by light water pumped through the tank itself. The heavy water re-circulating pipes and the heat exchangers were huge, but the light water system was even larger. Cooling water was pumped through miles of pipes from the Savannah River. Encompassing a system that extended from the river, to the five reactors, and back again, the reactor hydraulic system was the largest of the three basic components that went into the reactor tank.

The active nuclear elements that went into the reactor tank were relatively simple in the beginning. They were basically small "cans" of natural uranium, sheathed in aluminum, and stacked into vertical elements that were inserted into the tank from above. These cans were called "slugs," and they were loaded into vertical elements called "quatrefoils," since they consisted of four small tubes bundled into a single element. Later, nuclear materials were produced in a series of nested tubes that became known as fuel and target elements. Even though quatrefoils were no longer used by that time, the vertical tube elements still had to go into the reactor tank top openings designed for the quatrefoils.



The five production reactors at Savannah River were big tanks designed to hold heavy water, and the many vertical elements that had to be inserted into the tanks. The Process Development Pile, or PDP, in Building 777-M, was a test reactor, not one of the production reactors, but it was the same size as the other tanks, and it used the same vertical elements.

The quatrefoils and later the tube elements were arranged in the assembly area before their use in the reactor. They were then taken, one by one, from the edge of assembly and placed into the reactor tank by a mobile crane known as the "charging machine." After the reaction process was complete, these vertical elements would be withdrawn from the tank and taken to the edge of the disassembly area by a "discharging machine." Together, these cranes were referred to as the C and D Machines.

With the addition of quatrefoils or fuel and target tubes in the reactor, the resulting chain reaction is basically the same as what happens in an atomic bomb, but on a much smaller scale, with much less intensity, and under far greater control. The potential for problems is great. As a result, safety is a huge part of the operation of any reactor. At all times, the reaction process must be controlled, and this includes being able to stop the process on a dime. This was managed by two types of rods: control rods and safety rods. The 61 control rods regulated the speed of the reaction, and they were situated in vertical elements that each had seven tubes joined together.

Continued on Page 54

ANATOMY OF A HEAVY WATER REACTOR CONTINUED

For this reason the control rods were called "septifoils." The 66 safety rods were more straight-forward. When they were dropped into the tank, the reaction would cease altogether.

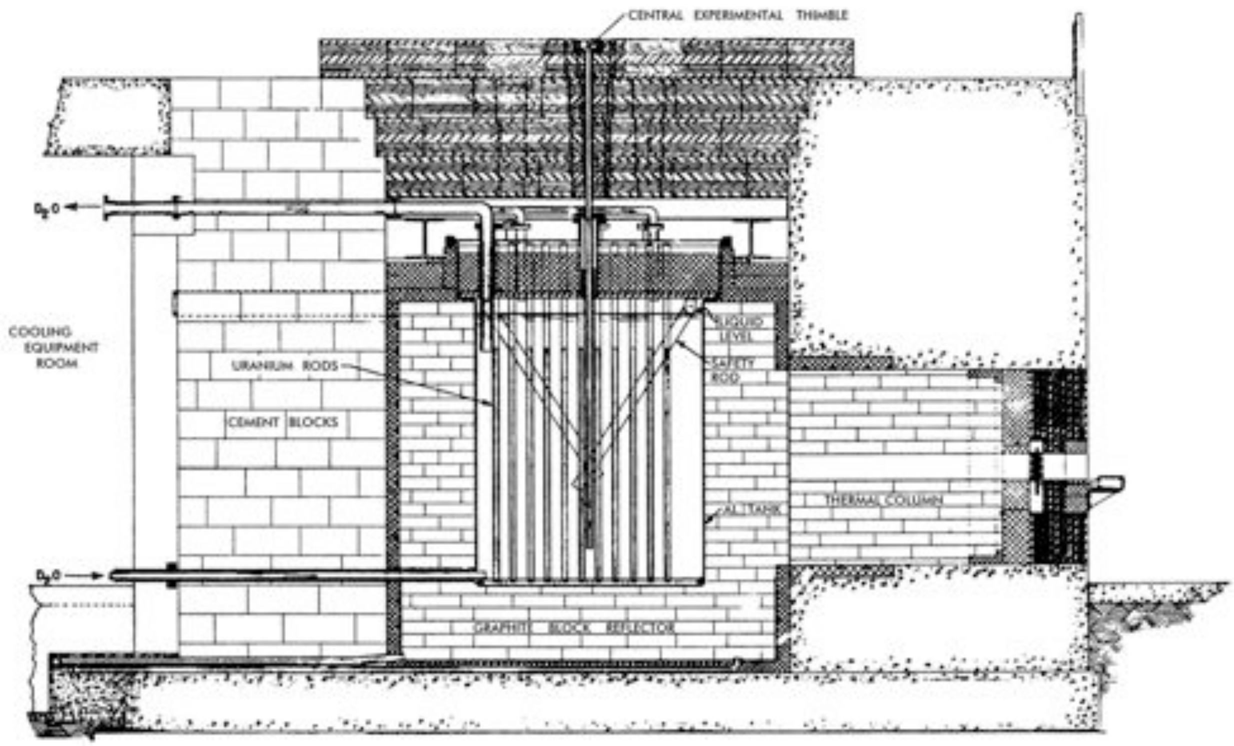
These three basic processes, the moderating and cooling hydraulic system, the nuclear fuel and target elements, and the control system, all came together in the reactor tank. In fact, everything in the reactor building existed to serve the nuclear reaction inside the tank. The tank was the unifying element for every function in the reactor buildings. The area below the reactor tank was largely devoted to the hydraulic system. The areas above it held the control system. The areas to the sides, primarily the assembly and disassembly areas, either put the nuclear materials assemblies together before they went into the reactor tank, or pulled them apart afterwards for chemical processing and refinement. In the 100 areas, the reactor tank was the center of the universe.

CP-3, Argonne's Heavy Water Research Reactor, went into operation in 1944.

The Savannah River heavy water reactors, however, were another matter. In December of 1952, Charles Wende, who would later be head of the reactor work at Savannah River Laboratory, discussed this issue. This was months before any heavy water reactor would go critical at Savannah River. At the end of 1952, the only functioning predecessors to the large heavy water moderated production reactors being prepared at Savannah River, were the small research and test reactors at Argonne National Laboratory. These included: the Argonne exponential tank; the North American exponential tank; the CP-3 ["the world's first heavy water reactor"[5]]; and the Zero Power Reactor II, a small heavy water reactor commonly referred to as "ZPR-II" (the only other heavy water reactor in North America was the NRX Pile at Chalk River, Canada). Of these Argonne reactors, the most important to the development of the Savannah River reactors was the ZPR-II.[6]

While the Savannah River reactors were generally based on the ZPR-II design, there were still great differences between the two. The ZPR-II, a relatively small tank that operated with 25 tons of heavy water, was less than one-quarter the volume of a Savannah River reactor. ZPR-II could only determine neutron flux in the immediate vicinity of the fuel and target elements. It could not provide the big picture for a production reactor the size of those that were under consideration at Savannah River.[7]

In fact, the basic design of the R Reactor and the other production reactors at SRP, was based on measurements made in the "exponential experiment" and in the ZPR-II at Argonne (with reactors, the term "exponential" refers



Vertical Section of CP-3, Heavy Water Research Reactor, Argonne National Laboratory. Source: W.H. Zinn, Design and Description of ANL Reactors, Volume II P/861, (Washington D.C:GPO) 456.

to the rate of neutron flux in the reactor tank, and the conditions under which the neutrons fall off near the edge of the tank).

These measurements gave the designers the basic lattice information and the basic control data needed to operate the reactors. Even so, this information was obtained from tests in relatively small reactor tanks, and there was a need to run tests in a large-scale reactor tank before production got underway in R Area.[8]

Just having a large-size test reactor was found to make a difference in any tests pertinent to a large reactor. Testing element components in a small reactor was fine, but a small test reactor was not adequate for testing the behavior of neutrons in a larger setting. The loss of thermal neutrons was much less in a large reactor, simply because of the greater mass. One researcher compared the situation to a coal fire, where one lump of coal will hardly burn because it loses heat faster than can be generated through combustion. Only a pile of coal will burn efficiently.[9]

There were at least two effects that researchers wanted to test in a large reactor before any attempts were made to start up R Reactor. One was the "rooftop" effect of having so much heavy water moderator above the fuel and target elements in the tank. It was believed that this effect would improve power output in the larger reactors by at least ten percent. Such an effect was barely suggested in the ZPR-II because the reactor tank was not high enough.

Another effect was a "tilt" in the "flat zone" of the ZPR-II. The "flat zone" in a reactor is the central area that is exposed to the greatest concentration of thermal neutrons; the area surrounding the flat zone is often called the "buckled" zone, where the concentration of neutrons falls off, usually around the edge of the reactor tank.

A tilt in the flat zone is any irregularity in the concentration of the thermal neutrons caused by an asymmetrical arrangement of the control rods. This appeared to have been a problem of "radial neutron distribution"– a problem that threatened to affect twenty percent of the reactor's output. Just noticeable in the smaller test reactors, it was expected that there would be greater tilt in the flat zone of a much larger reactor like R. Since researchers were not certain how this would be handled in R Reactor, they wanted to first test this effect in the Process Development Pile (PDP), a full-scale experimental reactor located in Building 777-M, later designated 777-10A. A suitable resolution of this matter would allow power level increases within the large production reactors.[10]

Another issue that merited investigation was the addition of safety features for the larger reactors. In a study written by B. H. Mackey in 1953, it was determined that the ZPR-II and the Savannah River reactors would have many of the same potential hazards. As a result, it was decided to have sixty safety rod actuators for the PDP and a backup of shutdown rods. Once inserted, the shutdown rods would hold the reactor at a sub-critical level.[11]

There were a number of other safety features new to the Savannah River reactors. There was the use of interlocks that would force operators to use the proper procedures when operating the reactor. Also, the Savannah River reactors could be brought to criticality only by withdrawing the control rods; the ZPR-II could be brought to a critical state by either raising the water level or pulling out the control rods. There would be at least 21 health monitors around the Savannah River reactors; there were none for the ZPR-II. The Savannah River reactors would also be below ground level for additional protection from radiation.

REACTOR WORK AT DU PONT

While Argonne handled most of the physics work associated with the new reactors, Du Pont quickly became involved, certainly by 1950, when it was clear that the company would be chosen to construct the new plant. On the Du Pont side, much of this work was done by the Atomic Engineering Division (AED) and by the Design Division. It was Du Pont's responsibility to translate the required physics of the reactor to the design of a large-scale project. The thought processes that led to the development of the building and equipment for the reactor areas were duly recorded in the Du Pont Engineering and Design Histories, compiled in 1957.[12] As recorded in these histories, in 1950 and 1951, Du Pont's AED either compiled or closely reviewed at least three sets of reactor design drawings that illustrated the rapid but radical development of the large-scale production reactors at Savannah River.

At Hanford's original graphite reactors, all reactor elements and control rods entered the pile horizontally. By the time of the Argonne experimental heavy water reactors, many of the elements went into the tank vertically, but this was not the case with the control rods, which still entered the reactor horizontally, through tubes built into the heavy water tanks. This idea was carried over to the first conception of the Savannah River reactors. The development of the reactor tank, and the arrangement of all the elements that would have to go into it, were absolutely critical, and had to be completed very early in the development of the plant. A great many other features, such as the nature of the elements themselves and even the size of the reactor building, could not be finalized until the reactor tank and all of its elements were completely understood. For this reason, a great deal of the early design work at Du Pont was centered on the problems of the reactor tank.

During this critical period, there was a huge amount of overlap in the design and testing work associated with the Savannah River reactors. There were certain limiting factors that had to be kept always in mind. These were the limits imposed by the temperature of the river water, the maximum temperature of the fuel elements, comprised of uranium clad with aluminum, and the heat carrying capacity of the moderator, which had to remove the heat from the fuel channels and take it to the heat exchangers. At this point, it was determined that the circulating rate of the river water should be 69,000 gallons per minute, later bumped up to 76,000, and that the total heat exchanger surface should be an estimated 400,000 square feet.[13]

From the beginning, it was understood that the reactor fuel, at least initially, would be natural uranium, but it was important that the reactors be flexible enough to handle many other possible fuels as well.[14] As early as the summer of 1950, months before the location of the plant was even known, Du Pont studied three different fuel and moderator combinations for the proposed production reactors: 1) heavy water moderated, natural water cooled, and natural uranium; 2) heavy water moderated and cooled, with natural uranium; and 3) natural water moderated and cooled, with enriched uranium. Argonne recommended the second option, and Du Pont decided on this venue as early as August of 1950. This became the basis of the first conception of the Du Pont reactor, known as the "Pi-Pile."[15]

The "Pi-Pile" was the first reactor concept worked up by Du Pont's AED Technical Group, and it had features not originally envisioned by Argonne. Among its unique features were a highly flexible control system; the use of producer materials in the control rods; multiple fuel element loading; and the use of downward flow in the coolant water via a header system. This last would allow changes in the lattice, a reduction in the need for heavy water, and make flow monitoring easier to accomplish. At that time, coolant flow was projected to be 70,000 gallons per minute, with power levels at 315 megawatts (MW). Still undecided was the nature and number of the fuel element channels, and the basic lattice positions.[16]

The earliest formal drawings of the proposed reactor tank at Savannah River consisted of four plans worked up in October of 1950. These plans called for horizontal control rods, positioned around the reactor tank at the level of minus 19 feet below grade. The building size around this arrangement was a proposed 440 by 320 feet, with a depth below grade of minus 40 feet, and a height above grade of 50 feet. The heavy water pumps were to be found at minus 38 feet and the heat exchangers were positioned vertically. This early reactor was envisioned with "sector-shaped plenums" that carried a complement of fuel tubes. The sector plenums, together with their fuel tubes, were designed to be moved as one piece from assembly, to the tank room, and finally to disassembly. This movement from room to room was to be done by a series of canals, with buggies used to move the assembly on and off the reactor tank itself. These early plans also called for a helium atmosphere inside the entire process room.[17]

These initial plans were superceded by a second set in December of 1950. These plans dropped the requirement for the whole process room to be supplied with helium, which would now be restricted to the plenum. In most regards, the original plans still held, but there a few other additions. The sides of the reactor buildings were to be kept open for the possible addition of another reactor at a later date. This required the assembly area and the disassembly areas to be situated on opposite sides of the reactor room. The maximum height of the reactor building was raised to 76 feet above grade, but the other main features remained the same: the heat exchangers were still vertical, the plenum sections and their fuel assemblies were still moved around by buggies, and there were still horizontal control rods positioned around the reactor tank.[18]

According to these December 1950 plans, the tank size was a proposed 17 feet high, with an outer diameter of 17 feet. The distance between the top "poison plate" and the "instrument plate" or false bottom was 14 feet, 9 inches. It was designed to handle uranium columns 14 feet long. Like the control rods, which were horizontal and positioned around the reactor tank, the pumps and heat exchangers that served the reactor were likewise situated in a circle around the reactor tank.

There were now more details on the sector plenum and its gun barrels. These plans called for fuel tubes that entered the reactor tank not as individual tubes, but as part of a "sector plenum," with "gun barrels." This gang of tubes, constructed as part of a section of the plenum itself, would be inserted into and pulled out of the tank together, and would be processed together as well.[19]

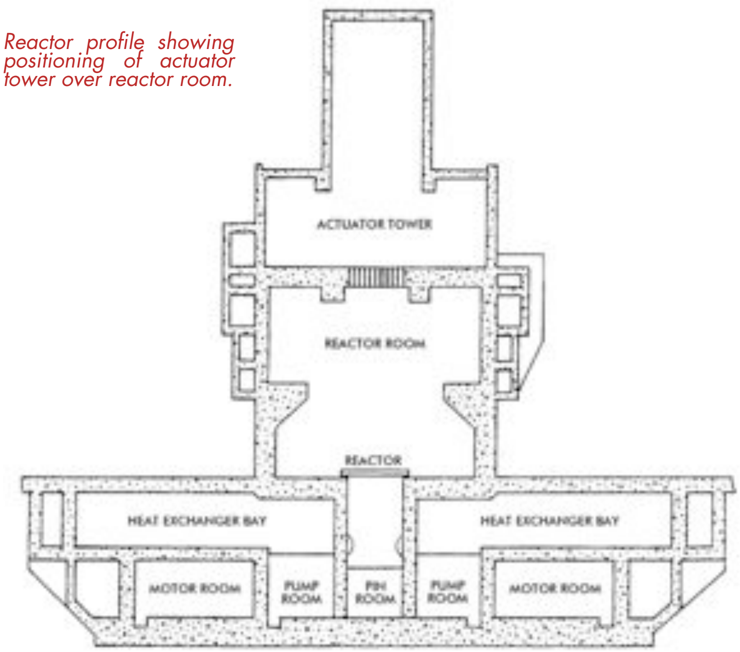
These December 1950 plans were modified only slightly in January of 1951, when Du Pont came out with more detailed engineering drawings of the reactor building itself. The issue of blast-resistant construction was first integrated into the plans. This called for the reactor building itself to be constructed of reinforced concrete, and led to the establishment of a formal building code for Savannah River Plant, based on Class I through Class III construction (see Chapter 4).[20]

The very next month, in February of 1951, Du Pont produced a third set of reactor drawings that came closer to the design that was eventually adopted. The heat exchangers were now positioned horizontally, not vertically, and they were positioned along two lines on either side of the reactor, not in a circle around the tank. This allowed the reactor room to be more narrow, and the heat exchangers themselves could be removed for cleaning or repair from either side of the reactor room, not through the reactor room floor. The horizontal control rods were still arranged around the reactor, but the idea of bulk fuel handling, which had inspired the sector-shaped plenums, was finally dropped in favor of single fuel tube handling. Process pumping was conceived in two stages, even though this might require more heavy water than was then available. These plans also called for a much lower reactor building, with the bottom level at minus 86 feet, with scram pits located at minus 106 feet.[21]

In March of 1951, this third set of reactor drawings were revised. The building depth was reduced from 86 feet below grade, to 40 feet. The height was still relatively low, around 55 feet above grade. The control rods, while still horizontal, were no longer positioned around the tank, but rather were collected into a compact assembly to one side. The heat exchangers were moved to the minus 20-foot level and were mounted on railroad cars so they could be moved in and out of position by means of transfer cars and hoists. The solid bottom of the reactor tank was replaced by a "tube-sheet type bottom shield," with a "pin room" added under the reactor. Due to the lack of heavy water, the process pumps at each of the six lines, would be reduced from two to one. Massive steel shielding doors were incorporated for the first time. The scram tanks were placed at minus 60 feet, but this arrangement was considered provisional.[22]

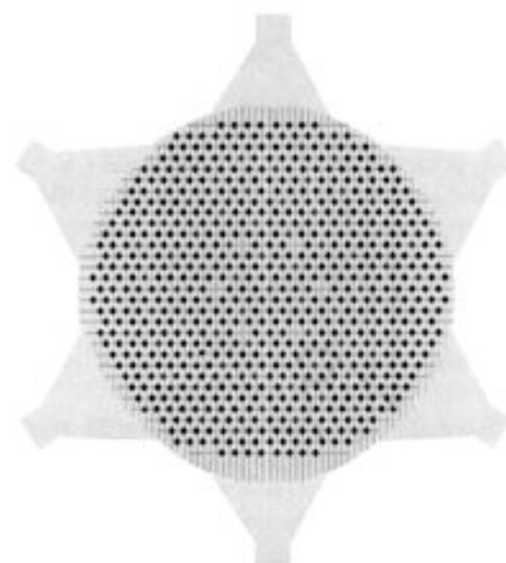
Major revisions again occurred in April and May of 1951. The concept of horizontal control rods was finally abandoned in favor of vertical control rods. This momentous decision was made just weeks before the commencement of construction work at R Area, and it changed the size and shape of the reactor building. The process area could now be more compact and narrow, but it would also have to be much higher to accommodate the upright control rods.[23]

Reactor profile showing positioning of actuator tower over reactor room.



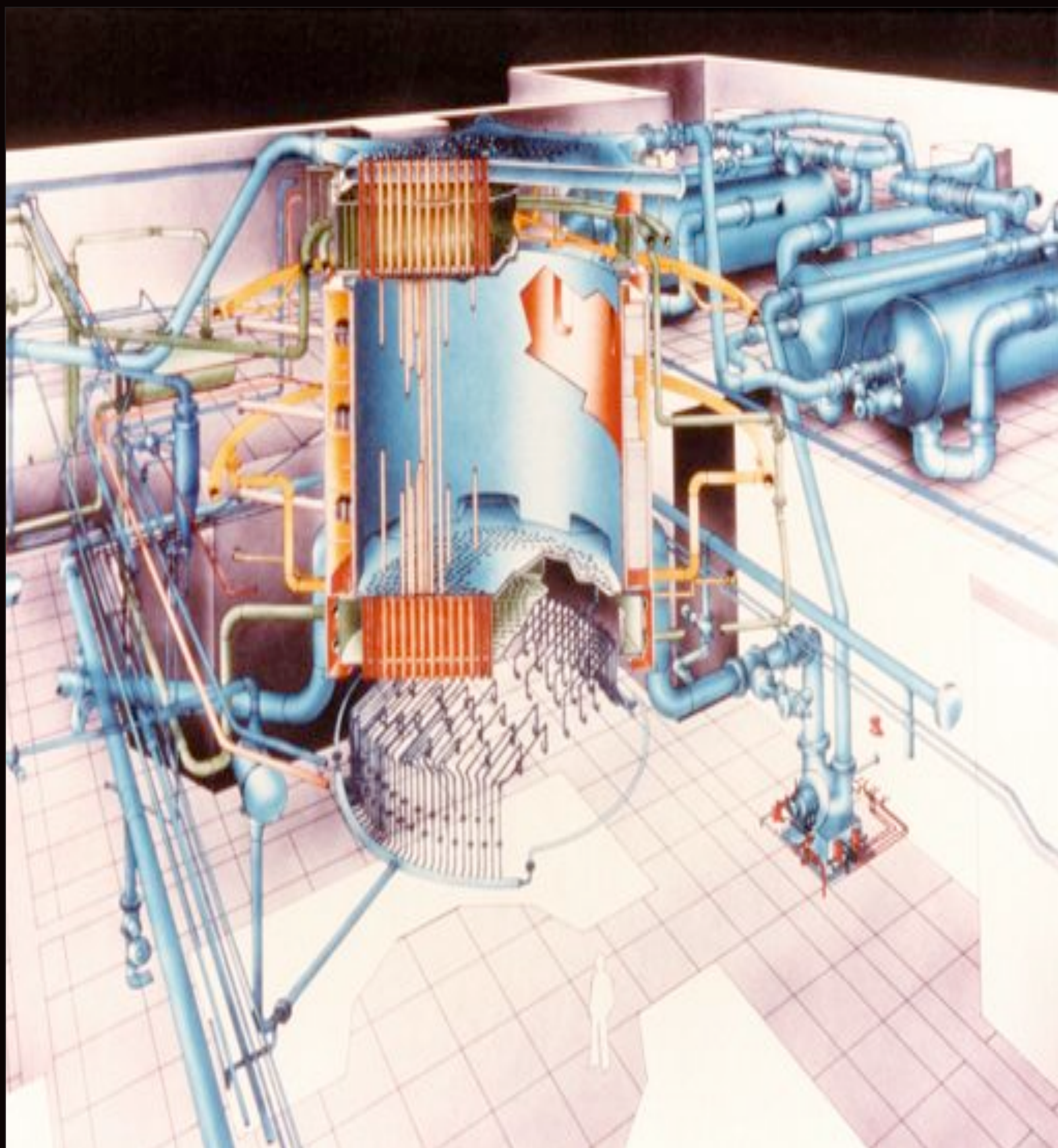
This change to vertical control rods was significant and represented perhaps the last major change to the layout of the reactor building itself. Throughout the summer of 1951, during the early construction of R Reactor building, the vertical control rod system was fully developed, and was soon known as the "actuator system." The late date of these changes meant that the first two reactor buildings, R and P, would have slightly different vertical control rod systems than the later three, L, K, and C.

A crucial part of the actuator system came to be the "forest," a movable aluminum structure with vertical tubes and inner concentric members. The forest served as a guide for the entry of the control rods into the reactor tank. During reactor operation, the forest would be situated directly over the reactor. The original method for moving the forest, when the reactor was not in operation, called for it to be taken in and out of the reactor room by a 120-ton crane. A later proposal, known as the "elevator scheme," called for the forest to be hoisted up to the ceiling when not needed. The first method was incorporated into the final building plans for R and P; the second method was installed in the last three reactors.[24]

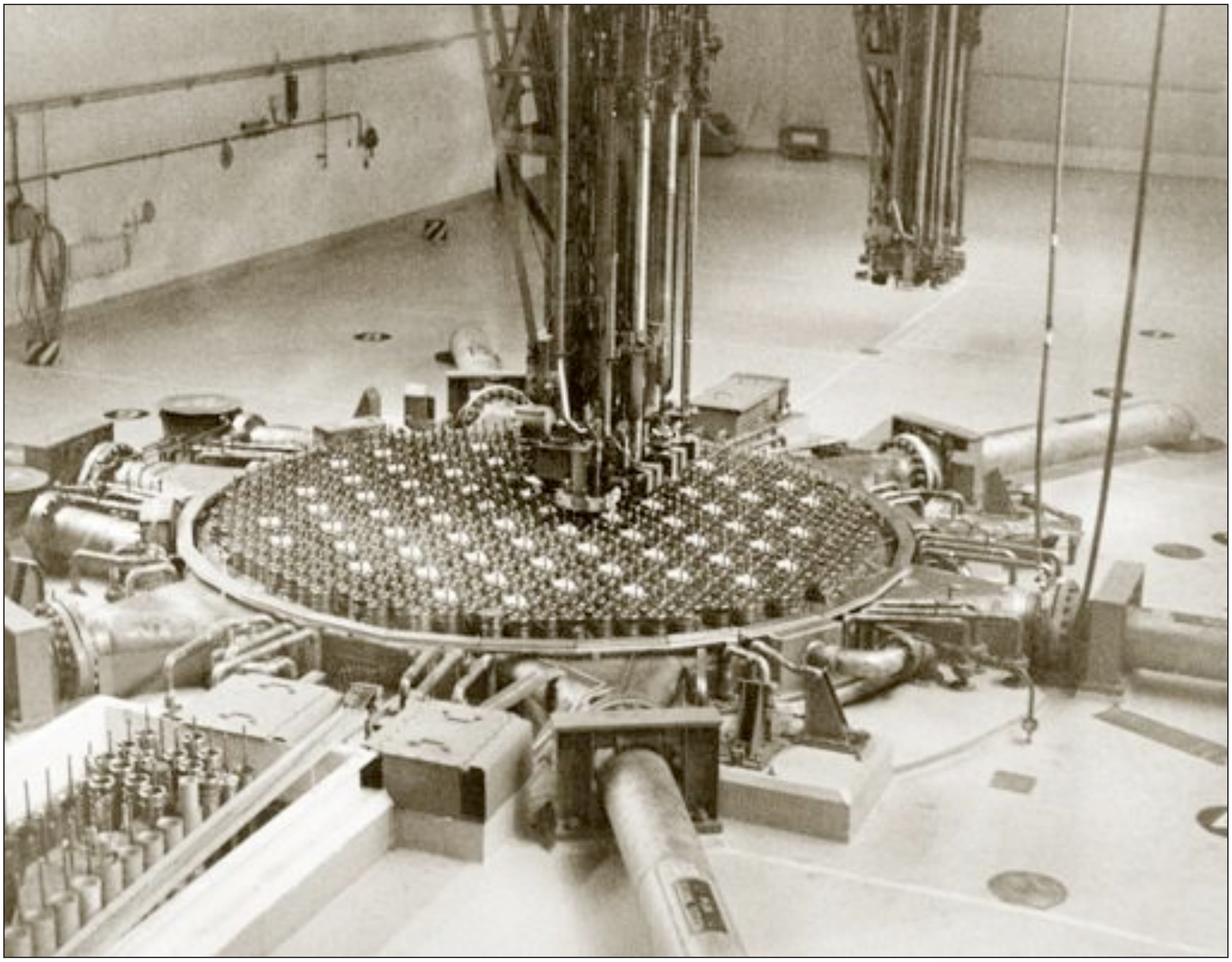


Plan view of reactor face sowing lattice positions, holes through which the elements would be positioned within the tank.

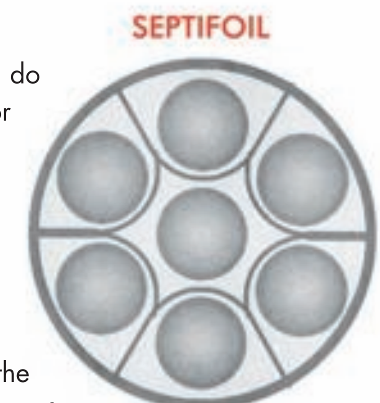
In a period of just one year, from the summer of 1950 to the summer of 1951, the whole arrangement of a heavy water reactor was revolutionized, developing from a set of small experimental reactors at Argonne, to large commercial-grade



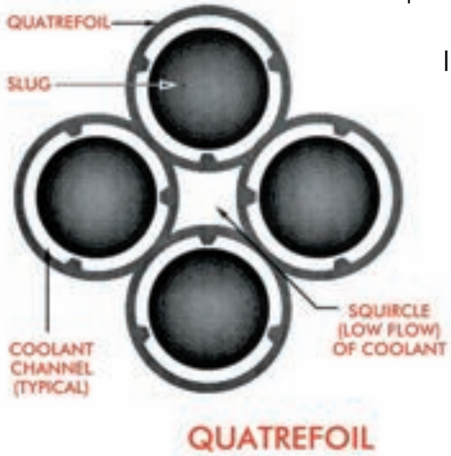
Presentation Drawing Completed by Voorhees Walker Foley and Smith for Du Pont's use Showing Cutway view of the Reactor Vessel. SRS Negative No. 1146-2.



View of Plenum, Showing Discharge Machine at Work SRS Negative No DPSPF-11395-9.



production reactors at Savannah River. All elements that entered the reactors would do so vertically, from the top. By the summer of 1951, when the design was frozen for production of the tank and its components, there were 673 lattice positions. Of these, 606 were fuel tube slots, with each fuel tube having four channels. Each channel was loaded with a stack of one-inch diameter, aluminum-clad uranium fuel slugs.[25] As a result of the four channels, the fuel tubes were called "quatrefoils" or "Q-foils" for short.



Interspersed evenly throughout this number were the 61 control rod positions (and the final six positions for gas tubes). Each control rod had a tube with seven channels. For this reason, the control rods were known as "septifoils." Because of the critical importance of the septifoils, it was decided to have the moderator flow go upward in these channels, rather than downward, as with the rest of the reactor tank. In this way, an abnormally low flow of the cooling water to any of the 61 septifoils could be more easily discerned.[26]

These 673 tube positions were arranged to create a lattice pattern having a seven-inch triangular pitch, divided into two zones: a central flat zone, with each control rod surrounded by six fuel positions, and a buckled zone around the edges of the reactor tank, with fuel positions and no control rods.[27]

This arrangement, however, could be changed if needed. Another early arrangement for the 673 tube slots, was to use 165 positions for small components, with 66 safety rods, 39 instrument rods, and 60 other rods. Blanket clusters of secondary producer components could be used in the outer ring of the lattice instead of fuel tubes.[28]

Versatility was the name of the game for the Savannah River reactors. By this time, the reactors at Savannah River had earned their basic description as "heterogeneous thermal reactors, with aluminum-encased fuel arranged vertically on a 7-inch triangular spacing in a cylindrical tank; heavy water moderated and cooled. It was assumed that the reactors normally operated on natural uranium, however, they have flexible design, for other fuels, too."[29]

After the sector-plenum idea was dropped in favor of the one-piece, fixed plenum, it was understood that the reactor would be loaded with individual tubes, one tube at a time. These tubes ranged from Q-tubes, blanket rods, control rods, 35W5 rods (bismuth producer rods, similar to control rods), instrument rods, and "S" or safety rods.[30]

A buggy was not really suitable for this sort of individual tube loading and unloading, also called charging and discharging. Fortunately, the new narrow reactor room made possible the construction and operation of an overhead crane capable of loading and discharging individual fuel elements and other vertical rods. This, however, takes us into the realm of the process room rather than the reactor tank. This issue and the others that deal with this portion of the reactor room, will be covered in our treatment of the reactor process itself, where we cover process and equipment in each part of the reactor building, from assembly, through the processes of the process area, to disassembly.[31]

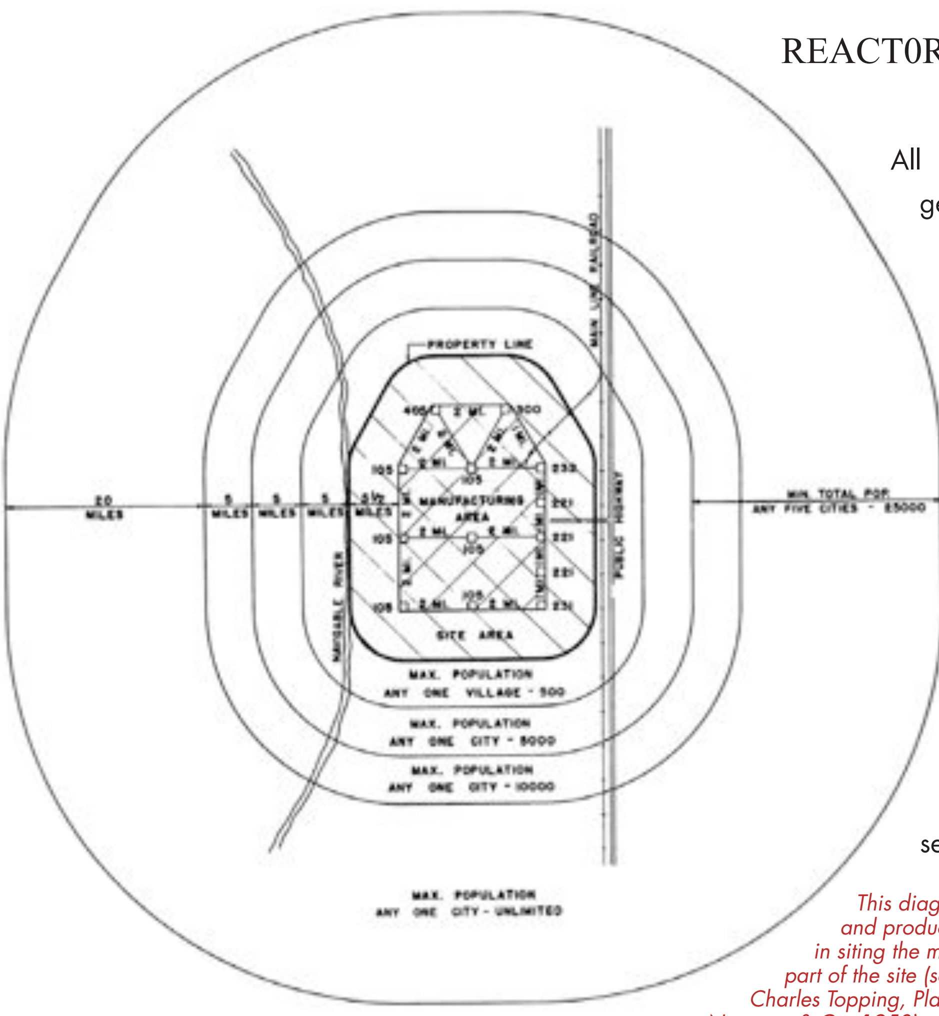
The final design plans for the Savannah River reactor areas and buildings were presented in a series of isometric and profile drawings commissioned by Du Pont and prepared by Voorhees Walker Foley & Smith (VWF&S). In addition to perspective drawings of the 100-areas, they showed the interior of the reactor buildings and the reactor process arrangement. They included cut-away interior perspectives of the reactor tank and other features, drawings of the central control room, and 36 line drawings for the Manual for R Reactor.[32]

IV. CONSTRUCTION

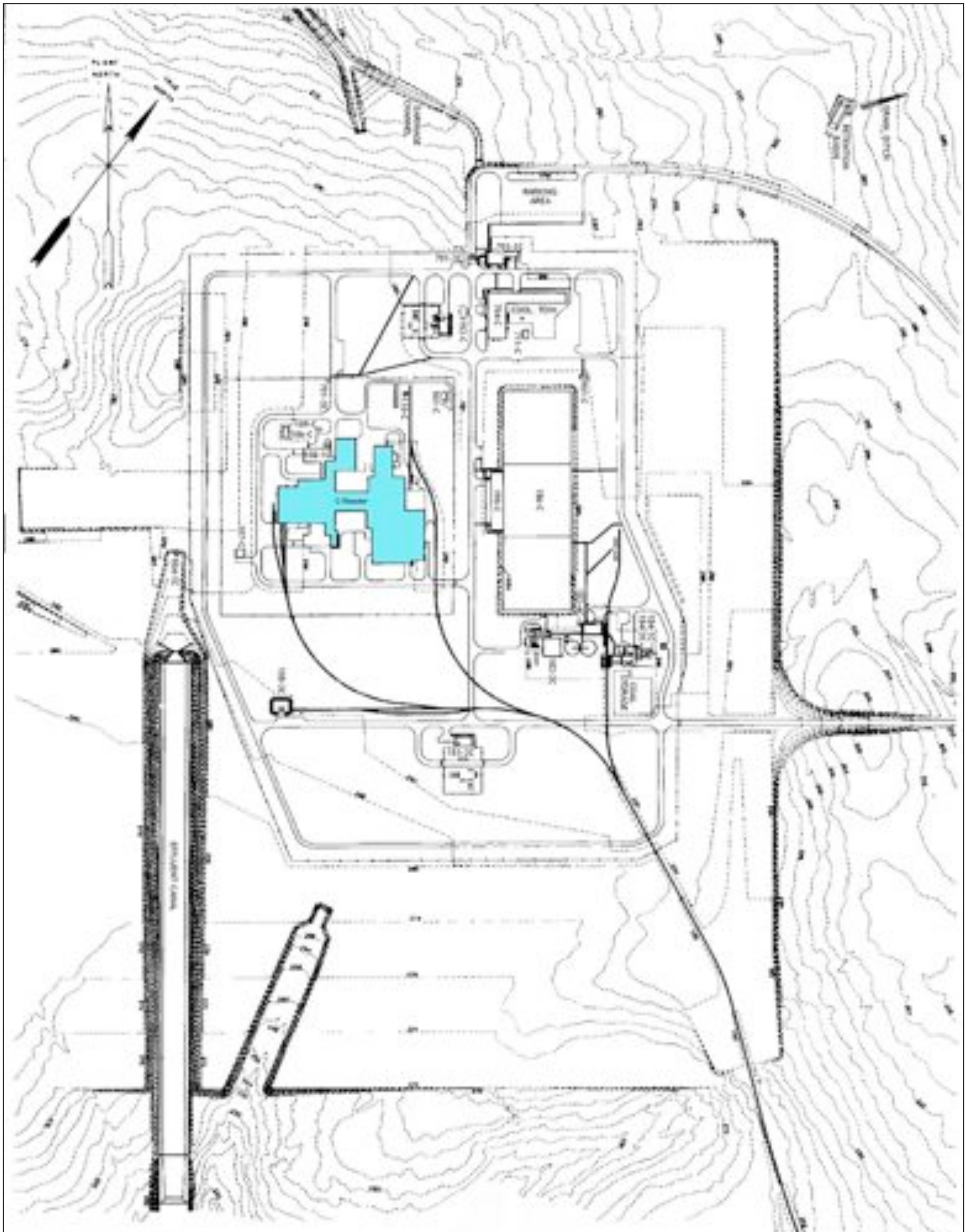
Five separate reactor areas were constructed at the Savannah River Plant between 1951 and 1955, designated 100-R, 100-P, 100-L, 100-K, and 100-C respectively. The location and dispersal of these facilities onsite was the result of a joint effort between the Atomic Energy Commission (AEC), Department of Defense, and the United States Air Force. It was decided that the reactor areas should be arranged along a horseshoe curve with no permanent facilities located inside the pattern. Basic AEC requirements further dictated that each reactor area be located approximately 2.5 miles away from the next, a distance of 3 miles from any passenger carrying rail line, and at least 6 miles from the site perimeter. Working within these parameters, the specific locations of the five reactor areas were then selected based on topographical advantage, one sought after benefit being the gravitational return of cooling water effluent from each area to the river through natural drainage channels. [1] The reactor areas were eventually sited deep within the southern half of the site. Each was accessible by at least two of the plant's highways, except 100-C. They were also accessible by the plant's railroad system.

REACT0R AREA LAYOUT

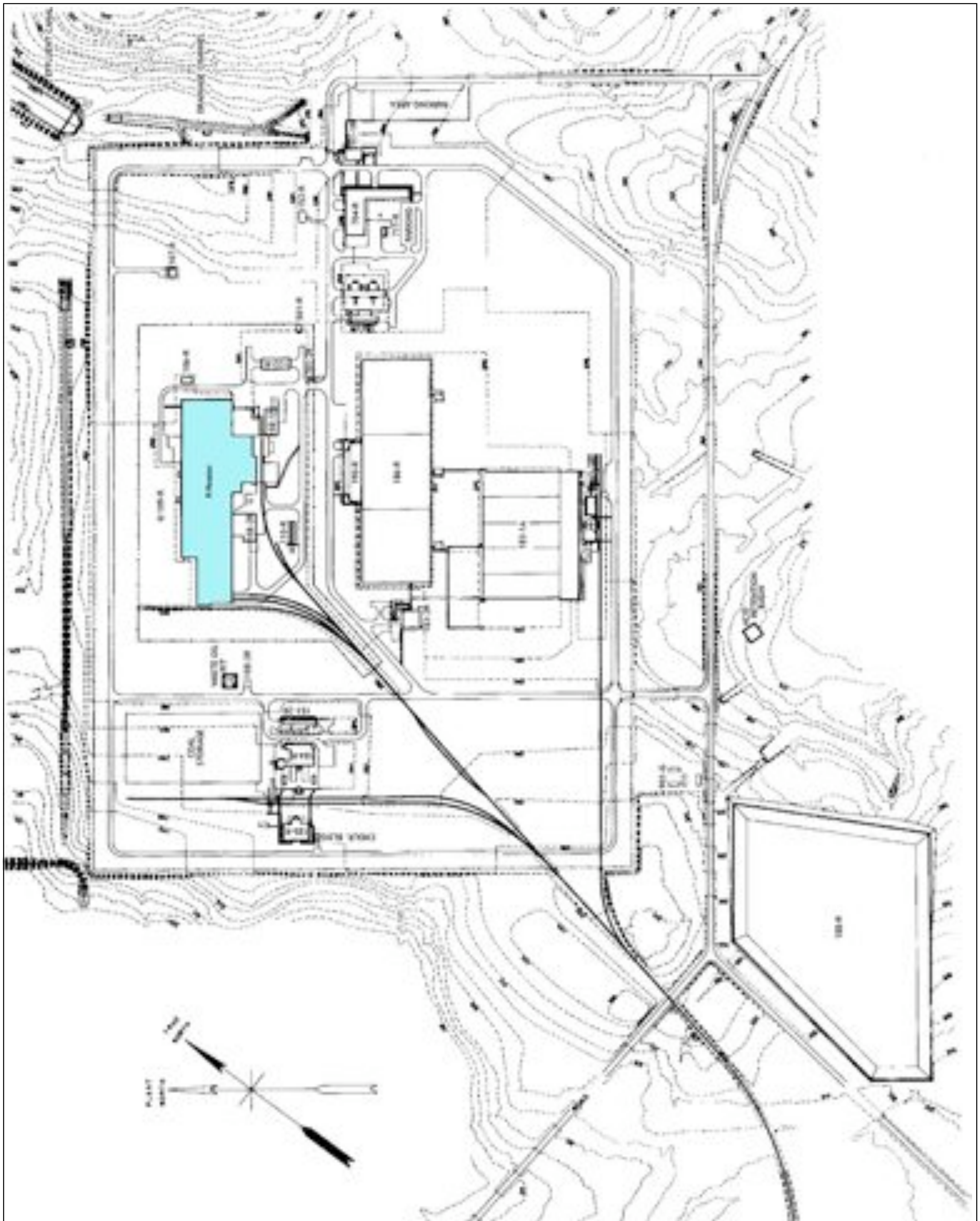
All five reactor areas share the same general layout with a "clean" side and a "dirty" side, mirroring the division within the reactor building itself. The clean side of the reactor area included the gate area, the main personnel buildings, and the electrical substations. The "dirty" area, located at the opposite end, included the reactor building's Disassembly area and area power plant. The main water facilities and reactor were located in the center of the area.[2] A perimeter fence surrounded the entire area, while a second interior fence further secured the reactor building.



This diagram shows Du Pont's approach to the safety and production requirements of the Savannah River Plant in siting the manufacturing facilities deep in the southern part of the site (see Buildings area map in Chapter 1). Source: Charles Topping, Plant 124-Site Survey (Wilmington:E.I. du Pont De Nemours & Co, 1950).

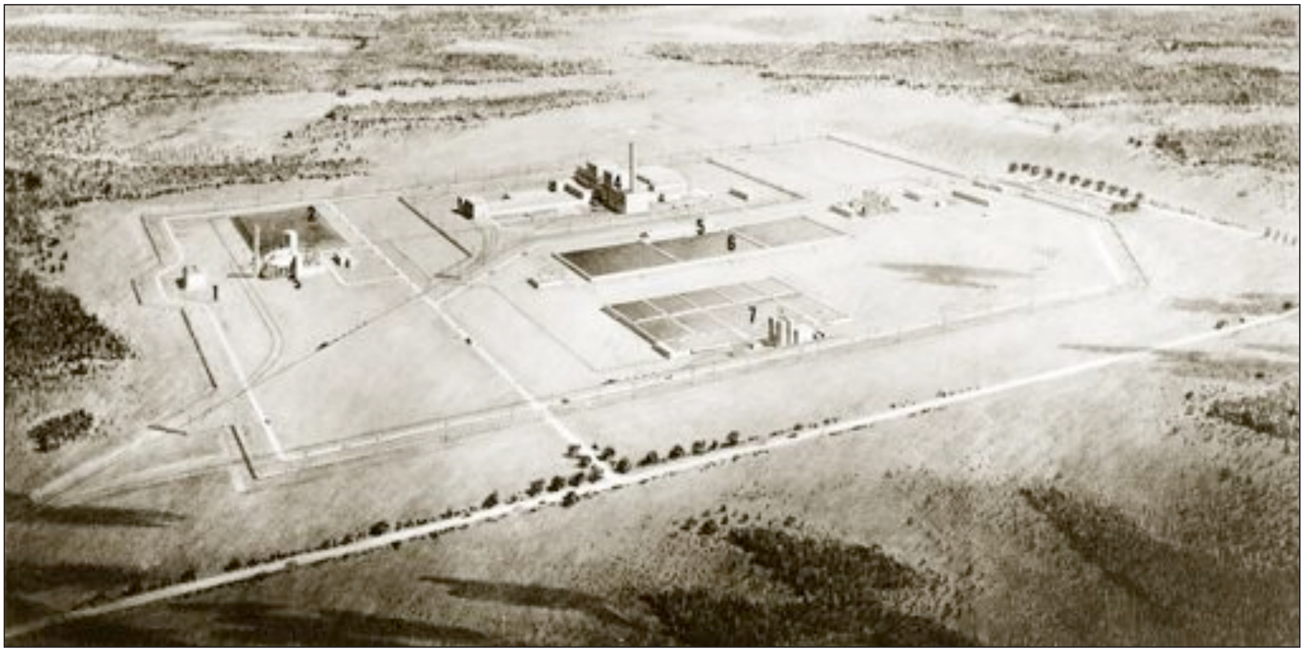


100-C Area, General Plan and Building Map, Basic Information Map, 1956.

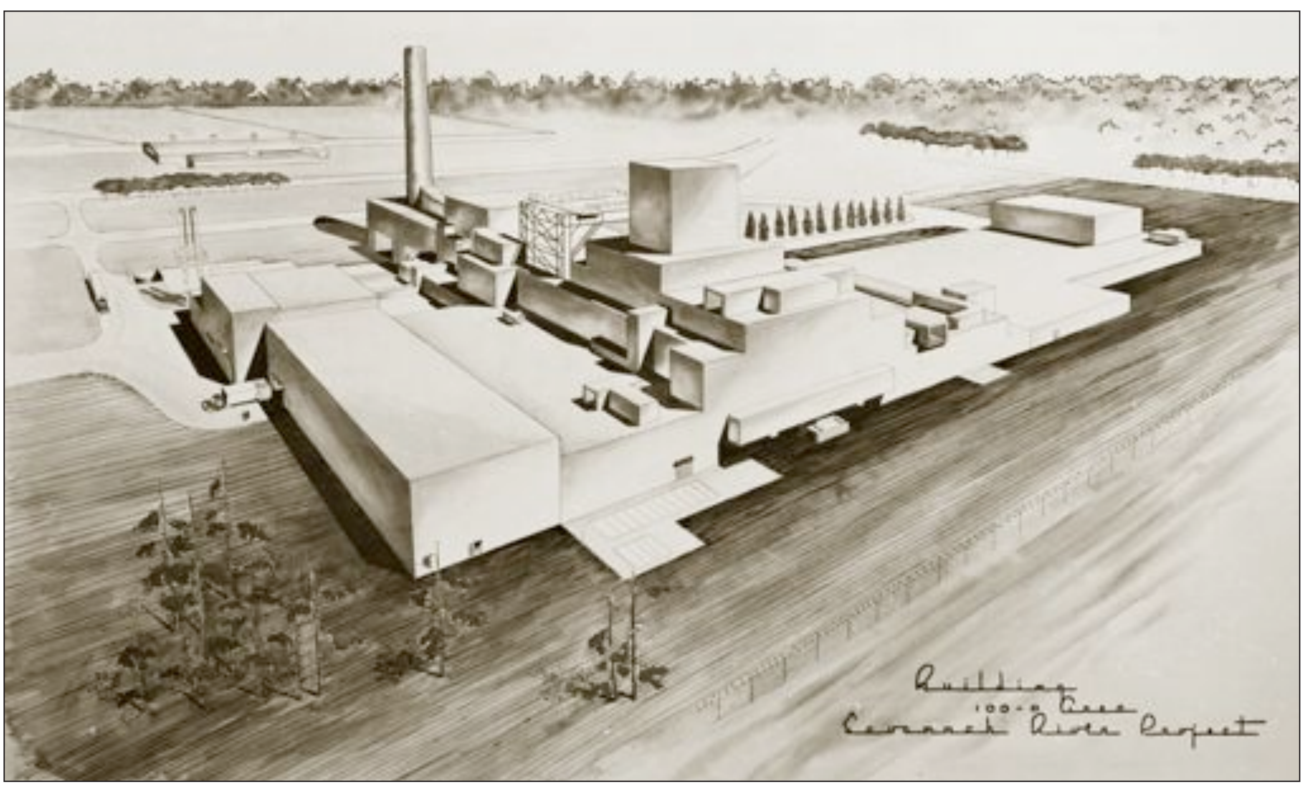


100-R Area, General Plan and Building Map, Basic Information Map, 1956.

In each reactor area, the massive reactor building was the obvious focal point. These enormous buildings, each requiring around 200,000 cubic yards of concrete to build, easily comprised around three-quarters of the construction work at the reactor areas.[3] Even so, the remaining work was essential. Each area contained



Conceptual Drawing of R Reactor Area Layout, Voorhees, Walker, Foley, and Smith, February 5, 1963. Numbered facilities include reactor (4); pump house (5); cooling basin (6); clarification plant (7); power house (3); cooling tower (1); and substation (2). The administrative buildings are grouped to the right of the basins and are not numbered, SRS Negative DPSPF 8869-14.



Conceptual Drawing of P Reactor, December 8, 1952, SRS Negative M-1678-12.

approximately 40 permanent facilities; this number includes process-related buildings as well as buildings and structures related to area infrastructure, such as water and power facilities, roads and walks, fencing, and sewage systems.[4] This constellation of smaller structures around the reactors provided fundamental services and supplies

View of K Reactor, Looking North, August 9, 1955, SRS Negative DPESF 1-1268-04.

Unidentified Visitors View L Reactor, May 8, 1958, SRS Negative DPSPF 5178-06.

for the operation of the reactors. In fact, each reactor area, with the exception of 100-C, was designed to be self-sufficient with all its supporting facilities located within the area boundaries.

The 701-1 Patrol House, located on the perimeter fence, was the first building encountered in the reactor area. All pedestrian traffic entered the area through the badge alley in this building. Vehicular traffic entered through a gate adjacent to the building, but was very limited in the reactor areas; most workers parked in a parking lot located outside of the area fence and entered the area as mentioned above. The 704 Office and Shops Building was located directly behind the 701-1 building and was the final destination for many reactor area office and maintenance workers.

The center section of the reactor area contained the reactor building itself, which was adjacent to the area water treatment and storage facilities. An interior fence surrounded the reactor and several smaller associated structures. Anyone requiring entry into the reactor building area entered through a second Gate House, 701-2, on the interior fence boundary. Just outside the fence were the 190 Pump House and the 186 Cooling Water Reservoir, which provided water to cool the heat exchangers in the reactor buildings. Those facilities associated with the treatment of water for service and domestic use, the 183 buildings, were located at the far corner of the 186 Reservoir, from which they were supplied.

The backside of the reactor area was occupied by facilities associated with area power generation, the 184 Powerhouse and 185 Cooling Tower, as well as a coal storage yard and the 188 Ash Disposal Basin. The area rail line entered through a fence on this side of the area. One spur serviced the power plant, bringing in coal for the Powerhouse and fuel for the 108-3 Fuel Unloading Facility. The second spur serviced the reactor building area, delivering materials to be irradiated to the Assembly area and taking irradiated materials from Disassembly to their next destination in one of the separations areas.

Because each of the five reactor areas was laid out and constructed using the same set of building types, this study will concentrate on those types rather than the individual buildings. For example, 190 Pump Houses were constructed in each of the reactor areas and are virtually indistinguishable from one another, with identical floor plans and equipment layout. This study will describe and document the 190 building type by using a composite of information and images from all five 190 buildings. The other reactor area building types that will be considered in this study are identified in the following table and a thorough discussion of each type can be found later in this chapter.

Table 4. Reactor Area Building Types covered in Thematic Study.

Building #	Name	Original to Area
106	Process Water Storage Tank	CKLPR
107	Cooling Water Effluent Sump	CKLPR
108-1	Engine House	CKLPR
108-2	Engine House	CKLPR
108-3	Fuel Unloading Facilities	CKLPR

Building #	Name	Original to Area
108-4	Emergency Diesel Generator/Fuel Storage	CKLPR
109	Purge Water Storage Basin	CKLPR
110	Gas Storage	CKLPR
122	Process Storage Building	R only
183-1	Clarification Plant (Cooling Water)	R only
183-2	Filter & Softener Plant	CKLPR
183-4	Clarification Plant	CKLP
184	Power House	CKLPR
185	Cooling Tower	KLPR
186	Cooling Water Reservoir	CKLPR
188	Ash Disposal Basin	KLPR
190	Cooling Water Pump House	CKLPR
701-1	Area Gate House and Patrol Headquarters	CKLPR
701-2	Gate House	CKLPR
704	Office and Shops Building, Change House and Stores	CKLPR
706	Reactor Technology Building	C only
711	Steel & Pipe Storage	CKLPR

Du Pont clearly did most of the design work and the construction work associated with the reactor buildings. Du Pont even designed and built much of the equipment. But there were some major exceptions, and the biggest of these was the American Machine and Foundry Company, which designed and helped build many of the reactor components, the fuel handling machines (the C and D Machines), the control rod actuators, as well as many other devices associated with Assembly and Disassembly.[5] New York Shipbuilding, located in New Jersey, fabricated the reactor vessel itself.[6]

Another company that performed some of the work on the reactor building was Gibbs and Hill, Inc. The main responsibilities of this company at Savannah River Plant were to do design work for the electric power facilities, steam generation, the water pumping facilities, and the communication and alarm systems. In the 100 areas, they were directly responsible for the electrical work in many of the outlying buildings, such as Buildings 151, 184, 185, 183, 107, 186, 190, and 108.[7]

Another firm that did work in the 100 areas was Voorhees, Walker, Foley and Smith (VWF&S). The firm did not directly design the reactor building – even though they did prepare for Du Pont a series of drawings depicting the reactor and the reactor system. They did, however, design many of the administrative and service buildings that surrounded the reactor buildings. The VWF&S buildings included 122, 701, 704, and 711. The firm also worked on plans for the general reactor area lay-out, which included roads, railroads, and other area features.[8]

SRS CONSTRUCTION PARAMETERS

At an early date the Atomic Energy Commission informed the Du Pont Company of its preference for spartan simplicity in building design. This policy required Du Pont and its subcontractors to design facilities with maximum economy consistent with functional requirements and to standardize designs and specifications for buildings and associated facilities to achieve uniformity.[9]

Functional Design

SRP encapsulated a multi-purpose factory system that produced more than one product. Despite its unique mission and the safety, security, and environmental issues it imposed, the layout of individual building areas and their architecture had their roots in American industrial architecture and factory design. Industrial architects in the first half of the twentieth century adhered to the tenet that form should follow function, espoused by modernist Le Corbusier. Reinforced concrete became the preferred building material for factories and industrial architects such as Albert Kahn championed the need for the integration of specialists such as process engineers in the development of well-designed factories. Buildings constructed within this functional vocabulary were enclosed by smooth planes, featured industrial materials, and eschewed decoration.[10]

By World War II, a factory type had emerged that was a mechanical unit for the production of goods. It typically had a steel superstructure, a flat roof, and panel walls. Its interior was an open bay characterized by uninterrupted floor space with support and personnel related use areas on a mezzanine level, penthouses, or in wings. Single story in height, windowless, and boxlike, the factory building typically had suspended walkways that connected to mezzanines where restrooms were located. The walkways allowed non-manufacturing employees and visitors entry without disturbing the work process. Conveyors, winches, and other handling mechanisms were also suspended to keep the floor clear.[11]

Successful industrial architecture provided for the efficient movement of materials through a production process and enabled employees to perform their work efficiently: “from parking space, to changing room, to machine station to cafeteria and back.”[12] This called for analyses of the flow of materials to determine equipment layout and its consequences for the building envelope. Design would begin with the process line, move to the support and storage facilities, and end at the parking lot. Should a shift system of work be employed, the number of parking spaces needed for efficient flow of personnel was doubled. Materials handling and personnel flow were charted as architects and engineers grappled with the best “flexible” design to allow for changes in process that may cause change in necessary manufacturing equipment and/or its arrangement and for future factory expansion. “Flexibility” was the key design guideline.

The use of “functional design” was second nature to VWF&S, a leader in industrial design for laboratories. VWF&S had an impressive number of projects such as the Murray Hill Bell Telephone Building that included a cyclotron building at Columbia University and Argonne National Laboratory in the atomic energy field. Its credits in 1954 included laboratories and factory facilities for NY Telephone, Ford, GE, IBM, R.H. Macy, Proctor & Gamble, General Foods and others.

The New York firm was also responsible for the site plan and design of Du Pont's Experimental Station in Wilmington, Delaware, described as a "campus of six modern laboratory establishments" and an additional campus for Du Pont's rural headquarters at Milford Crossroads near Newark, Delaware. The laboratory complex was designed using the flexible-modular concept: "VWF&S studied the particular requirements of each of the six participating (Du Pont) departments, then 'added up the modules' in every instance and juggled them around and around - rather like children's blocks– until they all slipped into the one best possible combination for each case."[13]

For Du Pont's rural headquarters project, VWF&S, under the guidance of senior partner, Perry Coke Smith, designed immense H-shaped buildings that pivoted on a "space unit" design. This design hinged on a unit of space – a floor of a wing – that could be subdivided in whatever manner the client needed. Given this experience with specialized building types and a functional modular approach and their corporate experience with Du Pont, VWF&S was an easy choice as subcontractor for architectural and engineering.

The first generation of buildings at SRP were simply designed using the functional ethic described above. The AEC's specification that the project's buildings be austere in their design was a done deal given the climate of American post-war industrial architecture. The choice of building materials, reinforced concrete and Transite™ paneling, were mandated by the building code. Articulated in reinforced concrete or steel frame with Transite™ panels, the majority are beige or gray boxes built for maximum flexibility and for government service. Their uniformity in color, their number and size, and their geometric forms create a harmonious grouping of buildings within an ordered industrial landscape where form reverberates function. This functional perspective is further emphasized by the placing of the Site utilities aboveground so that massive pipes parallel roads or arch over them. Economically motivated, this design feature has strong visual impact.

As-built drawings show that the architects developed "typical modules" for each building's elevations when possible. Using structural columns, reinforced concrete, and Transite™ panels in which windows could be placed as their main vocabulary, the architects repeated the typical exterior module as many times as necessary to create an envelope for the space required. This approach plus the use of neutral colors produced the desired effect - a rhythmic feel to the buildings and symmetry that contributed to their anonymous and functional character.

Blast Proof Construction

Meetings between Du Pont, the AEC and other sub-consultants were ongoing in November and December of 1950. A meeting at Drexel Institute of Technology in Philadelphia between Professor H. L. Bowman and Du Pont engineers tackled the building criteria needed to protect the proposed facilities from atomic blast and to allow it either wholly or in part to operate in the face of such an attack. Three types of construction were developed and this classification system was codified and placed into a supplement to the Uniform Building Code published in January 1, 1946 that was adopted for plant construction use.

Class I buildings were described as massive, reinforced concrete, monolithic structures with a static live load of 1000 lbs per square foot.[14] Their exterior walls and roof were to be poured, reinforced concrete with a supporting frame of reinforced concrete or structural steel. Critical process buildings were to be constructed of

Building a Reactor

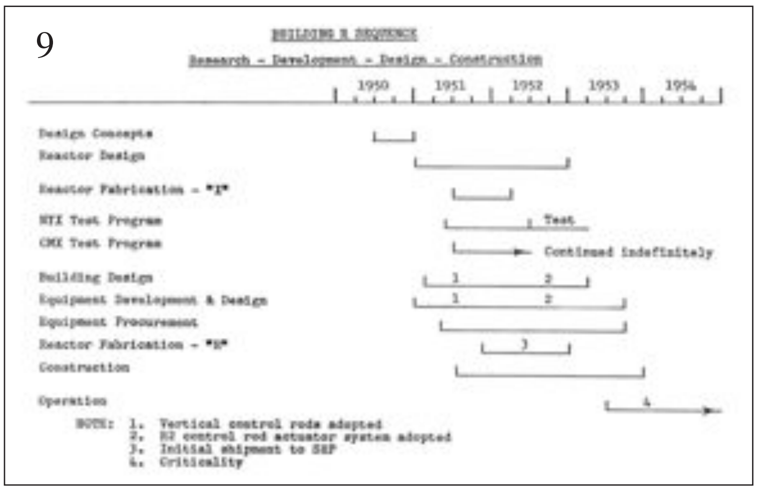
1. A corn field occupies R Reactor site, May 28, 1951, negative DPESF 1-126. 2. Excavation for R Reactor involved moving 2,300,000 cubic yards of earth, August 24, 1951, negative 1-44-1. 3. Reactor building begins to take shape, September, 25, 1951, negative 1-158-1. 4. Below-ground area built and levels above

grade are readied for concrete pours, December 19, 1951, negative 1-206-1. 5. Concrete forms and supporting scaffolding on reactor building, negative 1672-4E. 6. R Reactor's construction required 19,300 tons of reinforcing steel and 235,500 cubic yards of concrete, June 28, 1952, negative 1-206-1. 7. Construction proceeds around the clock, June 16, 1952, negative 3692.

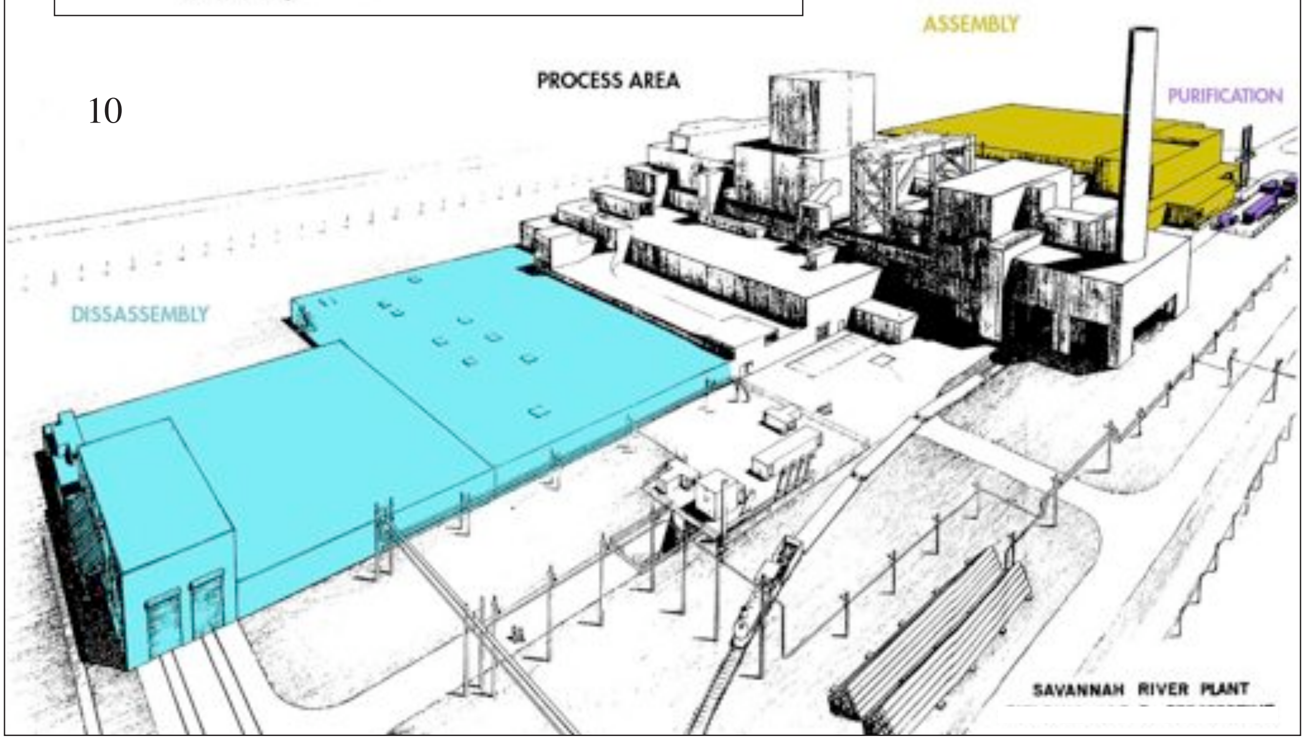
Constructing the Site's Monumental Architecture

8

9



10



8 and 9. Completed Reactor building, April 30, 1953 and timeline of the entire process involved from conception to start of operations, negative 1-855-2.Source (graph): Engineering Department, *Engineering and Design History*, Vol. II. E. I. du Pont de Nemours & Co., 1957. 10. Profile of R Reactor, the largest of SRP's five production reactors and the first to achieve criticality. The reactor building was essentially an envelope covering four main process areas: the assembly area, the process area, disassembly and the purification area. Source: Engineering Department, E.I. du Pont de Nemours & Co. Savannah River Plant Engineering and Design History , Volume II, DPE 971, 1957.

blast proof materials throughout. Reinforced concrete construction was selected for its ability to take stress, the protection it affords from alpha and gamma rays and intense heat, and the speed and economy it would lend to construction.

Class II buildings were considered to be of friable construction with a structural frame of reinforced concrete or structural steel and expendable wall materials. If bombed, the structural frame remained intact while the exterior walls were considered expendable. Fifty percent of a building's exterior wall area had to be covered with friable materials to suit this class of construction. Roofs were poured concrete and designed for a live load of 150 pounds per square foot; all floors were of poured reinforced concrete. If equipment or areas in these buildings required further protection concrete blast-resistant walls were added or floor levels were placed below grade.

Extensive tests were undertaken at Sandia National Laboratory in New Mexico to identify possible friable wall materials by exposing the candidate materials to TNT explosions that simulated atomic bomb blasts. After analysis, Transite™, a short fiber, cement-asbestos siding material, was chosen because it broke into small pieces on impact.[15]

Transite™ was sold in the form of flat and corrugated sheets.[16] As an exterior sheathing it reduced the load bearing factor considerably from 120 to 20 pounds per square foot when compared to masonry walls and it was further desirable as it did not rot, rust, burn and was impervious to insects and rodents.[17] Advertised as smart, modern, and economical in period advertisements, Transite™ boards became the primary building material for exterior wall sheathing between 1950 and 1956 at SRP. The presence of the smooth, natural cement color exterior board is the hallmark of the Site's first generation of buildings for this class of construction.

Class III construction, which provided no protection from blasts, was considered normal construction carried out under the building code. All service buildings, shops, and change houses were considered expendable. This category included a plethora of prefabricated metal buildings manufactured by Butler, Hudson, Mesker, and other firms. Examples of Class I, II, & III constructions can all be found in the reactor areas.

Standardized Construction in a Unique Industrial Context

As noted, facility designers sought to standardize design as a cost saving measure, to promote uniformity, and to aid the construction force in adhering to a tight construction schedule. Building types allowed replication and as most of the building areas were to be self-sufficient, this potential was essential. The reactor areas are a good example of this standardization.

Between 1950 and 1956, Du Pont and VWF&S created a repertoire of types, mostly in the service or support categories, that could be duplicated when and where needed. In terms of the design process, Du Pont's design division gathered design data, which was then transferred to VWF&S for resolution into a building or facility. Consultation between the architectural firm, the Wilmington Office, and the on-site engineers was undertaken via teletypes, telephones, and face-to-face meetings. Power-related and water treatment facility types were handled by Gibbs and Hill. The use of Class II construction also played into standardized construction. Transite™ walls offered unlimited potential for door openings and fenestration so that standard building types could be easily altered to suit new needs.

The numbering applied reflected the building types and their function to a large degree. The 700 building series, for example, referred to facilities associated with administration and support functions. In this series, buildings duplicated often such as gatehouses were all referred to as 701 buildings; a suffix such as the -5A in 701-5A indicated its geography and the number of gatehouses in a building area. This numbering system allowed for expansion should more of a given building type is needed. With the exception of the 700 and 600 buildings, the hundreds place in each buildings' three digit number indicated a process area. The remaining places in the numerical label indicated a building's function. Thus, a powerhouse in a 100 Area was 184-R, a cooling tower 185-R. The same building types in the 700 Area would have been labeled 784-A and 785-A.

BUILDING DESCRIPTIONS

Reactor (CKLPR)

The reactor buildings housed equipment that would carry out the site's essential function - the irradiation of elements to produce fissionable material. That task was performed in a heavy water moderated and cooled reactor, situated in the core of the building. All other functions of this building and indeed, the entire site, supported that singular mission.

Each SRS reactor was a multistory, irregularly shaped building primarily constructed of reinforced concrete with stacks reaching approximately 200 feet in height, substructures reaching 40 feet below grade, and featuring different configurations at grade level. They are procedurally alike but different in their size and layout. All had the same main subdivisions: Assembly, Process Area, Personnel Area, Disassembly, and Purification.

R Reactor was the first and largest reactor constructed at Savannah River and logically, more difficulties were encountered during its construction than with the remaining four reactors. As design and construction challenges were met and solved on the drafting table and in the field, changes were implemented in subsequent reactors, resulting in slight variations in all of the reactor buildings. Over time, the reactor buildings became smaller, with a more efficient layout.[18] R and P reactors, the first two constructed and the largest of the five, are most similar and can be considered a replicated "type" within the Savannah River reactor group. L and K reactors form the next generation type while C reactor, the last to be constructed, represents a third type.

Modifications in layout and materials also influenced reactor design. The R and P reactor buildings were made of reinforced concrete throughout identified as Class I construction in the context of Du Pont construction at Savannah River. Even though R and P were similar, there are still some minor differences between the two. In P, the Assembly and Disassembly areas are slightly smaller than those in R. The big change in the reactor building design came with L and K. The layout is different from R and P, and while most of the building is still Class I construction, some of the building was demoted to Class III, specifically the Personnel area, most of the Assembly area, the Disassembly fan room, and other small miscellaneous sections. Other changes were the elimination of the heat exchanger bays, shorter Disassembly area canals, the elimination of the hot lab in the Disassembly Dry Cave, and the elimination of two cells and the shielded cab in the Purification area. C was like L and K in most regards: the Disassembly area was different in some respects, but the biggest difference was the larger reactor tank in C.[19]

Table 5. Reactor Construction Statistics.

Building	Start Date	Final Acceptance	Went Critical	Building Dimensions	Total Cubic Feet
R Reactor	6/11/1951	11/3/1953	12/28/1953	737′ x 348′	12,450,000
P Reactor	7/6/1951	1/13/1954	2/20/1954	613′ x 348′	11,485,000
L Reactor	8/27/1951	9/30/1955	7/2/1954	560′ x 457′	9,000,000
K Reactor	10/5/1951	10/31/1955	10/15/1954	560′ x 457′	9,000,000
C Reactor	11/26/1951	9/6/1955	3/28/1955	546′ x 458′	8,950,000

Source: Engineering Department, E. I. du Pont de Nemours, Savannah River Plant Construction History, DPE **1957, Volume III, p. 109.

REACTOR BUILDING COMPONENTS

The next several chapters are devoted entirely to discussing the function and equipment in the five major areas of the reactor buildings - Assembly, Process Area, Personnel Area, Disassembly, and Purification. For that reason, the following paragraphs will offer only a physical description and discussion of the construction materials used in those areas. In most cases, R Reactor will be used as the example and differences between it and the other reactor buildings will be noted.

ASSEMBLY

Assembly is the location in each reactor building where fuel elements and target materials to be irradiated are received, cleaned, assembled, and stored prior to loading in the reactor. Though functionally alike, there are discernable differences in the size, orientation and layout of the five Assembly areas. The principal components of all the Assembly areas include receiving, operations and component storage, final storage, and a transfer station; however, their arrangement and size within the Assembly area differs from the earlier to the later reactor buildings due to design differences implemented during construction.

Assembly is a single-story area with a basement and is approximately square, measuring 186 feet by 191 feet. The roof height of roughly two-thirds of this area is 43 feet 11 inches, with the remaining third at 34 feet. P Reactor's Assembly area is similar though smaller, while L, K, and C's Assembly area is irregular in plan. All Assembly area foundations are reinforced concrete with spread footings. R and P are Class I constructions and also have reinforced concrete floors, walls, and roof. L, K, and C, have areas of both Class I and Class III portions, in which exterior walls of corrugated asbestos board are secured on steel studs. Flat cement asbestos board is used for interior partitions and ceilings.

Table 6 Assembly Area Comparison (square footage).

Room	R	P	L	K	P
Receiving	2,940	2,074	2,160	2,160	2,160
Operations/Storage	26,969	19,336	19,682	19,682	19,682
Final Storage	5,376	4,704	5,016	5,016	5,016
Transfer Station	1,056	1,056	4,100	4,100	4,100
Fan Room	3,416	3,416	-	-	-
TOTAL	**39,757**	**30,586**	**30,958**	**30,958**	**30,958**

Source: Engineering Department, E. I. du Pont de Nemours & Co. *Savannah River Plant Engineering and Design History*, Volume II, DPE 971, 1957, p. 343.

PROCESS

This portion of the building extends from an elevation minus 40 feet below ground to 150 feet above ground. As the name of the area indicates, this is where actual irradiation process takes place and as such, this portion of the all of the reactor buildings is of Class I construction. Though dimensions vary between the five buildings, the main construction material used is the same - concrete. Foundations, walls and floors slabs are reinforced concrete. Concrete is also used for ceilings and most interior partitions.

Table 7. Process Area Comparison (square feet).

	Room	R	P	L	K	C
-40' Elevation	Pump Room	8,042	8,042	8,470	8,470	8,470
	Motor Room	7,992	7,992	7,992	7,992	7,992
	Transfer Pit	25,914	25,914			
	Fan Room	8,728	8,728			
	Storage & Scram	4,418	4,418	4,032	4,032	4,540
	Inst. & Observ.	2,132	2,132	2,570	2,570	2,570
	Corridors & Misc.	15,571	15,571	18,291	18,291	18,291
	Stack Foundation	5,625	5,625			
	TOTAL	**78,422**	**78,422**	**41,355**	**41,355**	**41,863**
-20' Elevation	Heat Exchanger	19,558	19,558	24,638	24,638	24,638
	Transfer Pit	25,914	25,914			
	Fan Room	10,488	10,488			
	Storage & Scram	4,418	4,418	4,032	4,032	4,032
	Corridors & Misc.	22,235	22,235	21,533	21,533	21,533
	Stack Foundation	5,625	5,625	5,625	5,625	5,625
	TOTAL	**88,238**	**88,238**	**55,828**	**55,828**	**56,336**

	Room	R	P	L	K	C
0' Elevation	Process Room	7,360	7,360	10,656	10,656	10,656
	Crane Wash	1,624	1,624	2,304	2,304	2,304
	Crane Maintenance	7,992	7,992	8,856	8,856	8,856
	Personnel (Inc. Fan)	11,400	11,400	8,640	8,640	8,640
	Canal (Transfer)	8,142	8,142			
	Power Transfer Rooms 1-4	4,126	4,126	4,258	4,258	4,258
	Motor Gen. And Rod Equip.	2,000	2,000	1,938	1,938	1,938
	Stack & RR	5,625	5,625	5,625	5,625	5,625
	Corridors & Misc.	24,152	24,152	29,229	29,229	29,229
	Fan Room			10,128	10,128	10,128
	TOTAL	**72,421**	**72,421**	**81,634**	**81,634**	**81,634**
15' Elevation	Process Room	9,600	9,600	10,656	10,656	10,656
	Crane Wash	1,624	1,624	2,304	2,304	2,304
	Crane Maintenance & Fan	9,752	9,752	11,768	11,768	11,768
	Master Control Room	4,796	4,796	4,300	4,300	4,300
	Locker Rooms	2,664	2,664			
	Office Space	3,170	3,170	1,200	1,200	1,200
	Crane Control Room	1,870	1,870	888	888	888
	Corridors & Misc.	6,680	6,680	6,103	6,103	6,103
	Stack & RR	5,625	5,625	5,625	5,625	5,625
	Fans			9,578	9,578	9,578
	TOTAL	**45,781**	**45,781**	**52,422**	**52,422**	**52,422**
34' Elevation	Crane Runway	25,920	25,920	25,632	25,632	25,632
	Corridors & Misc.	5,930	5,930	3,872	3,872	3,872
	Exhaust Fans & Seals			3,584	3,584	3,584
	Air Conditioning Room			3,264	3,264	3,264
	TOTAL	**31,850**	**31,850**	**36,352**	**36,352**	**36,352**
48' and Above	Main Tank Supply Fan Blast Tee	6,264	6,264	5,712	5,712	5,712
	Process/Actuator Room	4,752	4,752	4,752	4,752	4,752
	Roof Area – Shield Doors	4,896	4,896	6,936	6,936	6,936
	Main Tank Exhaust Fan	3,456	3,456	4,200	4,200	4,200
	Stack Area	6,900	6,900	5,625	5,625	5,625
	Actuator Hat	1,156	1,156	1,156	1,156	1,156
	TOTAL	**27,424**	**27,424**	**28,381**	**28,381**	**28,381**

Source: Engineering Department, E. I. du Pont de Nemours & Co. *Savannah River Plant Engineering and Design History*, Volume II, DPE 971, 1957, pp. 349-367.

DISASSEMBLY

This area of Class I construction is single-story with a water basin beneath most of the area. The majority operations in this area take place under water in order to shield personnel from irradiated materials. In R and P, the Disassembly areas are "L"-shaped, while in L, K, and C they are roughly rectangular. Roof heights in all are 15 feet, except a small area that rises to 40 feet. Basin depths ranges from 17 feet to 30 feet below grade.

Foundations, roofs, and exterior walls are reinforced concrete, except for L, K and C fan rooms, where corrugated asbestos board is used for the walls. Concrete is also used for ceilings and most interior partitions, with some areas of flat cement asbestos board. The floors in this area are a mixture of concrete and removable wood panels treated with linseed oil.

Table 8. Disassembly Area Comparison – square feet.

Room	R	P	L	K	P
Temporary Tube Storage	11,900	7,960	5,809	5,809	4,480
Machinery Area	10,044	7,750	6,955	6,955	4,096
Repair Shop	2,139	1,755	1,170	1,170	1,768
Bucket Storage	14,784	8,036	7,777	7,777	4,416
Dry Cave and Cask Floor	5,202	5,005	4,862	4,862	7,144
Monitor Basin and Storage	2,600	2,600	1,848	1,848	1,280
Transfer Area	3,564	3,483	4,012	4,012	4,816
Corridors and Misc.	1,299	400	873	873	400
Fan Room		704	2,236	2,236	1,512
Dry Cave Fan Room	640	640	640	640	640
TOTAL AREA 0′ Level	**52,072**	**38,333**	**36,182**	**36,182**	**31,720**
TOTAL AREA –17 & -30	**42,712**	**29,531**	**25,590**	**25,590**	**26,482**

Source: Engineering Department, E. I. du Pont de Nemours & Co. *Savannah River Plant Engineering and Design History*, Volume II, DPE 971, 1957, p. 374.

PURIFICATION

The Purification portion of the R and P reactor buildings was a single-story, Class I construction that covered an area 97 by 158 feet; in L, K, and C, it was about 30 percent smaller. There was a main floor and a basement, with the roof elevation found at the 22-foot elevation in R and P and 18 feet 6 inches in L, K, and C. The foundations and exterior walls were of reinforced concrete. Interior partitions were generally of poured concrete, with some rooms formed by metal studs and cement asbestos boards.[20]

Table 9. Purification Area Comparison – square feet.

Room	R	P	L	K	P
Cell Space	2,272	2,272	1,110	1,110	1,110
Hot Tunnel and Hot Pipe Space	1,212	1,212	1,938	1,938	1,938
Cold Pipe Space	2,800	2,800	4,028	3,578	3,578
Unexcavated	2,976	2,976	690	1,140	1,140
TOTAL Basement Area	**9,260**	**9,260**	**7,766**	**7,766**	**7,766**
Trailer Space	928	928	1,200	1,200	1,200
Cell Space	2,272	2,272	1,110	1,110	1,110
Corridors and Miscellaneous	2,142	2,142	1,961	1,961	1,961
Gas Equipment Rooms	1,178	1,178	1,386	1,386	1,386
Resin Prep Area	1,860	1,860			
Refrigeration and Gas Dry Room	1,300	1,300	480	480	480
Distillation Area	756	756	756	756	756
Office, Elect. & Inst.	3,901	3,901	1,485	1,485	1,485
Make Up Room			630	630	630
TOTAL First Floor Area	**14,337**	**14,337**	**9,008**	**9,008**	**9,008**
TOTAL	**23,597**	**23,597**	**16,774**	**16,774**	**16,774**

Source: Engineering Department, E. I. du Pont de Nemours & Co. *Savannah River Plant Engineering and Design History*, Volume II, DPE 971, 1957 , p. 385.

REACTOR AREA SUPPORT BUILDINGS

The reactor buildings were naturally the focal points for each of the five reactor areas. They were by far the largest single building in each complex, and naturally the most important. Even so, there were a number of other buildings common to each area that also played essential roles in the functioning of the reactor areas. These support buildings are the subjects of this section.

106 – Process Water Storage Tank (CKLPR)

The 106 buildings weren't actually buildings at all, but rather underground storage tanks. They were located in close proximity to the reactor buildings and were connected by a 16-inch line. Known as the Process Water Storage Tank, this facility was designed to receive heavy water moderator from the reactor building in case of a major break in the system. A full charge of process water totaled approximately 40,000 gallons. Because the moderator in each of the reactors was estimated to cost several millions of dollars, the potential loss of the moderator was not an acceptable option.

Construction of 106-L Building, Process Water Storage Tank, Prior to Burial, October 1, 1953, SRS Negative DPESF 1-994-01.

Building 106-R, Process Water Storage Tank, After Completion, March 28, 1953, SRS Negative DPESF 1-823-01.

All of the tanks are Class I structures measuring 44 feet by 25 feet with a depth of 18 feet. The tank top is level with the ground elevation. The bottom of the tank is 3 feet thick reinforced concrete, while the walls and top are 2 feet thick. Waterproofing was applied to the structures in the form of a single-ply membrane. Each tanks' total volume is 20,760 cubic feet, with a capacity of 60,000 gallons.[21]

107 – Cooling Water Process Effluent Sump (CKLPR)

Also known as the Process Effluent Sump, Building 107 was a rectangular underground facility that measured 35 feet by 31 feet by 29 feet deep. In an emergency situation, or in the case of an interruption in the flow of river water, these sumps provided a means of recirculating all or a portion of the emergency cooling water flow back to the 186 Reservoirs, so that it could be reused. The Class III 107 basins were constructed of reinforced concrete; the sump walls and bottom slab were two feet thick, with a capacity for 100,000 gallons of water. The cover was a combination of reinforced concrete and removable steel grating that served to ventilate the sump. The pump and motor were mounted on the top of the sump, which was slightly above grade.[22]

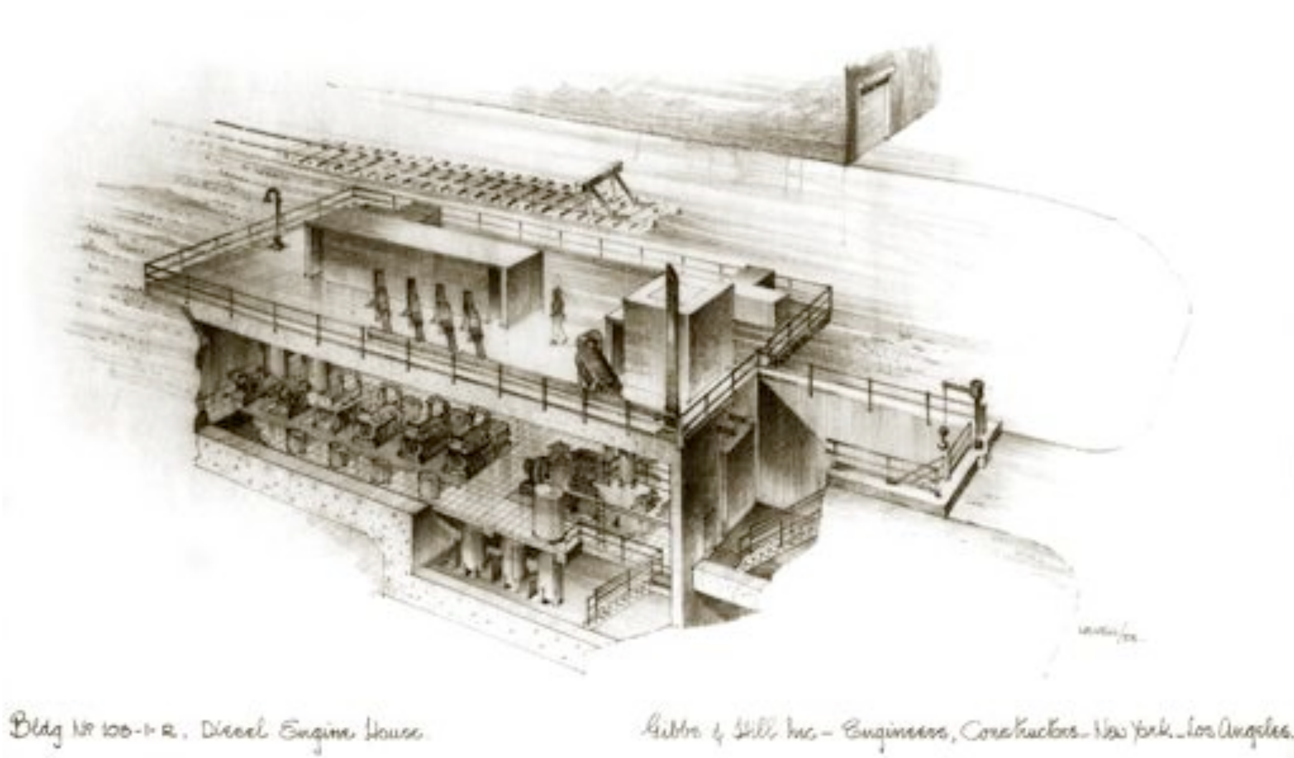
Building 107-L, Cooling Water Effluent Sump Under Construction, October 26, 1953, SRS Negative DPESF 1-1053.

Building 107-C, Cooling Water Effluent Sump, After Completion, March 31, 1954, SRS Negative DPESF 1-1171-08.

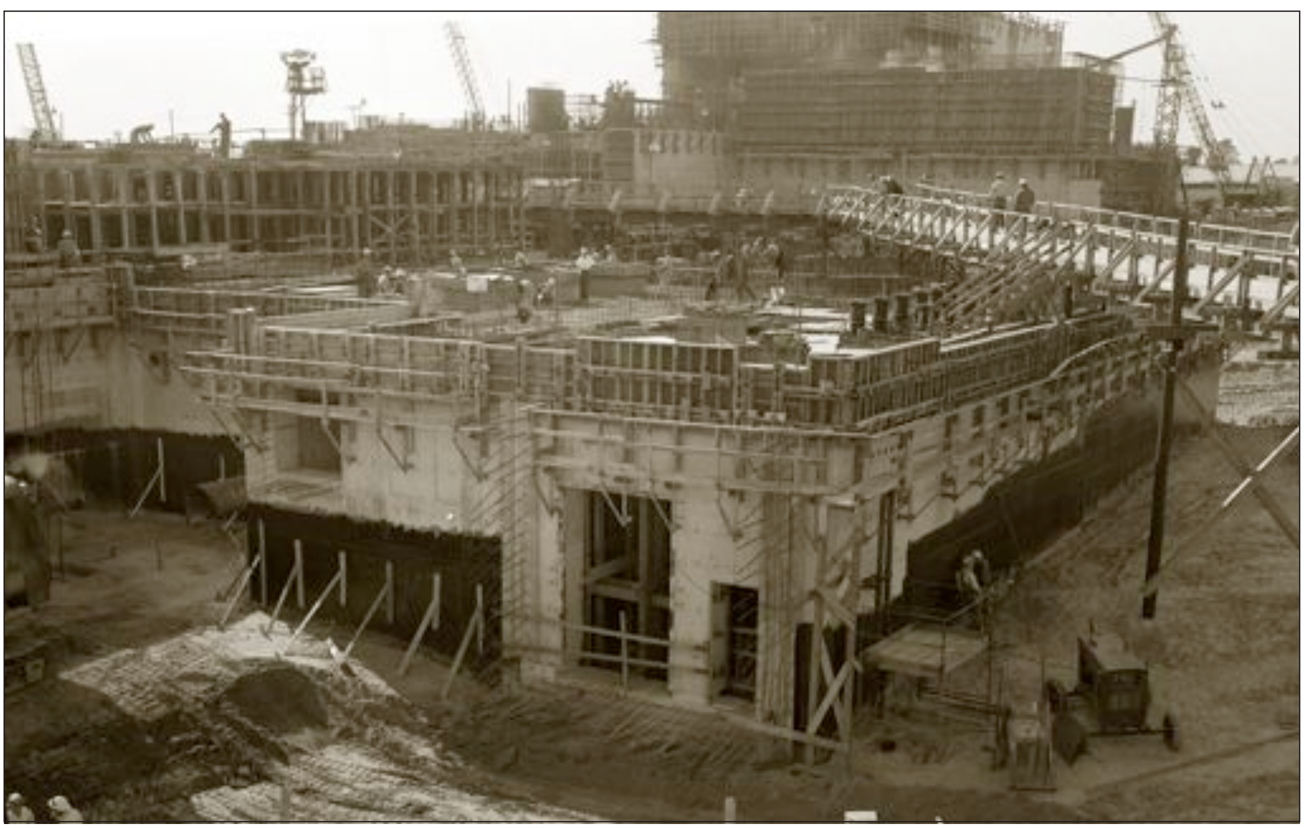
108-1, 2 – Engine Houses (CKLPR)

These underground facilities housed diesel driven generators, which supplied emergency DC power to the process heat exchanger water pumps in the reactor buildings. The 108s also provided power to the area substations in the case of an emergency. Additionally, they provided instrument air and plant service air to the reactor and 108 buildings. Electric power was absolutely essential to the functioning of the reactor and as such, the 108 buildings were kept constantly at the ready in case of a primary system failure.

The overall importance of their function was reflected in the location of the 108 buildings, adjacent to and almost indistinguishable from the reactor building. They were, in fact, connected to the reactor buildings by way of underground passages and in some cases, a common wall. There were two 108 buildings for each reactor building, identified as 108-1 and 108-2. They were virtually identical, and flanked either side of the reactor building at the minus 20-foot level.

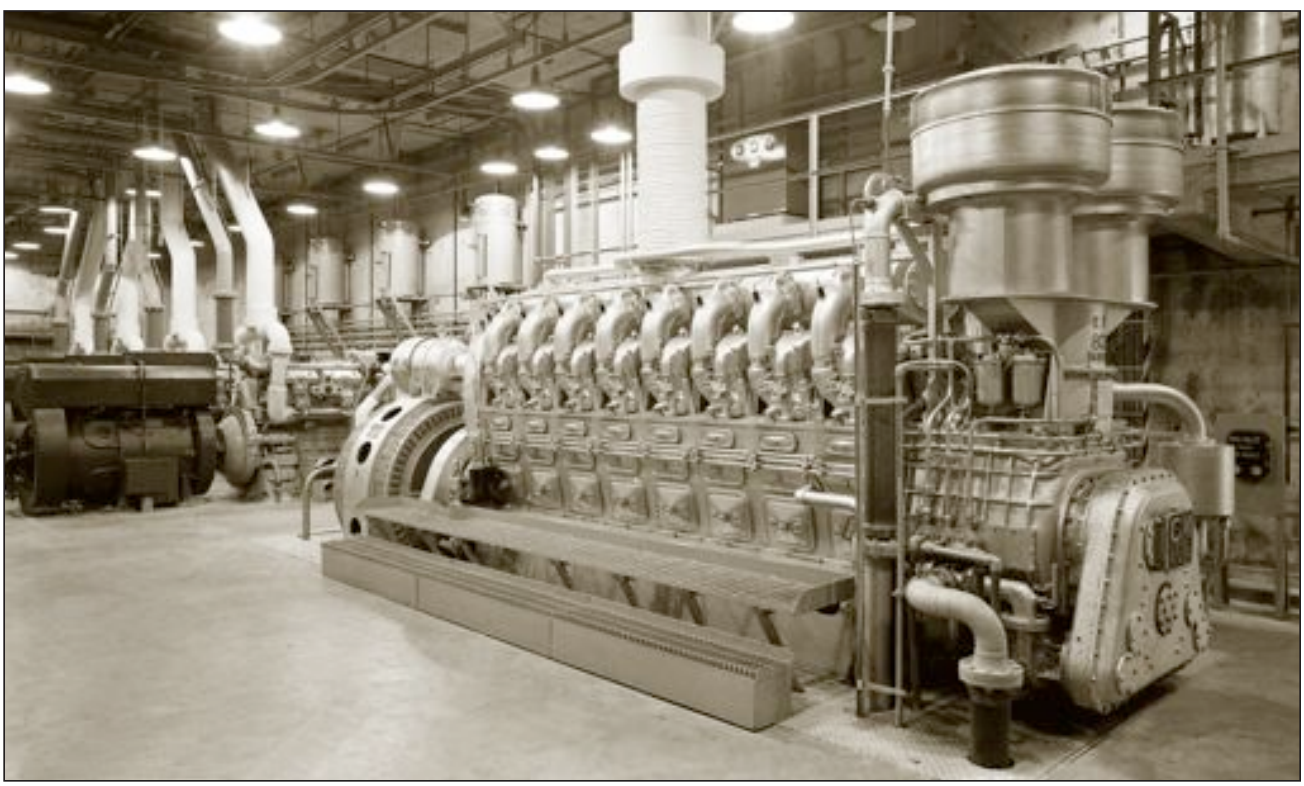


Drawing of Building 108-1R, Diesel Engine House, done by Gibbs and Hill.



Building 108-1R Under Construction, SRS Negative 1-892.

Building 108-2P, Engine House, as Seen from Surface, October 2, 1953, SRS Negative DPESF 1-1017.



Building 108-R Interior, Showing Diesel Generators, October 12, 1953, SRS Negative DPESF 1000-36.

Each 108 building housed four sets of 170 horse-power (103 KW) diesel engine generators that operated at 900 revolutions per minute (rpm). These four generators were designed to provide emergency direct-current (DC) power to the DC motors that were connected to the same shaft as the primary AC motors, which were in turn connected to the heavy water pumps in the reactor building. These DC motors were always running during the operation of the reactor, so they would be ready in case of power failure. Each 108 building also contained one 1000-kilowatt diesel generator set, which powered an AC generator that provided emergency electricity for various auxiliary functions, as well as emergency lighting in both the reactor and the 108 buildings. In either case, this emergency power could go directly to the reactor/108 buildings or be routed through the two reactor substations, as needed.[23]

In addition to these generators, each 108 building housed two 10,000 gallon diesel fuel storage tanks, two air compressors rated at 480 cubic feet per minute, and several other pieces of equipment related to the maintenance of the diesel generators and air compressors. (Gibbs and Hill 1954 v.3:105).

The 108 buildings were blast-proof, Class I constructions, rectangular in shape and measuring approximately 102 feet by 49 feet by 20 feet deep on the main operating floor. A basement section at 29 feet below grade was situated under the 1000 KW diesel generator and measured 40 feet by 28 feet. The entire structure was constructed of reinforced concrete, with some interior partitions being concrete block. An open well, 35 feet by 21 feet, sat at one end of the structure. Equipped with a jib crane, this area provided an area to move heavy equipment in and out of the building. As it was an underground structure, there were no windows; however, there was one blast-proof exterior steel door that provided access into the structure from the access pit.

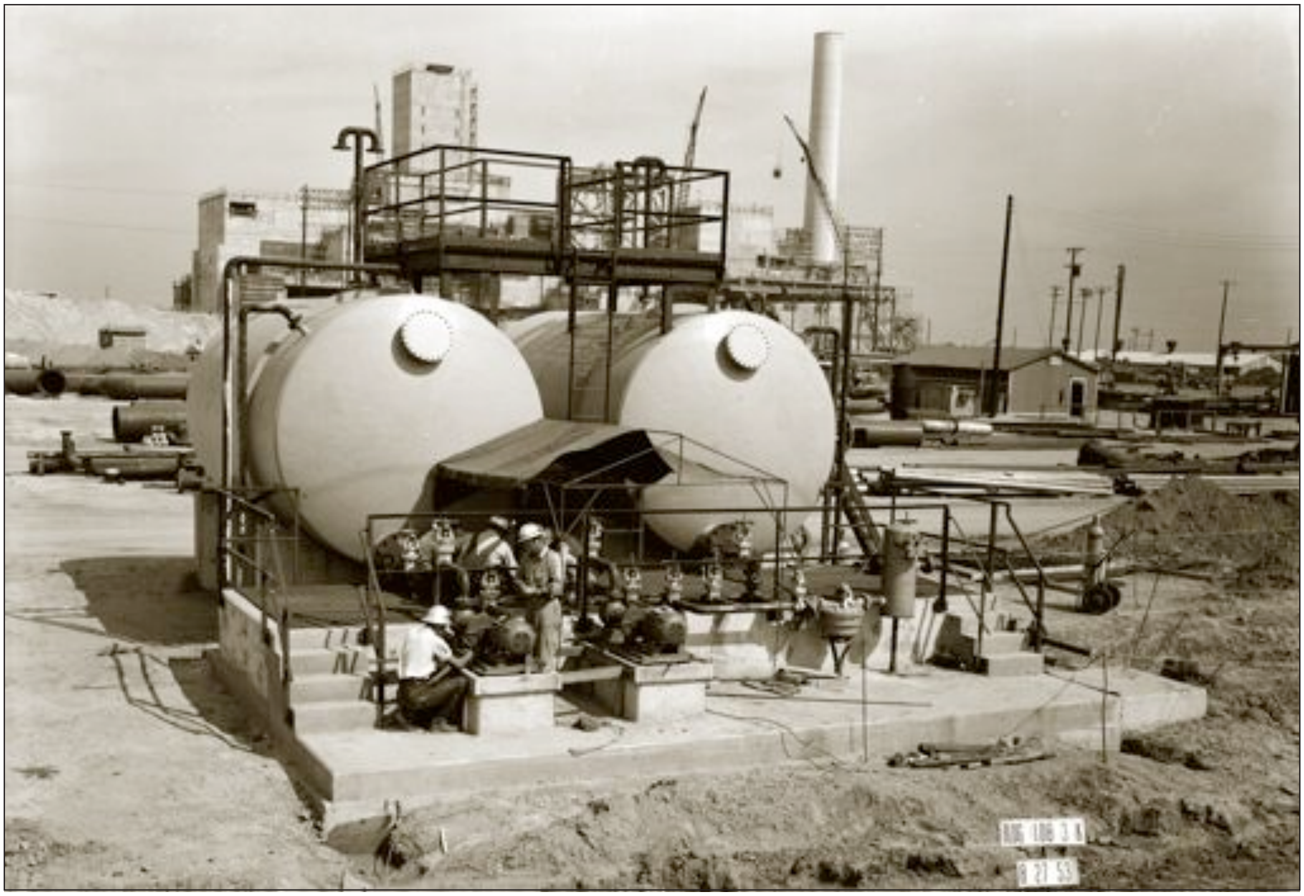
As with so many other things in the reactor areas, there were modifications in the design of the 108 buildings from those built in R and P to those in L, K, and C. Nevertheless, their function, equipment, and basic design scheme remained the same. [24]

108-3 - Fuel Unloading Facilities (CKLPR)

Building 108-3P, Fuel Unloading Facilities After Completion, October 2, 1953, SRS Negative DPESF 1-1018.

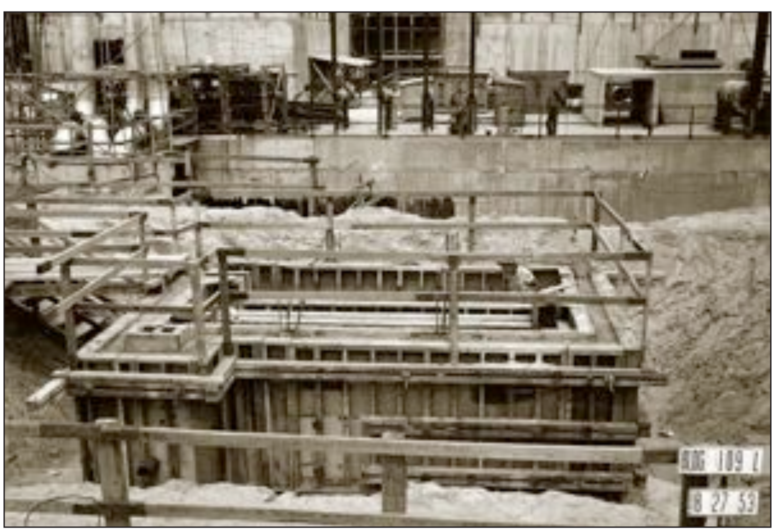
All diesel fuel that was to be used in the 108-1 and 108-2 buildings was unloaded from rail or truck via this facility. It is held here temporarily for sampling, then transferred to the main storage tanks of the 108 Engine Houses. Each 108-3 structure is equipped with pumps for unloading fuel, two 10,000 gallon storage tanks, two fuel oil transfer pump to deliver oil to the main storage tanks, as well as related equipment.

The 108-3R and P facilities were rectangular, measuring 23 feet by 22 feet by 16 feet deep, and completely underground. They were Class III constructions, built entirely of two-foot thick reinforced concrete. Also included within this complex were the adjoining railroad car unloading facilities, the truck and trailer unloading facilities,



Building 108-3K, Fuel Unloading Facilities, August 27, 1953, SRS Negative DPESF 1-956.

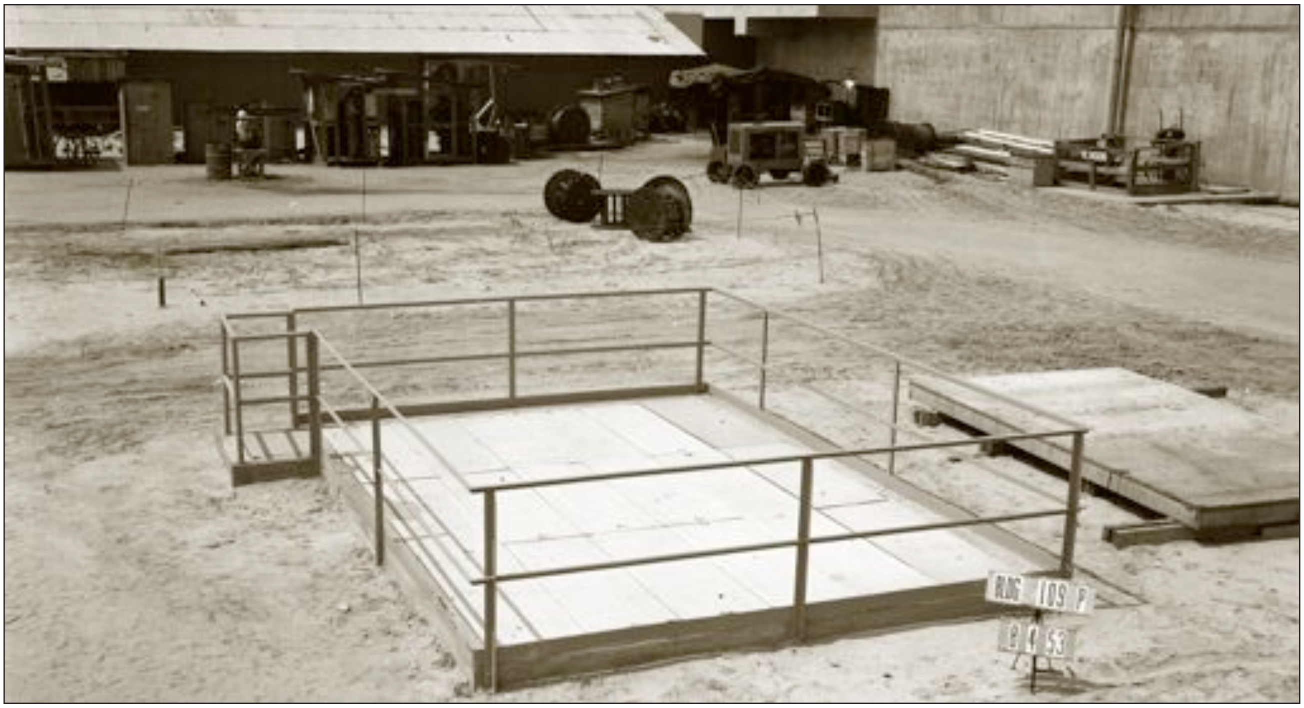
and storage and transfer facilities. An earthen waste oil pit, approximately 50 feet square and 6 feet deep is also a component of this facility.[25] In L, K, and C, the 108-3 facility was above ground and consisted of two 10,000 gallon tanks sitting on saddles, adjacent to a concrete pad.



Building 109-L, Purge Water Storage Basin Under Construction and Prior to Burial, August 27, 1953, SRS Negative DPESF 1-950.

109 – Purge Water Storage Basin (CKLPR)

Building 109, or the Purge Water Storage Basin, was designed to hold de-ionized water discharged from the reactor building reactor shield cooling system until it could be safely emptied into the sewer. Water would flow through a series of baffles for approximately 12 hours, during which time the half-life of the radioactive material would have dissipated. At that point, the water could be released to the sewer. The rectangular basins measure 13 feet by 19



Building 109-P, Purge Water Storage Basin After Completion, August 4, 1953, SRS Negative DPESF 1-944.

feet, with a depth of 7 feet. Concrete thickness is 10 inches for exterior walls and 12 inches for the floor; the volume capacity is 1740 cubic feet. The basin cover is removable in order to facilitate cleaning is and composed of three 2 3/4 inch precast concrete tiles. A handrail sits atop the basin walls. The 109 basins were identical in all of the reactor areas.[26]

Building 110-C, Gas Storage, After Completion, October 26, 1953, SRS Negative DPESF 1-1044.

110 – Gas Storage (CKLPR)

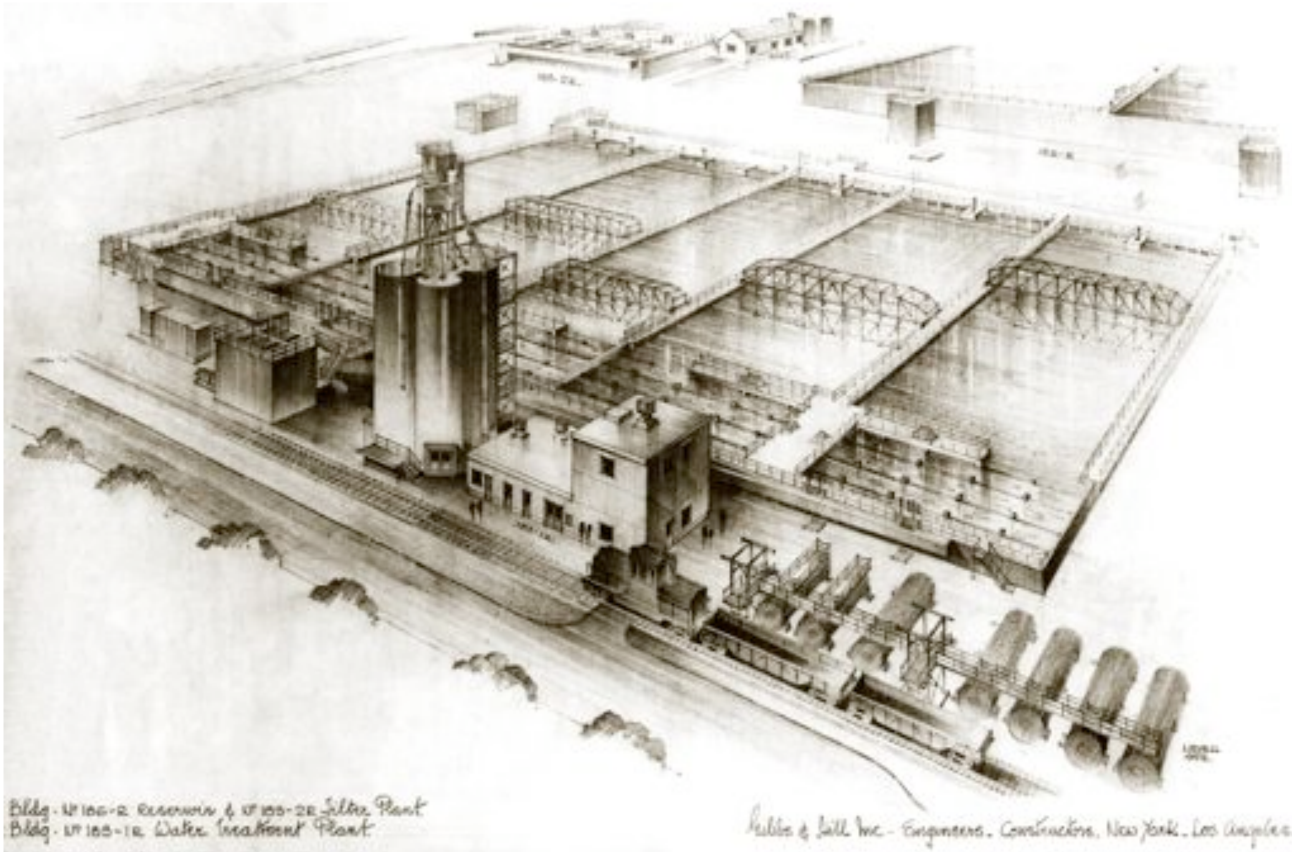
Building 110 served as the storage facility for the helium blanket gas supply that would be used in the reactor building. In R area, this facility consisted of 30 gas storage tanks set on concrete piers, capable of providing 300,000 standard cubic feet (scf) of helium at 700 pounds per square inch pressure. Considered part of this facility was a small compressor house of Class III construction measuring 12 feet by 20 feet; its walls rose to a height of 12 feet, 10 inches. The foundation was reinforced concrete and structural steel framing supported the walls and double-pitched roof. Exterior walls and roof were sheathed with corrugated cement asbestos board. Instrumentation in this facility consisted of various pressure valves and gages and temperature indicators. The compressor house was the same in each of the reactor areas, but the storage area was reduced to 60,000 scf for P area; this modification was followed in all subsequent 110 buildings.[27]

122 – Process Storage Building (R)

The Process Storage Building or Heavy Water Storage Building served as a storage vault for 55-gallon drums of heavy water, brought in on pallets from either the Dana Plant or Savannah River's own 400 Area. This Class I building measured 45 feet by 105 feet 9 inches, had a height of 14 feet 10 inches. Foundations, walls and floor were all composed of reinforced concrete. The building is accessed by one of two motor-driven rolling steel doors at either end. It was designed to hold up to 110 pallets in plan, stacked three pallets high—each pallet holding four drums. This translated into a capacity of over 1,300 drums, enough for a complete charge of any one reactor. This type of facility was only found in R Area.[28]

Building 122-R, Process Storage Building, Right Center, with Door Open,Negative (4 x 5 inch) 122R-002.

Building 122-R, Process Storage Building, Right Center, with Door Open, Negative (4 x 5 inch) 122R-002.



Drawing of Building 183-1R Clarification Plant Basin, by Gibbs and Hill.

Building 183-1R, Clarification Plant Basin, Nos. 1 and 2, Showing Basin Baffles and Paddles, SRS Negative DPSPF 5976-08.

183-1 – Clarification Plant (Cooling Water) (R)

This facility was constructed expressly for the clarification of raw river water, which was to be used in the reactor heat exchangers. Experiments at CMX eventually determined that chlorinated water was preferable to clarified water; hence, the 181-1R facility was the only one of its kind built onsite.

The clarification issue was considered critical because the clarity of the river water at Hanford, during the Manhattan Project, had proven to be a problem. There, water from the Columbia River was found to leave a film that had to be treated chemically in order to maximize the effect of the cooling water. Du Pont did not want a similar situation to develop at Savannah River. Testing facilities were established at CMX on the Savannah River to determine the condition of the river water, but the entire project was considered so urgent that the first reactor, R, was built with the assumption that the river water would have to be clarified before it could enter the reactor building. By 1952, testing at CMX determined that the natural grit of the Savannah River would prevent the build-up of any film.

The 183-1R facility had three basic components: a chemical building, chemical storage facilities, and clarification units. The chemical building was equipped with a lab, an office, change room, air compressors, and chlorine-feeding equipment. The chemical storage facility was basically a series of tanks that held lime, alum, chlorine, sulphuric acid, and sodium silicate, all to be used in the clarification process. The clarification units included a stilling chamber, a chemical mixing chamber, flocculation basins, and settling basins.

Building 183-1R, Chemical Building, c. 2000, Negative (4 x 5 inch) 183-1R-004.

River water was delivered from pumping stations on the Savannah River via two 72-inch pipes. The plan was to treat the raw river water so that that it had a low level of turbidity, not greater than five parts per million. Once in the clarification units, the river water was subjected to a series of mixers. There were four high-speed

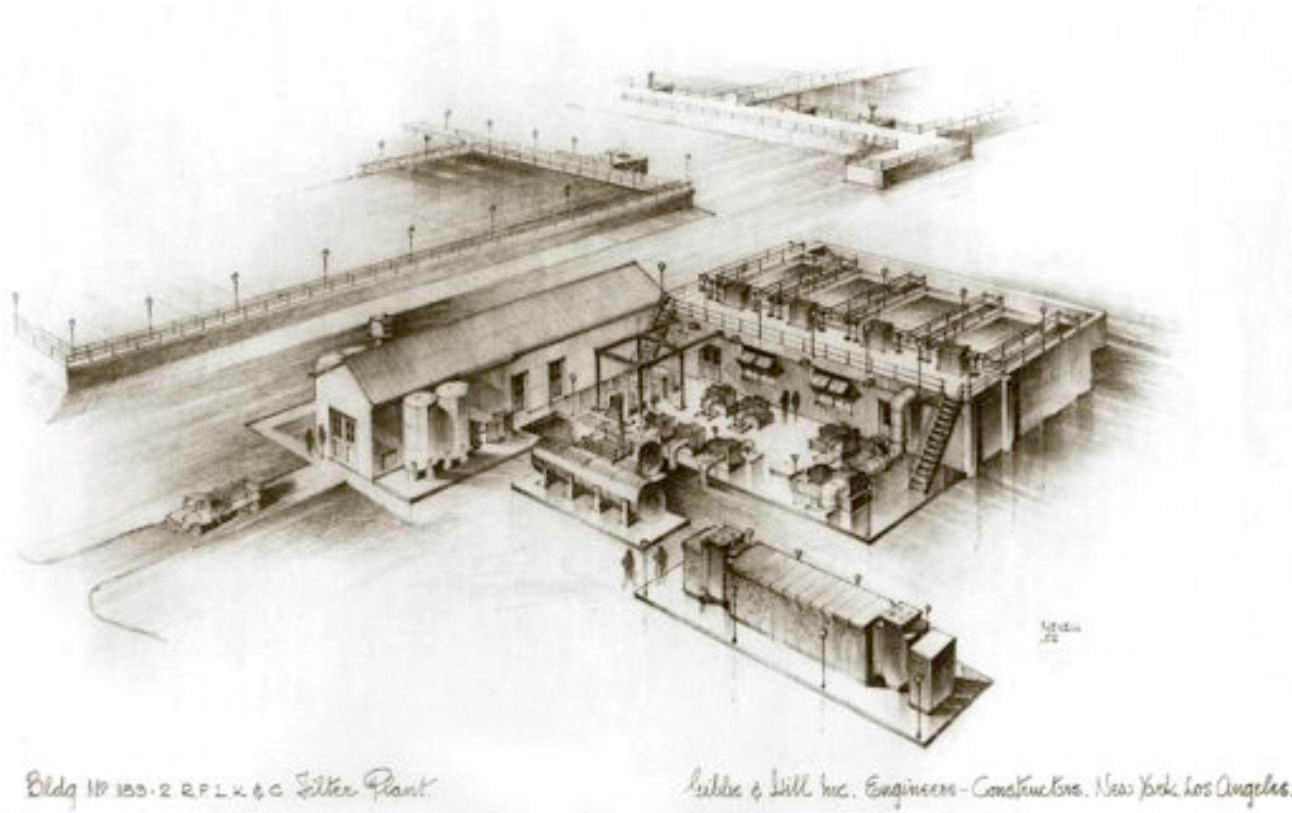
Laying Concrete Pipes for River Water, P Area, January 11, 1954, SRS Negative M-3244-8.

mixers for flash-mixing, and others for the chemical treatment. Flocculator tanks were provided for low-speed paddle agitation. After the suspended solids settled out of the water, they were removed by means of mechanical scrapers. The water then traveled by gravity flow to the huge 186 reservoir by way of two 84-inch pipes. A 30-inch pipe took some of the water to 183-2, which was the Filter and Softener Plant. It is interesting that the piping was designed so that river water could be sent directly to the 186 reservoir, bypassing 183-1R, just in case CMX demonstrated that the 183 clarification basin was not actually needed, which of course it did.[29]

The entire 183-1R facility was a Class III construction. The chemical building was rectangular with a three-story section and a one-story section. The foundation was reinforced concrete with spread footings; the frame was structural steel sheathed with corrugated cement asbestos board and the roof was a built-up concrete and slab supported by girders. Four concrete silos, adjacent to the chemical building, stored chemicals for the clarification process. For the most part, the clarification unit was also constructed of reinforced concrete.[30]

183-2 – Filter & Softener Plant (CKLPR)

The 183-2 facility is the only 183 facility actually found in all five reactor areas. These facilities were constructed to supply chlorinated filtered water to the entire area for domestic use and to the reactor buildings for operational use. Additionally, the 183-2 plants supplied softened water to the boilers in the184 Powerhouses.

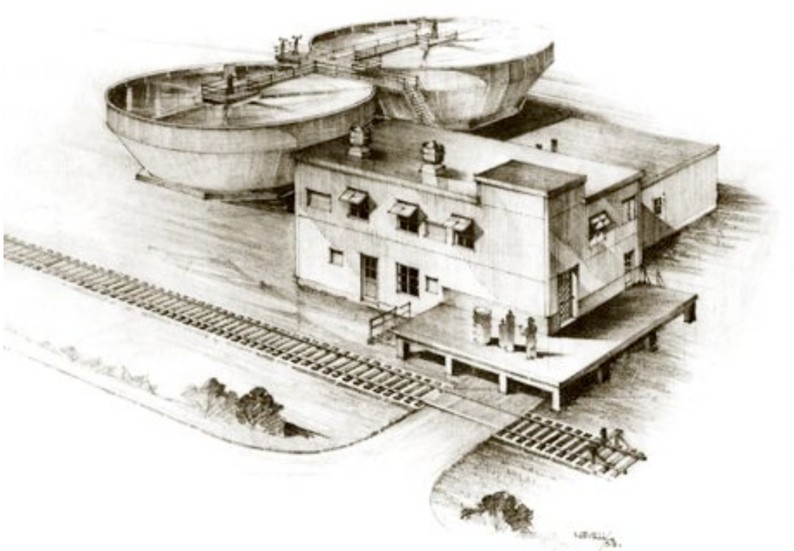


Drawing of Building 183-2, Filter and Softener Plant, by Gibbs and Hill.

Building 183-2K, Filter and Softener Plant, After Completion, March 31, 1954, SRS Negative DPESF 1-1188.

As the name suggests, there were two major components to this facility, a filter plant and a softener plant. The filter plant was constructed of reinforced concrete and included four filters, each 13 feet by 25 feet at an average depth of 12 feet, as well as an adjacent gallery and partitioned clear well. The clear well had a 38,000-gallon capacity tank for domestic water and a 92,000-gallon capacity tank for operational water. The softener and silica absorber building was a Class II construction. It was rectangular and measured 67 feet by 14 feet in R area and slightly smaller in the other areas. The foundation was a reinforced concrete mat, on which sat a steel frame sheathed in corrugated asbestos board. The roof peaked at 14 feet. Windows were commercial steel sash and doors, hollow metal.[31]

183-4 – Clarification Plant (CKLP)



Drawing of Building 183-4, Clarification Plant, by Gibbs and Hill.

The 183-4 building, found at P, L, K, and C, provided clarified water for 183-2. Although the decision had been made that large quantities of raw river would not need to be clarified for use in the heat exchangers, clarified water was still needed for use in the 183-2 Filter & Softener Plants. The resulting design was a clarification facility with a capacity of 4,000 gallons per minute. The 183-4 plants were supplied with raw river water from the 186 reservoirs, which entered the clarification process consisting of chemical feeding, flash mixing, flocculation, and floc removal.

Building 183-4K, Clarification Plant, August 9, 1955, SRS Negative DPESF 1-1268-02.

Building 183-4, Clarification Plant Precipitators and Chlorine Tanks, August 9, 1955, SRS Negative DPESF 1-1268-8.

Building 183-4, Clarification Plant Precipitators and Chlorine Tanks, August 9, 1955, SRS Negative DPESF 1-1268-8.

The major components of the plant included a chemical building, two precipitators, four transfer pumps and two chlorine storage tanks. All of the 183-4 facilities were of Class III construction. The chemical building was irregular in shape, with one-story and two-story portions. It has a reinforced concrete foundation, structural steel frame sheathed with corrugated asbestos siding, a flat concrete slab roof, and an area of 2940 square feet. Two Spaulding precipitators, with a capacity of 2000 gallons per minute each, were provided for clarification. Each precipitator consisted of a steel tank 14 feet high with a top diameter of 55 feet and a bottom diameter of 41 feet. These large aboveground, round tanks were this buildings' most distinctive feature. Transfer pumps were provided to supply raw water from the 186 reservoirs and deliver clarified water to the reactor buildings. The two chlorine tanks at the facility were located adjacent to the chemical building. The tanks' capacity was 14,900 gallons of liquid chlorine each, which would supply both the 183-4 buildings as well as the 186 reservoirs.[32]

Building 186-C, Cooling Water Reservoir During Late Construction Period, June 29, 1953, SRS Negative DPESF 1-892.

186 – Cooling Water Reservoir (CKLPR)

These massive open reservoirs stored river water used for cooling in the reactor buildings, as well to meet service water requirements throughout the area. These facilities were found in each of the five reactor areas, and were located directly beside the 190 pump houses and adjacent to the reactor buildings. Its enormous size is testament to the crucial importance of a constant source of cooling water for the reactors. Designers wanted to ensure a continued flow to the reactors even in the event of a malfunction of the water delivery system from the river.

Close-up of 186-C Cooling Water Reservoir, with Reactor in Background, no date, SRS Negative DPESF 1-1221.

The overall reservoir measured 250 feet by 800 feet, with a depth of 18 feet. The reinforced concrete basin was divided into three equal storage compartments, each measuring 266 by 248 feet, and separated from its neighbor by a concrete dividing wall with sluice gates. In addition to the storage compartment, each section of the basin has an inlet chamber, overflow facility, and drain box. The center basin was also equipped with a pump suction pit for the 190 pumps, which directly connected the 186 reservoirs to the reactor buildings. The total capacity of the entire facility was around 25 million gallons, enough to provide emergency cooling water to the reactor for about six hours at normal power, or for 10 days under shutdown conditions.[36]

Building 186-K Cooling Water Reservoir, Showing Choppy Water in the Basin, October 12, 1953, SRS Negative M-2959-06.

Building 188-L, Ash Disposal Basin, October 26, 1953, SRS Negative DPESF 1-1057.

188 – Ash Disposal Basin (KLPR)

These facilities functioned as settling basins for the ash discharged from the 184 powerhouses. They were basically shallow pits surrounded by an earthen dike. They ranged from 11 to 20 acres in size and 12 to 16 feet in dept. The top elevation of the dike was maintained throughout its total length.

The ash was delivered through a sluicing system elevated pipeline. The ash would settle in the basin, while the sluicing water drained out through a line installed at the lowest elevation of the basin. The basins had a storage capacity of several million cubic feet of ash and were designed to serve their purpose for up to ten years.

190 – Cooling Water Pump House (CKLPR)

The 190 buildings were designed to deliver cooling water to the heat exchangers in the reactor buildings, and service water to the other parts of the reactor building. They also supplied service water to most of the other buildings in the reactor areas.

Building 190-L, Cooling Water Pump House, Nearing End of Construction, March 25, 1953, SRS Negative DPESF 1-795.

The two principal components of the 190 buildings were the pump house and the switch gear room. The first was a Class III construction, measuring 214 feet by 44 feet, with reinforced concrete foundation and walls. The most distinguishing elements of this portion of the building were the four large roof ventilators atop its peaked roof. The switchgear room was a Class I construction, measuring 137 feet by 20 feet, with a flat roof of concrete; this portion of the building was partially underground.

Building 190-R Interior, September 16, 1953, SRS Negative DPESF 1-971-02.

Inside the pump house were eight large centrifugal pumps driven by 600-horse-power AC motors. Each pump was capable of delivering 14,000 gallons per minute of river water. Each also had a flywheel to reduce the flow slowly in case of power loss. Only six pumps operated at a time; two were spares. In addition to the main pumps, there were also another four smaller pumps that could provide 3,000 gallons per minute of service water. In case of an emergency or some electrical failure, the 190 pumps were designed so that gravity flow would still supply water to the reactor building.

The 190 building was critical to the overall function of the water system in each of the reactor areas. To help analyze the proper flow of the water system, Du Pont asked VWF&S to prepare a series of isometric drawings for the R Area water system in the spring of 1952. It was from these that the final arrangement of pipes was determined for the 190 buildings in R and the subsequent reactor areas. [37]

Building 701-1K, Area Gate House and Patrol Headquarters, August 9, 1955, SRS Negative DPESF 1-1268-13.

701-1 – Area Gate House & Patrol Headquarters (CKLPR)

Located at the outer perimeter security fence, the 701-1 buildings were the first buildings encountered at each of the reactor areas. It was the central headquarters for the area patrolmen and served as the primary control point for all traffic into and out of the 100 Areas. Pedestrians would enter the building on the outside of the area fence, walk through the badge alley where their credentials would be checked, and then exit the building through the "back" door inside the area fence. Several hundred area workers would pass through this building twice daily, once on the way to work and again on the way out. The building also served communications hub for the entire area.

All five of the 701-1 buildings were single-story, combination Class I and Class III constructions. The Class I wing, approximately 23 feet by 51 feet, housed emergency control and communications equipment. A small Class I unit, 8 feet by 8 feet, was attached to this wing and housed a generator. The Class III portion, approximately 48 feet by 64 feet, housed the health metering area, patrol offices, lunchroom, storage area, locker and toilet rooms. The top of the flat roof slab was 11 feet above grade.

The entire building's foundation was reinforced concrete and the Class I portion's exterior walls and roof was constructed with the same material, in order to ensure the continued operation of the vital communication facilities during an emergency situation. Interior walls in this section were concrete baffle. Doors were hollow metal and there were no exterior windows. The Class III portion had a structural steel frame sheathed with corrugated asbestos board. The roof of this portion of the building was concrete slab on rib lath. Interior walls were flat cement asbestos board on steel studs. Doors were hollow metal and windows, double-hung steel.[38]

701-2 – Gate House (CKLPR)

These facilities provided an additional security checkpoint for pedestrian and vehicular traffic entering the security zone around the reactor building. They were small, rectangular, single-story Class III constructions. 701-2R and 701-2P measured 10 feet by 15 feet, while the 701-2 buildings in L, K, and C were slightly larger at 13 feet by 17 feet. The foundations of these buildings were reinforced concrete; the frames were fire-retardant treated wood sheathed with corrugated asbestos board. Doors and double-hung windows were all wood. A two-foot roof overhang provided weather protection for the guards on duty.[39]

Building 701-2K, Gate House, August 9, 1955, SRS Negative DPESF 1-1268-06.

Building 704-L, Office and Shops Building, Change House, and Stores, March 25, 1953, SRS Negative DPESF 1-801.

704 – Office and Shops Building, Change House and Stores(CKLPR)

Building 704 served as the area administration headquarters, providing 22 offices and a conference room for area operating and maintenance personnel. Additionally, it housed a cafeteria, medical center, stores facility, and maintenance shop. A service island located outside of the shops section of the building provided gasoline and tire service for area vehicles.

Building 704-L, Office and Shops Building, Change House, and Stores, July 7, 1953, SRS Negative DPESF 1-928.

Building 704-L, Showing Workers in the Maintenance Area, September 24, 1956, SRS Negative DPSPF 3728-2-04.

These were Class III single story, L-shaped buildings, with one leg measuring approximately 73 feet by 170 feet and the other 39 feet by 161 feet. The total area was around 18,500 square feet. The foundation was reinforced concrete, while the superstructure was structural steel. The exterior walls were corrugated cement asbestos board and the roof was a flat concrete slab.

Building 704-R was the first of these buildings to be constructed, and the 704s at P, L, and K were built identically. The 704-C building's office wing provided space for twelve additional offices, which housed supervisory personnel engaged with work that concerned all of the reactor areas. The 704 buildings were also among the first to be air conditioned, beginning in 1953.[40]

706 – OFFICE BUILDING (C)

This building, later known as the Reactor Technology building or Reactor Tech, housed the Works Technical Division and was only found in C Area. It was a one-story, Class III prefabricated steel building originally used as a Temporary Construction (T.C.) building. It measured 50 feet by 300 feet and sat on a concrete slab foundation.

Building 706-C, Office Building, later known as the Reactor Technology Building or Reactor Tech, May 9, 1969, SRS Negative DPSPF 13402-02.

711 – Steel and Pipe Storage (CKLPR)

The 711 buildings were located adjacent to the 704 buildings, and provided storage space for the steel and pipe needed for maintenance and repair. They were Class III constructions that covered an area 20 by 34 feet. The foundation was concrete. The superstructure was wood frame, with corrugated cement asbestos board forming the exterior walls. Much of this structure, however, was open on the sides. This shed-like building was identical in all five reactor areas.[41]

Building 711-K, Steel and Pipe Storage Shed, March 24, 1953, SRS Negative DPESF 1-992.

V. GENERAL REACTOR BUILDING AND ASSEMBLY AREA

Despite the differences among the reactor buildings, from a distance they looked alike. One former supervisor described the reactor buildings as "resembling a very large stacked collection of children's blocks."[1]

All five reactors were basically similar in what they did and how they did it. The reactor buildings themselves were all devoted to the production of fissionable materials, made in heavy water moderated and cooled reactor tanks. To this end, each reactor building, in addition to the reactor and the reactor machinery, had facilities for the assembly and storage of components that went into the reactor, facilities for the storage and disassembly of the discharged components, as well as facilities for the purification of the moderator and the blanket gas.[2] All five reactors shared what have commonly been identified as the system's most unique features: the reactor tanks themselves, the vertical lift steel doors, the actuator system above the reactor tank, and the charge and discharge machines, often referred to as the C and D Machines, for short.[3]

The five reactor buildings all shared the same basic divisions, even if the layout was different. Everything began in the Assembly Area, where the vertical elements that would go into the reactor first entered the building. In Assembly, the vertical elements were cleaned, loaded into their proper aluminum casings or tubes, and then stored. As needed, these elements were taken out of storage and "presented" to the Process Room. There, a charging machine or crane would seize the element and place it in the reactor tank. The reactor tank was naturally the focus of the process room (also known as the reactor room), but it was also the focus of a much larger area, known as the Process Area. Every piece of equipment that directly served the reactor was located in the Process Area. This included the pumps and heat exchangers, and the entire cooling water system; the actuator tower above the reactor tank; the reactor control room and crane control room; and the Personnel areas adjacent to the control rooms. After a period of time in the reactor, the irradiated vertical elements were removed from the tank by the discharge machine. They would then go to Disassembly. There, the irradiated materials were removed from their claddings and prepared for shipment to Separations. Last but not least, the purity of the heavy water moderator and the helium blanket gas, both essential for the operation of the reactor, was maintained in the Purification Area.

In the chapters that follow, each of these reactor building areas will be examined in much greater detail, beginning with this chapter, devoted to the Assembly Area. The other chapters will deal with Process Area, Disassembly Area, and Purification. Because of the differences among the five reactors, it is not possible to single out any one reactor as a stand-in for the others. Rather than try to do so, it might be more logical to follow the method normally used at Savannah River: use the first reactor, R, as the focus of the discussion, and then discuss the later reactors in terms of how they differ from R. This will be the method used here.

The reactor buildings, despite their monumental architecture, were essentially envelopes providing housing for the numerous and complicated equipment needed for reactor operations. In fact, much of the building was designed around this equipment. In R Area, the shift in emphasis from building construction to equipment installation took place as early as the fall of 1952.[4]

Everything at Du Pont's Savannah River Plant received a number, whether it was a reactor area, a reactor building, or the auxiliary reactor area buildings. The same was true for the equipment installed in the reactor areas. Every piece of equipment used at Savannah River was assigned a number, usually called an "E.P." number, short for "Equipment Piece." Just as there was a system to the organization of the building numbers, so there was a system to the E.P. numbers.[5] Table 10 shows how the equipment numbers were assigned within the reactor building as well as more general designations.

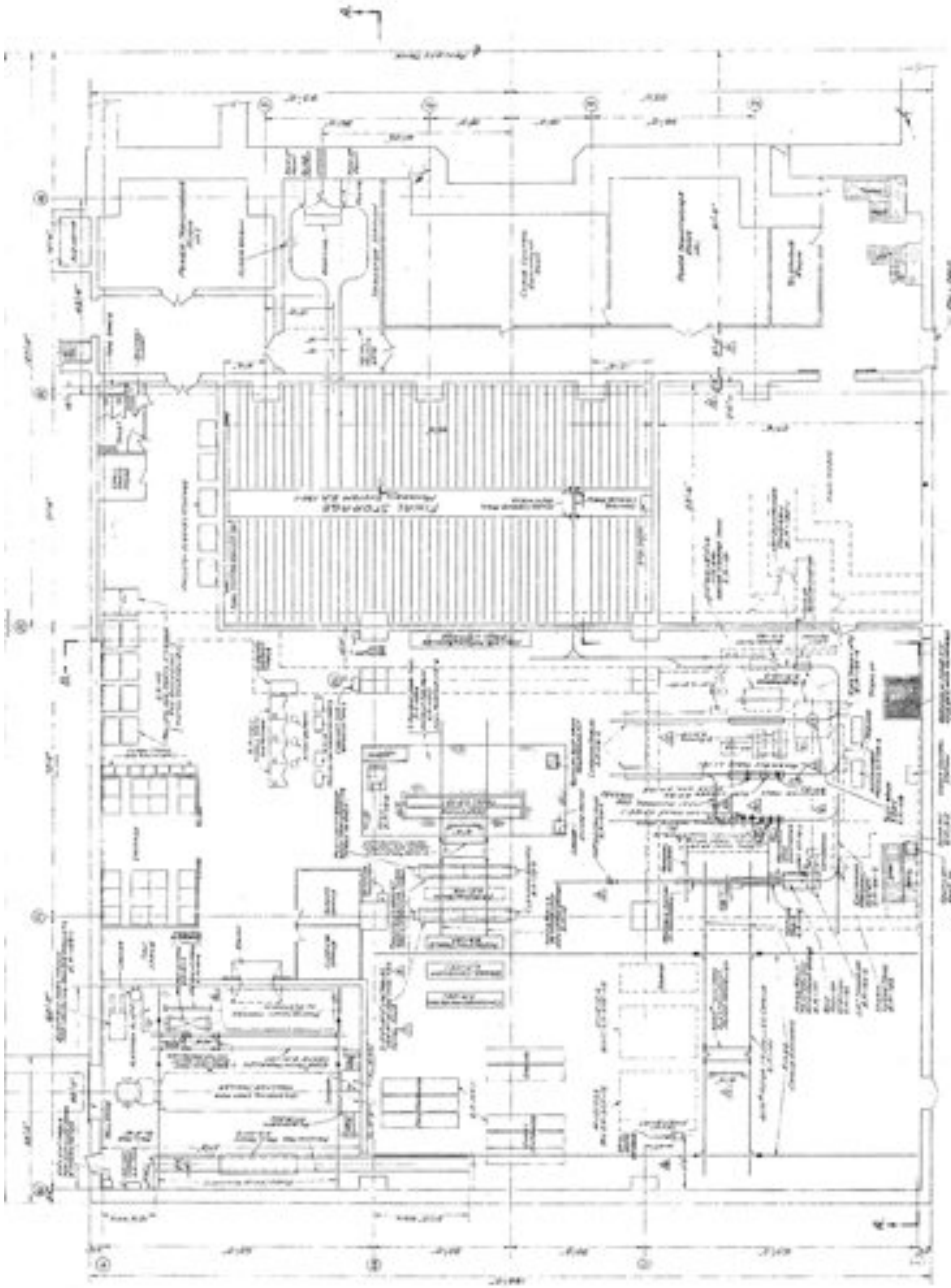
Table 10. Equipment Numbers and Function

E.P. Nos.	Functions
100-149	Assembly Area
150-199	Main Reactor Tank and C and D Facilities
201-239	Coolant Circulating System and Auxiliaries
240-299	Gas Purification; Coolant Recovery and Purification
301-399	Disassembly, Storage and Transfer
400-499	Instrumentation (including panels in Reactor Control Room)
500-599	Electrical
600-699	A&C
701-799	Administrative and Maintenance
800-899	Power

The lowest E.P. numbers belonged to the Assembly Area, where all materials to be irradiated must first enter the reactor building. Since everything in the reactor buildings has to begin in Assembly, any discussion of the reactor process should begin here.

ASSEMBLY AREA

The purpose of the Assembly Area was to receive, clean, assemble, and test the various elements that eventually go into the reactor. This area was kept as clean as possible, with radioactivity kept to a minimum. No irradiated materials were allowed into the area, and all materials were required to be as clean as possible to reduce the chance of dirt going into the reactor. In the early to mid-1950s, most of these elements that went into the reactor were fuel elements assembled into quatrefoils. After the final testing, the loaded quatrefoils went into final storage before leaving Assembly.[6] All of these operations are discussed below in greater detail.



Key Plan Arrangement for Assembly Area, R Reactor, Showing Receiving Area, Work and Inspection Areas, and Final Storage. SRS Engineering Plan W130770.

The first plans for the Assembly Area of the reactor building go back to early 1951, at which time it was not exactly clear which part of the assembly process would be completed in the 300 Area, and which in the 100 Areas. Initially, it was suggested that the elements to be irradiated should be assembled in groups and then transported out of the reactor in the same way. This would have required the use of a car-handling system, and it was not clear how such a car would move between the Assembly and Process areas without spreading radioactive contamination into the Assembly Area.[7]

After February 1951, it was decided to proceed with a more individualized form of fuel handling that required quatrefoils. From about that point on, it was determined to have all assembly functions occur in the 100 areas. This meant that the Assembly Areas in the reactor buildings would now be a production line to prepare quatrefoils for the Process Area. In the early 1950s, this meant that all materials to be irradiated were sent over from 320-M in aluminum sheaths. This included natural uranium fuel slugs and lithium-aluminum control rod sections. In the Assembly Areas, the fuel slugs were inserted into quatrefoils, the four-channeled aluminum tubes that were inserted into the reactor, while the lithium-aluminum went into septifoils, seven-channeled aluminum tubes.[8]

It was initially thought that the Assembly Area would process over 2500 quatrefoil assemblies per year. This made it imperative that the assembly and storage process be mechanized as much as possible. By May of 1951, the preliminary plans for the Assembly Area called for four bays, each with around 60 by 186 feet. At that time, loading of the assemblies was to be done vertically from a mezzanine level. This proposal, however, had problems. There was too much lifting of the materials, and there were concerns that the roof was not high enough for vertical loading.[9]

In June of 1951, the assembly area design was close to what would actually be built. Provisions were made for the loading and testing of the tubes. The tops of the tubes would be at the main floor level, with the rest of the tube extending below the floor slot and into the basement, which was 20 feet deep. Plans for the monorail were completed, and the places where the monorail entered the final storage area and the reactor room, were to be sealed by sliding steel doors. At that time, the proposed assembly area was 255 feet long by 180 feet wide.

By July of 1951, the Assembly Area was into its third design plan. By this point, the plans were basically "as built." The whole Assembly Area covered 35,000 square feet, or 186 by 191 feet in area. It was equally impressive in its size from floor to ceiling to accommodate the assemblies. Generally, the roof height was 44 feet above grade with one section of the area ten feet lower.[10] Earlier plans had called for a much larger area of 90,000 square feet. The main reason for the size reduction was the use of quatrefoil tubes and other vertical elements that could be brought into the Process Area one at a time by means of a monorail. Other reasons included the elimination of permanent sleeves for the assemblies, which allowed a reduction in storage space.[11] By this time, the Assembly Area in R Reactor had been divided into the following sections: the Receiving Area, Fan Room, the Working and Storage Area, the Final Storage Room, the Gripper Pick-Up Station and the Presentation Point.[12]

Receiving Area

The Receiving Area of Assembly was located in the southeast corner of the reactor building. It was the entry point for all materials into the building, with materials brought into the building by means of trucks, which had to be washed before entering the premises.[13] In the R Receiving Area, supply trucks were unloaded with a two-ton monorail bridge crane (E.P. 100), which could move boxes in and out of storage as needed. The pick up frames designed to be used with E.P. 100, were identified as E.P. 101, 102, and 104.[14] In R, the monorail bridge crane took the shipments to a tube box dolly on rails; in all later reactors, the crane could transport the boxes directly to the storage area.[15]

The materials received were usually fuel elements or control rod elements. Fuel elements, all made of natural uranium in the early days, came in as "slugs." These were solid uranium cylinders, one-inch in diameter and eight inches long, clad in aluminum. These were stacked into columns in quatrefoils, that were often referred to as "Q-foils." Each of the four channels of a Q-foil was stacked with slugs. Each quatrefoil went into a four-inch diameter hole, and there were over 600 such holes at the top of the reactor.

Control rod elements were slender and long, about 21 feet in length. Made of lithium-aluminum in the early and middle 1950s, they too were sealed in aluminum cladding and were inserted into a septifoil. For this reason, control rods were often referred to as S-foils or S-rods. Sometimes a septifoil was also referred to as a "cluster" of control rods. There were 61 clusters or septifoils for each reactor tank.[16] In the Assembly Area, both Q-foils and S-foils were often just referred to as "foils."

Fan Room

The Fan Room in the Assembly Area was only found in the R and P reactor buildings. Even there, its function was not specifically related to the Assembly Area; in L, K, and C reactors, this fan room was relocated to other parts of the reactor building. In R and P, the fan room contained machines to bring outside air to the assembly area, and moved air from the main assembly area into the final storage room. It also provided air to the crane control room inside the process area. In addition, there were two refrigeration units and two pumps for providing chilled water throughout the reactor building.[17]

Working and Storage Area

The main activity in the Working and Storage area of Assembly was the cleaning and loading of the foils, their testing, and their storage until needed in the Process Room. Initially, the materials brought over from 300 Area are stacked on the floor or on pallets. The main part of the working area had space for inspecting and cleaning all the components that had to go into the reactor. This included the slugs, the control rods, and all of the foils. After the materials have been placed into their proper foils, they must be tested to insure proper water flow through the assemblies. The final assemblies were then stored on hangers and went to Final Storage. The assemblies stayed there until needed in the reactor room.[18]

Crucial to all of these operations were the two-ton crane and the monorail system. The two-ton, twin-hook crane was capable of accessing the work and storage areas, and could reach the degreaser hoist, the test stations, and the tipping tables.[19] It was also tied to the monorail system, which moved the vertical elements into Final Storage by means of storage hangers, and then moved them out again as needed in the reactor room.

General View of Assembly Area, May 15, 1980. SRS Negative DPSPF 30605-26. (Inset) Degreaser Tank in Assembly Area. New South Associates D2X2110.

Assembly Area Views

(Above Left) View of Assembly Area, Showing Fuel Element Water Testing Area, December 22, 1959. SRS Negative DPSPF 6401-48. (Above Right) Loading Slugs for Flow Testing in Assembly Area, December 22, 1959. SRS Negative DPSPF 6401-03. (Below) General View of Assembly Area, March 20, 1963. SRS Negative DPSPF 8930-06.

The first step in loading the foils was a thorough cleaning of the components that had to be assembled. Often this required "degreasing," since the components might be contaminated with industrial oils and dirt as a result of their fabrication and movement from 300 Area. The Degreaser, E.P. 131, fabricated by G.S. Blakeslee Company, was comprised of a steamer element, service water, and a solvent solution.[20] In order for elements to be degreased, they were first placed into a basket and then dropped into a "boiling" liquid of trichloroethylene solvent. The degreaser basin was 27 feet in length, 6 feet wide, and a depth of 9 feet. Also included were a solvent recovery still, two solvent storage tanks, and a solvent pump. A vapor section provided the final rinse.[21]

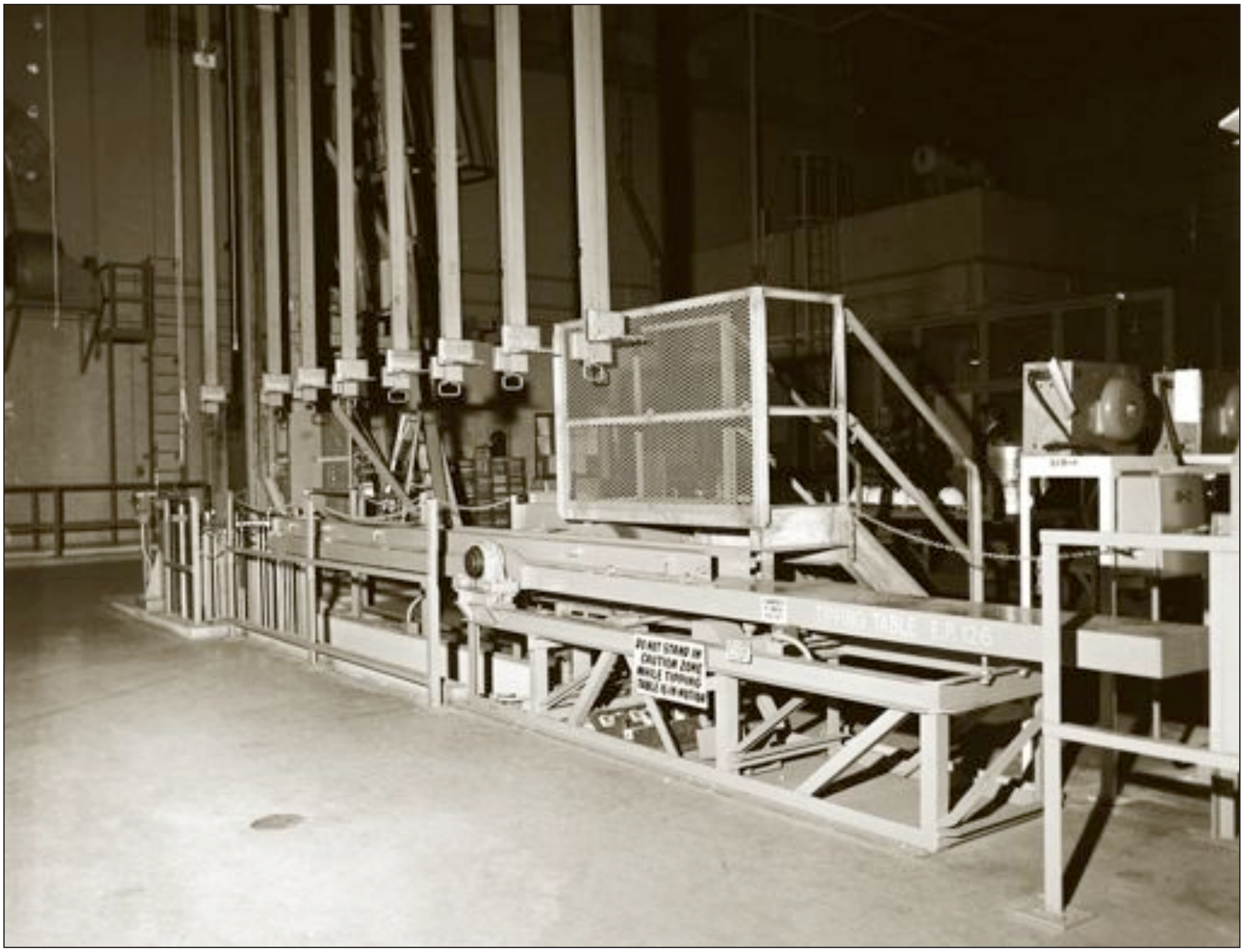
Once the components were cleaned, the process of assembly continued on the main floor, on the north side of the center bays. The critical issue here was the loading of the aluminum-clad uranium slugs into the quatrefoils, and a number of ways were entertained for doing this. Initially, it was thought to load the slugs horizontally, by sliding them into the foils. When this proved to be too damaging, it was decided to go with a method of vertical loading. The first attempt was with a hydraulic loading machine, but the results proved unsatisfactory. The second attempt called for a dry-type machine tested at New York Shipbuilding. This was a three cable and drum arrangement used to support the fuel column as it was lowered down the quatrefoil. This method still exhibited problems, which led to the third attempt, which was based on a simplified hydraulic loading method, capable of loading a single tube of the quatrefoil at a time. By the time this method was adopted, it was already well into the year 1953.[22]

The loading method adopted called for the quatrefoil to be lowered into a 20-foot basement chamber through a slot in the floor. With the top of the tube at ground level, the quatrefoil could then be loaded and tested with greater ease than would have been possible on an upper mezzanine level, as was originally envisioned.[23]

The Final Test Station was designed to flow-test each foil assembly to ensure that the water flow through each was correct and unimpeded. This was a test-run of the elements before they reached the reactor, when it might be too late to correct any flow problems. This safe-guard was established in large part because of problems found at New York Shipbuilding during the first loadings of assembled components into the Savannah River test reactor.[24]

The test station required special instrumentation. Manometers and pressure gauges measured total flow through the foils, as well as the flow through each of the separate channels. Monitor pin testers were installed in R Reactor Assembly, but were not used in the later reactors.[25] Other instruments and equipment at the Final Test Station included a water storage tank, pump, control console, top and bottom high-pressure seals, and top and bottom seal exhausts and evacuators, among other items.[26]

By now it should be clear that the equipment installed in Assembly was essential to the entire Savannah River Plant mission. The equipment ranged from the two-ton double girder bridge crane (E.P. 101) for the movement of boxes, together with the tube-box dolly, to a manually operated rail truck designed to move boxes from receiving to initial storage (the bridge crane and dolly were only found in R and P). Equipment in all of the Assembly areas included a two-ton fork truck for unloading pallets (E.P. 103); a crane with a half-ton hoist (E.P. 106.1); inspection benches and gauges for the foils (E.P. 107, 108); and the hydraulic loading machine for the Q-tubes (E.P. 110) and the associated pump (110.1). Other pieces of equipment included portable tube racks for moving the foils; a bench for the inspection of the small assembly parts (E.P. 112.1); and the degreaser complex that has already been discussed.[27]



Tipping minus in Assembly Area, C Reactor, January 12, 1973. SRS Negative DPSPF 16678-05.

Other critical pieces of equipment included the Tipping Table, which was a long narrow steel table for shifting the position of the elements from horizontal to vertical. There was also the Q-Tube Assembly Lag Rack, designed to hold the assembled Q-foils until they could be tested. In addition there was the portable tube rack; five of these aluminum "A" frames were constructed with rubber-tired castors. Each was designed to carry 10 Q-foils or septifoils, five on each side. Another piece of equipment was the Revolving Rack. This rack was mounted at the minus-20 foot level and was around 23 feet high, and facilitated interim storage for components before delivery to final storage.[28]

Final Storage Room

After the assembled components were tested, they were ready for the Final Storage Room, which was entered through sliding steel doors. This was where components would go after assembly and testing, but before they entered the process room. Most of the components, especially the quatrefoils, were stored vertically on hangers extending from the ceiling-mounted monorail ; the septifoils were stored on racks. The overhead monorail would pick up each tested Q-foil and position each on storage hangers.[29]

SRS Negative DPSPF 16678-08. Steel Door to Final Storage in Assembly Area, C Reactor, March 15, 1973. SRS Negative 16804-16. SRS Negative DPSPF 14456-04 (Above Right). View of Monorail System in Assembly Area, C Reactor, January 12, 1973.

Final Storage was one of those parts of the Assembly area where the details were different in different reactor buildings. In the R Reactor final storage area, there were 1095 hangers and 2000 feet of monorail track. The monorail system was comprised of an electric girder monorail for distance movement, and a non-electric monorail system for moving hangers around in Final Storage. In P, there were 879 hangers on 1800 feet of monorail track. This was altered again for L, K, and C, each of which had 951 hangers and 1600 feet of track.[30]

Gripper Pick Up Station and Presentation Point

When assembled components were ready for processing, they were moved by means of the electric monorail system into a room known as the Gripper Pick Up Station. There, they traveled through a tall, narrow baffle placed in the concrete wall between the Assembly Area and the reactor room. On the other side of the baffle was a tall narrow slot in the wall that separated the Assembly Area from the Process Area, through which vertical elements from Assembly could be passed to the process room on the other side of the wall. The baffle served as

View of the Gripper Pick Up Station and Presentation Point, C Reactor, January 12, 1973. SRS Negative DPSPF 16678-07.

a radiation buffer to block contamination that might enter Assembly through the narrow opening. The wall slot was known as the Presentation point. It was here that the vertical elements prepared in Assembly were passed into the process room to be picked up by the charging machine. The Presentation Pont was thus the culmination of the labor and preparation work that occurred in Assembly, where approximately 40 individuals were employed in assembling, testing, labeling, and storing the vertical elements prior to irradiation. The labor of the Assembly personnel ended at the Presentation Point, the portal to the reactor and the Process Room, the subject of the next chapter.

VI. PROCESS AREA

When assembled components entered the Process Area, they entered the very core of the reactor building, an area around 300 by 225 feet. And the center of the core was the reactor tank itself. Everything in the reactor building, and in fact everything in each reactor area, existed to serve the reactor tank. What happened in the tank was controlled in the Process Area, which also included the lowest and the highest parts of the reactor building, from 40 feet below ground surface, to 150 feet above.

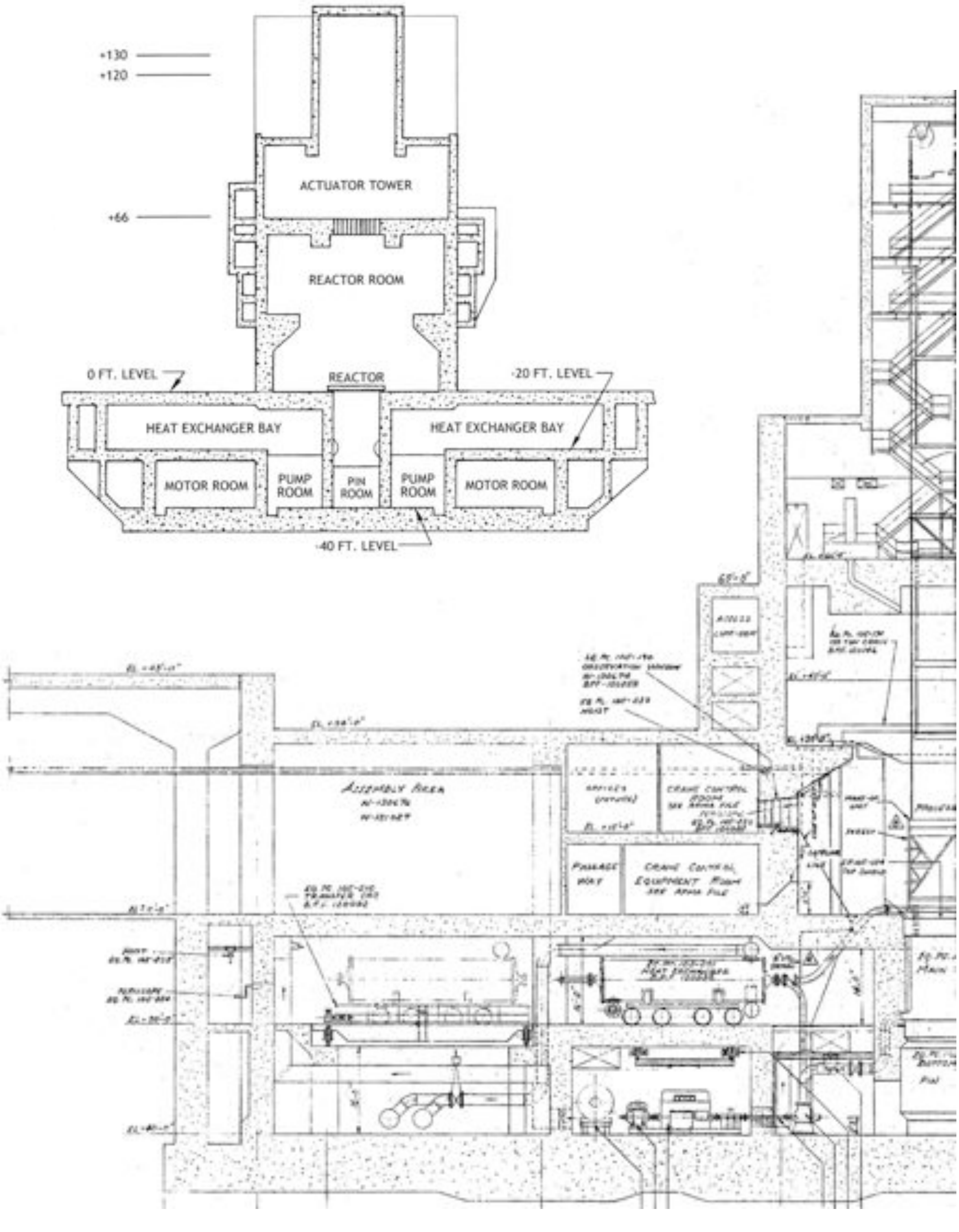
The reactor, located at grade level (0 foot level), was accessed by the charging and discharging machines, often called C and D machines. These machines brought vertical assemblies to the reactor from the Assembly Area and then after irradiation had occurred, took them out of the reactor, and placed them in the Disassembly Area. These incredibly important machines were the direct and only connection between the Process Area and both the Assembly and Disassembly areas.

Nothing, however, would happen in the reactor tank without the equipment both below and above the reactor itself. Absolutely essential to the operation of the reactor was the constant coursing of cooling water during reactor operation. This occurred in the levels below the Reactor Room, namely the minus 20-foot and minus 40-foot levels. Reactor control equipment was located above the reactor. This was basically the actuator and actuator tower, which extended to a height of around 150 feet above grade. The Process Area also contained the Main Control Room and the Crane Control Room, both located at the plus15-foot level. The main personnel areas for the reactor buildings were also located at this level.[1]

As finally constructed, the Process Area in R Reactor contained the following rooms and areas (Table 11). Some of these rooms in the later reactors might be in a different location or have a different orientation, but they were found at each of the reactors, and all served the same purpose.

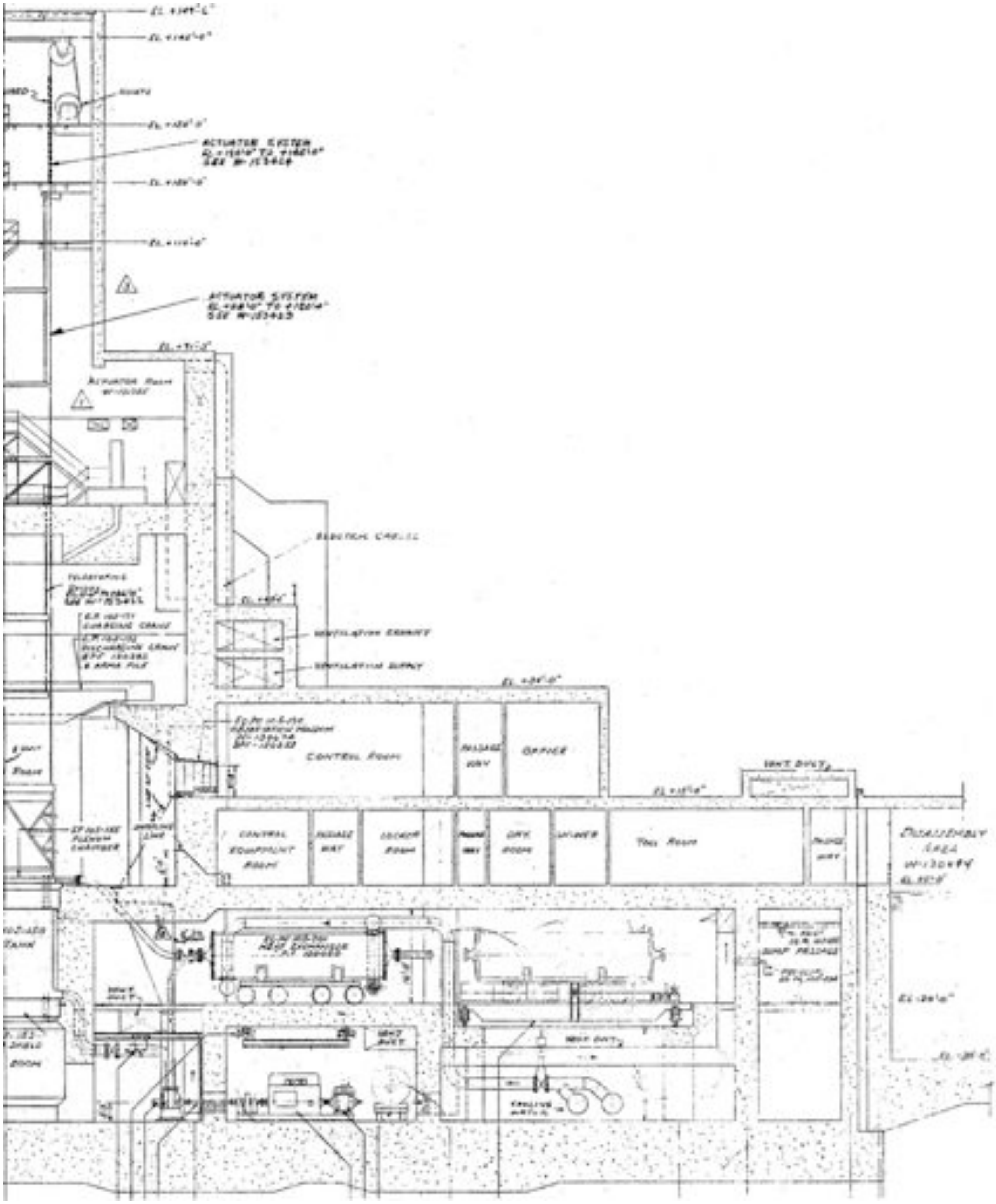
Table 11. Process Area Spatial Organization and Levels

Area	Location
Process Room (Reactor Room)	0 Level
Crane Wash Area	0 Level
Crane Maintenance Area	0 Level
Reactor Cooling and Gas Systems	Minus 20- and 40-Foot Levels
Heat Exchanger Area	Minus 20-Foot Level
Pump Room, Motor Room	Minus 40-Foot Level
Storage & Scram Tank Area	Minus 40-Foot Level
Overflow Tank Room	Minus 40-Foot Level
Pin Room	Minus 40-Foot Level
Instrument and Observation Rooms	Minus 40-Foot Level


+130
+120
+66
ACTUATOR TOWER
REACTOR ROOM
0 FT. LEVEL
REACTOR
-20 FT. LEVEL
HEAT EXCHANGER BAY
HEAT EXCHANGER BAY
MOTOR ROOM
PUMP ROOM
PIN ROOM
PUMP ROOM
MOTOR ROOM
-40 FT. LEVEL
ASSEMBLY AREA
CRANE CONTROL ROOM
PASSAGE WAY
CRANE CONTROL EQUIPMENT ROOM

Reactor Cross-section

R Reactor, and Key Showing Levels (Source: Drawing W130556).



Area	Location
Actuator Rooms	40- and 66-Foot Levels
Penthouse	120-, 130-, and 149.6-Foot Levels
Main Control and Equipment Rooms	15-Foot Level
Crane Control and Equipment Rooms	15-Foot Level
Personnel Area	0 and 15-Foot Level
Welfare Area (Locker Rooms, etc.)	15-Foot Level

Source: Design Division, SRP Description of Facilities, 1952, pp. 24-45.

The Process Area also contained a great number of fan rooms (Table 12). The main ones are listed below and are traditionally considered part of the Process Area, even if the areas they served were located elsewhere in the building.

Table 12. Process Area's Fan Houses

Fan Name	Location
Purification Area Fan Room	15-Foot Level
Disassembly Area Fan Room	15-Foot Level
Fan Room No. 2	0 Level
Fan Room No. 4	15-Foot Level
Fan Room No. 1	Minus 40-Foot Level
Exhaust Fan Rooms Nos. 1 & 2	Minus 40-Foot Level
Supply Fan Rooms	48-Foot Level
Exhaust Fan Rooms	48-Foot Level

Source: Design Division, SRP Description of Facilities, 1952, pp. 24-45.

Heating and ventilation might be peripheral to the main function of the reactor building, but it was essential, especially to the safety and comfort of the personnel that ran the facility. The reactor buildings were heated with air forced through steam coils. Air conditioning was provided in the control, personnel and welfare areas at a level of 80 degrees Fahrenheit and 50 percent relative humidity. Overall, the ventilation in the Process Area was divided between the upper levels and the lower levels due to differences in anticipated radiation. The upper levels -- the Reactor Room, and the levels above it – were isolated by one system, referred to as the "main tank room system." This was the area of lower levels of anticipated radiation. The pump rooms, motor rooms, and in fact most of the lower levels, where higher radiation was expected, were isolated to a second system that vented directly to the stack. This was known as the "pump room system."[2]

To facilitate the movement of air within these systems, and to meet the structural requirements of a Class I construction, liberal use was made of ventilation "wells" rather than intakes within the walls. Foremost of these was the "deep well" found in R Reactor that extended from grade level to minus 40-feet, located at the south end of the center section. Deep wells were constructed as part of the wall, to avoid weakening the fabric of the wall itself by the placement of intakes. In the same spirit, corridors doubled as ventilation ducts whenever possible. To provide access to air, the roof was equipped with specially designed concrete intake structures called "blast-tees."[3]

In addition to these general arrangements, there was specific attention given to the ventilation needs of particular rooms. Negative pressure was maintained in the process room, as well as the crane wash, heat exchanger, pump, and storage tank rooms. This was a safeguard against the escape of any contamination.[4] Another consideration in the Reactor Room was the maintenance of the ambient temperature at a level that was always above the dew point. This was to prevent any light water contamination of the heavy water in the reactor tank system.[5]

BASIC FUNCTION AND DESIGN ISSUES

In addition to the ventilation restrictions imposed on a Class I structure, there were a number of basic immutable building requirements that impacted the project from the beginning, and these had an impact on design details and the layout of the reactor building. From the beginning it was understood that the whole building would have to be as clean from dust and dirt as possible, and that much of the process area would have to be heavily shielded to protect workers from the harmful effects of radiation. This meant no exterior windows anywhere. It also required the remote operation of the reactor, as well as the C and D machines. Despite anticipated radiation in the lower levels, the heavy water pump motors had to be accessible during reactor operation. One very important consideration was that the reactor could not be allowed to stop suddenly as the result of a power failure, and this required emergency light and power sources within or adjacent to the reactor buildings. In case of accident or shutdown, a whole range of stand-by equipment was needed.

There were other, more specific requirements that had an impact on the design and development of the equipment. The machines had to work fast and they had to last, and to do this under the additional strain of radiation levels not experienced by other machines. It was calculated that the total time for the C and D machines to position any single assembly element, had to be less than four minutes. In addition, all machines and equipment had to be able to withstand the stress of reactor operating cycles that would last from 45 to 90 days.[6]

The considerations mentioned above applied to all of the Savannah River reactor buildings. There was, however, a very large design consideration that had an impact on the layout of the first two reactor buildings, R and P. In the first year of the project, it was thought possible that a second reactor would be added immediately adjacent to each of the five reactor buildings. By the time this idea was eliminated, it was too late to change the design and construction plans and both were laid out to allow for a possible second reactor. For this reason, the Process Room in R and P is oriented 90 degrees from what would otherwise be the preferred orientation.[7] Rather than having the C and D machines operating along a straight line from Assembly to the reactor tank, and then to Disassembly, the long axis of the process room was turned at a right angle to both Assembly and Disassembly. This created two right angles in the flow of materials: one from Assembly to the Process Area; and the other from Process to Disassembly.

In R and P, with Assembly off to the side, the charging machine-side of the Process Room faced the Crane Washing and Maintenance areas, while the discharging machine-side and the exit conveyor canal, which would normally go directly to Disassembly, faced the side of the reactor building left open for the hypothetical second reactor (it was anticipated that the second reactor would use the original Assembly and Disassembly areas). The alteration of plans in the design of L, K, and C, so that the process area lined up better with the natural flow of production from Assembly to Disassembly, was one of the main differences in both the size and layout of the last three reactors. In the new arrangement, Assembly was still off to the side, but this time on the opposite side of the Reactor Room from the R and P design. Disassembly, however, was located at the end of the discharge machine-side of the Reactor Room. This eliminated the need for the long canal between the exit conveyor and Disassembly.

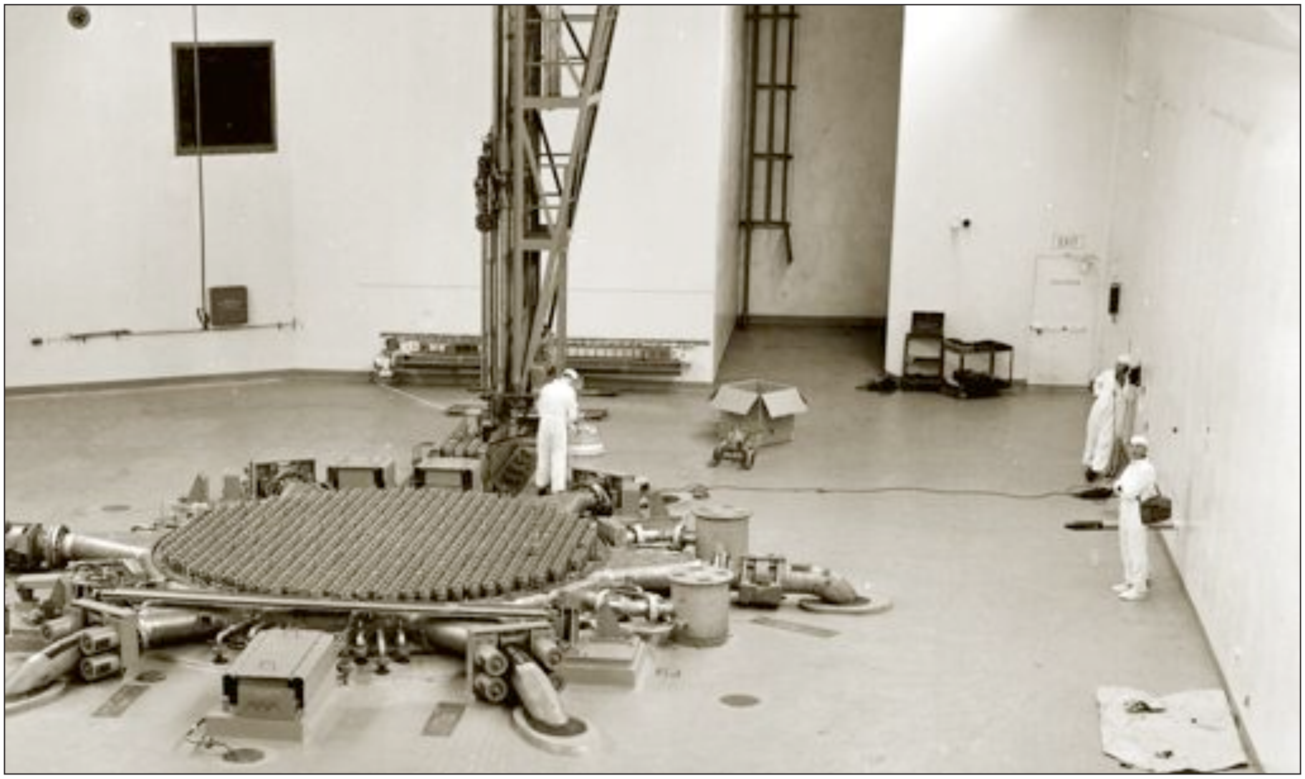
REACTOR ROOM

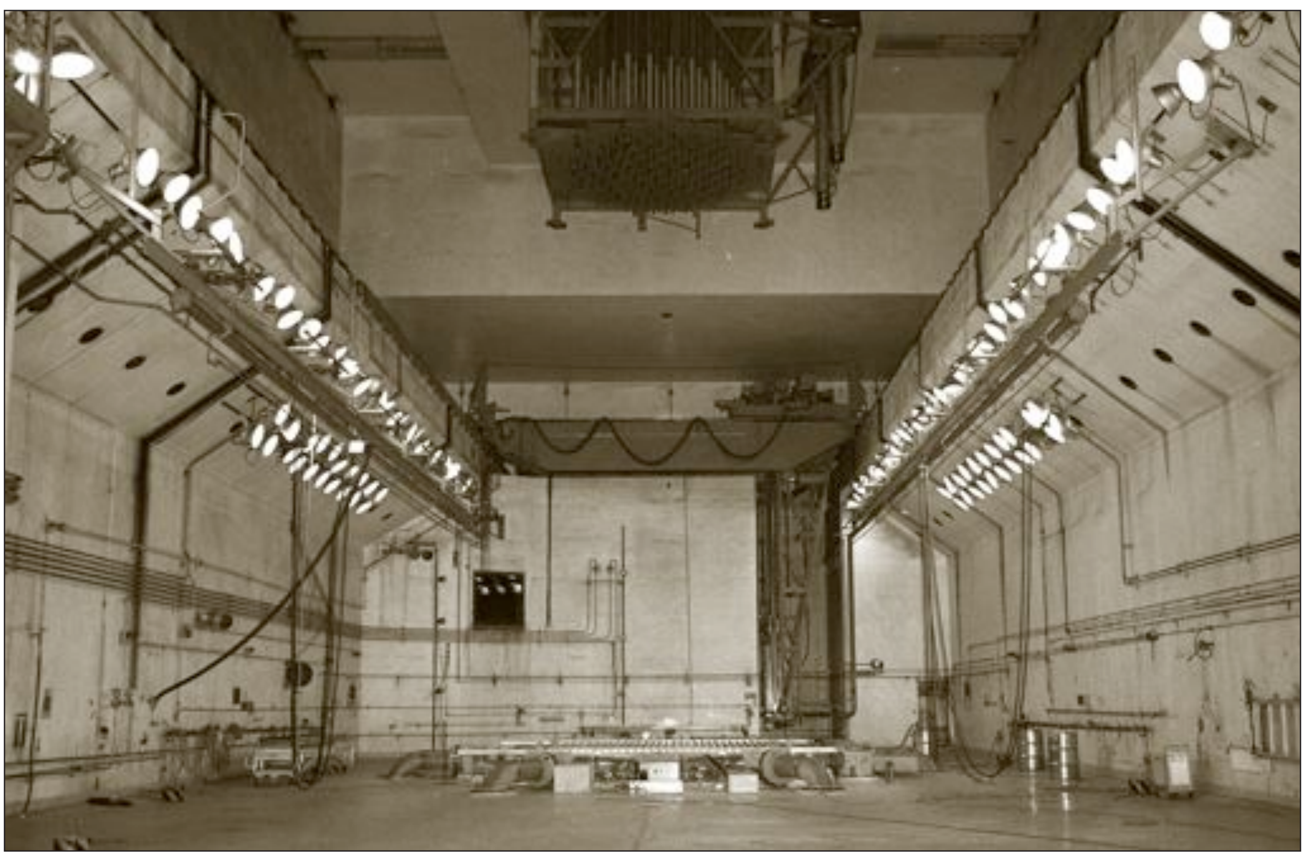
The importance of the Reactor Room, also known as the Process Room, cannot be overstated. Everything in the reactor building was connected to the Reactor Room. The Assembly Area was connected to the Reactor Room through the point of entry for all vertical assemblies, known as the Presentation Point. When they left the reactor, these same vertical assemblies were carried to the Deposit Point and Exit Conveyor, which was the connection to the Disassembly Area. The Reactor Room was also the connection for all the levels of the process area: the safety and control rods located above the reactor tank, and the water and Blanket Gas Systems located below.[8] This section of the report will deal with the features and the equipment found in the Reactor Room, minus the reactor tank itself. The tank will be examined in a separate section immediately after this one.

The Reactor Room is a rectangular-shaped room that measures around 150 feet long by 42 feet wide. Only the central portion, where the reactor tank was located, was wider, measuring 58 feet. The reinforced concrete walls are around seven feet thick. In R reactor, the reactor tank was 41 feet from the pick-up point at the south end of the room, while the tank was 30 feet from the edge of the discharge canal, located at the north end of the room. The ceiling height of the room is 43 feet above the floor, with the exception of the area over the reactor tank itself, which had a height of 61 feet. The only windows into the room are from the control rooms. There is a concrete “doghouse” in the room’s northwest corner for the drive and discharge station of the Deposit Point and Exit Conveyor.[9]

The ceiling of the Reactor Room was five-feet thick. In the part over the reactor, there were 427 openings through the ceiling to allow the control rod extensions to pass through and down to the reactor tank. Above the ceiling were the actuators that drove the control rods. The actuator tower, located above, rose to a height of 149.5 feet, and was one of the highest parts of the reactor.[10]

(Top) Early Oblique View of Reactor Room with Personnel at Work on C&D Machines. Reactor face and intake nozzles shown clearly. SRS Negative No, 1387-9. (Bottom) Reactor Room, 0 Level. Note Control Room Viewing Window in Far Wall. SRS Negative No. 30453-30.





Critical to the function of the Reactor Room were the concrete haunches that run along either side of the long axis of the room, located at a height of around 31 feet above the floor. These haunches support the rails on which ran the 120-ton crane and the Charging (C) and Discharging (D) machines. These machines had to be able to go to the Presentation Point to pick the vertical assemblies. In R Reactor, the Presentation Point is located on the east side of the room. The opposite side contains the access to the Disassembly Area. The south side opens up to the Crane Wash Area, which is separated from the Reactor Room by vertically raised steel doors eight inches thick. Beyond the wash area is the Crane Maintenance Area, where the 120-ton crane and the C and D machines were stored when not in use.[11]

The C and D machines, the two cranes used to load and unload the fuel and producer elements in the reactor tank, were the Reactor Room workhorses. The C machine picked up the reactor components from the Presentation Point at the edge of the Assembly Area, while the D machine, or Discharge Machine, took the components out of the reactor to the Deposit Point, the entryway to the Disassembly Area.[12]

The C and D machines were identified as E.P. 171 and 172, respectively. American Machine and Foundry Company manufactured them, with considerable oversight from Du Pont. It might be worthwhile at this point to take a moment and examine the work done by American Machine and Foundry (AM&F), since the C and D machines were some of the most important of all the pieces of equipment fabricated by the company for Du Pont Project 8980.

The Du Pont work completed by the American Machine and Foundry Company (AM&F) was carried out by the AM&F Special Projects Department, between 1950 and 1954. This work was performed under sub-contract AXC-8½, and was known at AM&F as "Project XYZ."[13] AM&F were responsible for developing equipment for Project 8980. AM&F work included the basic quatrefoil tube assembly (roughly 600 were needed for each reactor building), the C Cluster (control rods or septifoils), the Actuator Control Rod System, the Telescope Actuator System, the Rod Disassembly Machine and various other pieces of disassembly-handling equipment.[14] Arguably, the fabrication of the C and D machines was perhaps their most significant contribution to reactor operations.

The C and D machines were designed with the idea that they would be remotely controlled. The specifics of the design, however, changed greatly over time. The initial idea was to have the reactor tank charged by gangs or sectors of vertical elements, which would go in and out of the reactor tank as a unit. The difficulties in working out this system led to the idea of individual assembly handling. The problem with individual assembly, however, was one of speed, since the assembly had to be placed and replaced accurately and quickly. The first design work was completed by Consolidated Machine Tool Company in early 1951, when gang loading was still under consideration. With the switch to individual assembly handling, it was soon found that this company could not do the mast work required of the preliminary design. The general work on the overhead cranes themselves was then given to Whiting Corporation, which was tasked with producing 10 overhead cranes. The critical prototype mast work of the C and D machines was given to AM&F.[15]

From an early point, it was decided to use masts to hold the vertical components rather than cables. The number of masts for each C and D machine had enormous consequences for the size of the Reactor Room itself, since the number of masts determined the size of the crane, which would then determine the size of the haunches and rails that would have to support them. From an initial number of three masts per machine, it was briefly considered to have five, but eventually the number was reduced back to three. This allowed for a traveling crane that had a span of 39 feet and three motors, all located on a single trolley.[16]

The three masts had the following functions: No. 1 loaded and unloaded the control rods; No. 2 loaded fuel, control, and blanket rods; while No. 3 unloaded the same. The masts were later identified as A, B, and C, respectively. These masts were designed to grip the reactor components, which was reflected in their initial name at AM&F: "Q Crane Gripper."[17]

As it was finally designed and constructed, the basic parts of the C and D machines included the bridge, the trolley, the three masts, and the X, Y, and Z drive assemblies.[18] The movement of the C and D machines was predicated on the three-dimensional movement of the masts. The X drive controlled the bridge motion, which was along the long axis of the room. The Y drive controlled the trolley motion, which was from side to side along the bridge. The Z drive pulled the masts up and down. Each of the three masts (A, B, and C) had its own up and down drive, which could be operated manually in an emergency.[19]

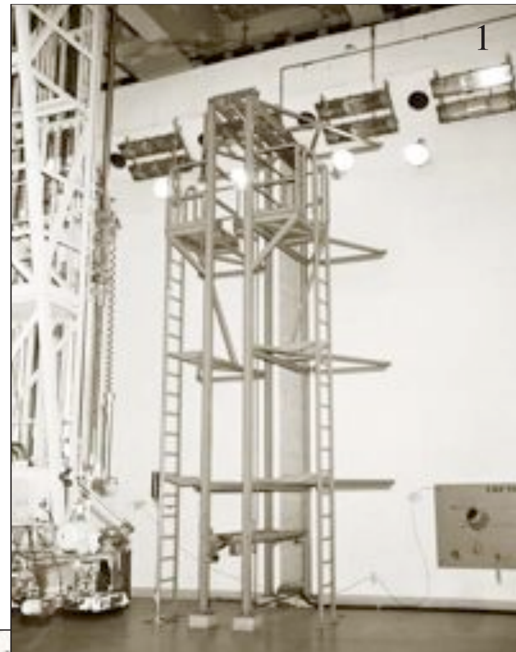
Control of the C and D machines and their masts was handled by electric current run through a ribbon of flexible cable. The masts normally operated semi-automatically, with information pre-punched on a tape and then put into the crane control system. The overall operation was based on a "servo system," where you could instruct the equipment to move to a particular point, and it would do so automatically, without an operator having to follow it through visually. In this fashion, the masts were initially designed to operate within an accuracy margin of 1/8 inch, but this was later improved to 1/32 inch.[20]

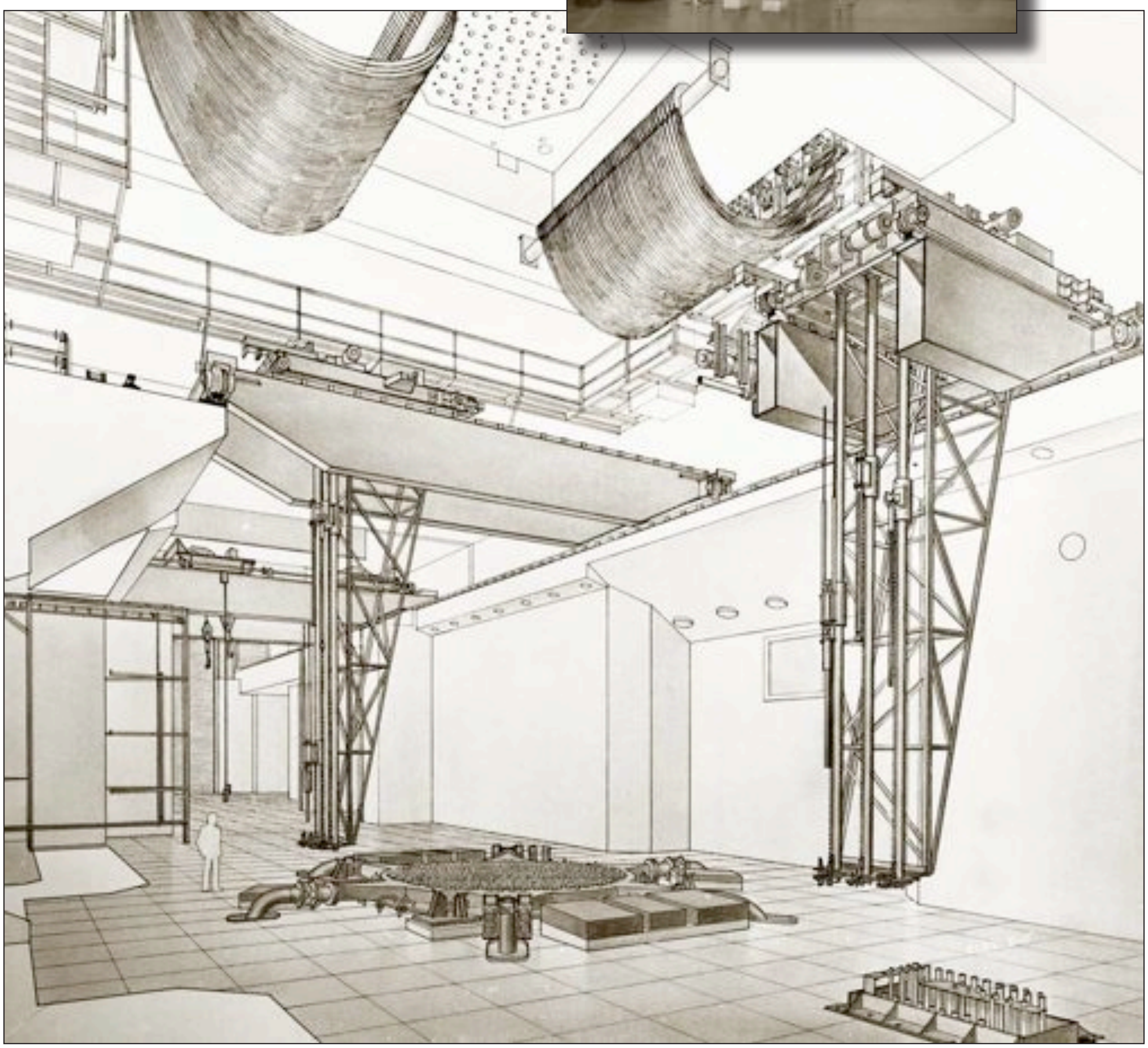
All of this was to insure that the quatrefoils (Q-foil) could be charged and discharged to the reactor tank properly. The entire process would go something like this. The C machine would pick up a Q-foil from the Presentation Point and put the new foil into one of the 606 empty holes at the top of the reactor tank. It then returned to the Presentation Point for another Q-foil, while the D machine put the shield plug over the Q-foil that had just been installed. When all of the Q-foil positions were filled, the C and D machines retreated behind the eight-inch vertical steel door, to be replaced by the forest and the control rod extensions, brought down by the actuator motors to the level of the reactor top so as to be in a position to control the reactor operation.

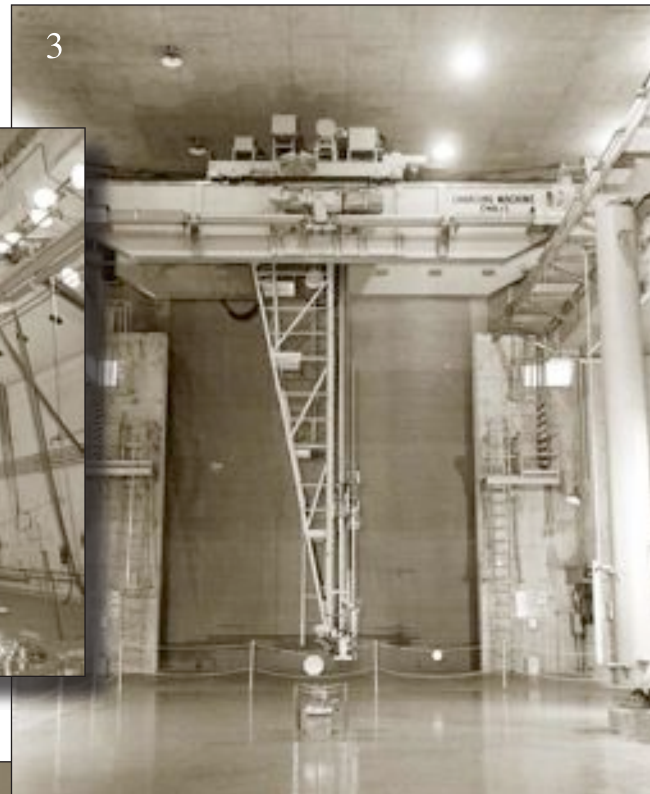
At the end of the reactor cycle, the C and D machines returned. The D machine removed the shield plug from the semi-permanent sleeve and placed it in a holding rack. The D machine then removed the irradiated Q-foil and took it to the Deposit Point and the Exit Conveyor. The conveyor arm removes the component out of the Reactor Room and returns for the next Q-foil. Simultaneously, the C machine is loading each empty quatrefoil hole with a new Q-foil. This process had to be repeated for each of the 606 quatrefoil openings on top of the reactor tank. For those occasions when the irradiated Q-foil was swollen or deformed, the D machine could be used to remove the Q-foil and semi-permanent sleeve together, with the entire assembly taken to the exit conveyor. A new sleeve would then be placed into the reactor by the C machine.[21]

Below: C and D Machines, Conceptual Drawing, Project 8980 Savannah River Plant, E.I. Du Pont De Nemours & Co., Engineering Department. Drawing by Voorhees, Walker, Foley, and Smith, SRS Negative No. 11046-8.

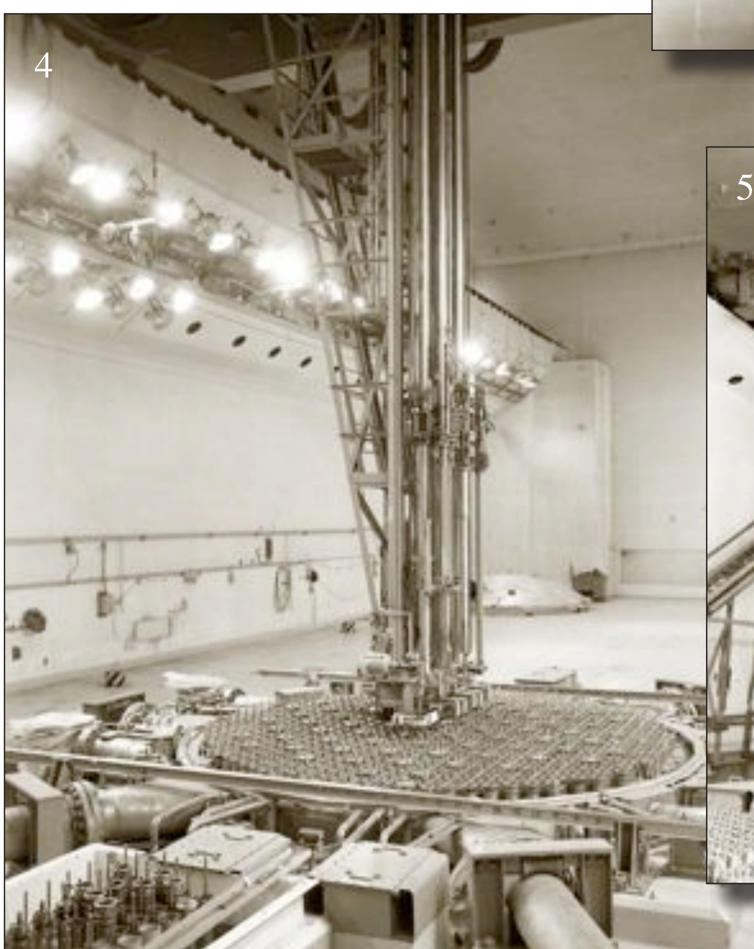
Photographs:
1. Presentation Point, SRS Negative No. 8459-02. 2. Reactor Room with Reactor Face in Foreground and C&D Machine Approaching. SRS Negative No. 30453-39. 3. Close up of Charging Machine, Crane Room Door in Background. SRS Negative No. 3832-07. 4. Discharge Machine in Action, Opening to Dissassembly Area at Lower Left. SRS Negative No. 1293-02. 5. Detail of Discharge Machine and opening to Disassembly Area in Floor. SRS Negative No. 1000-15.


1

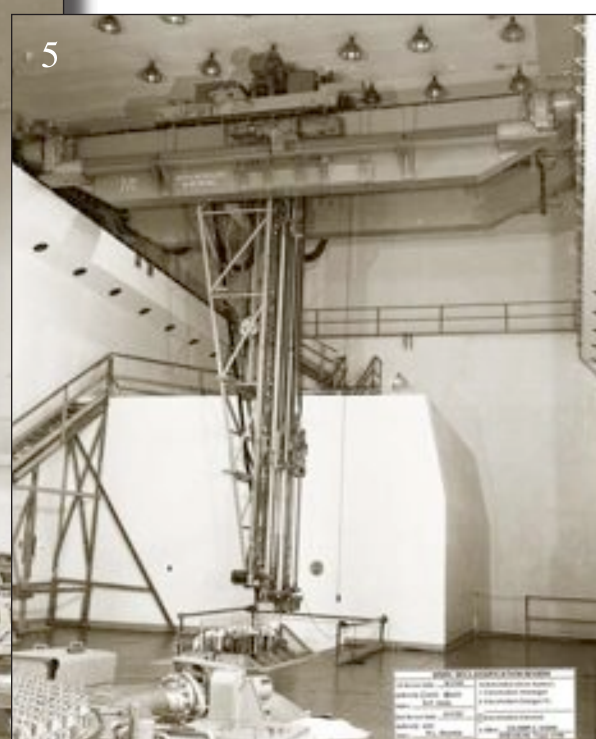




3

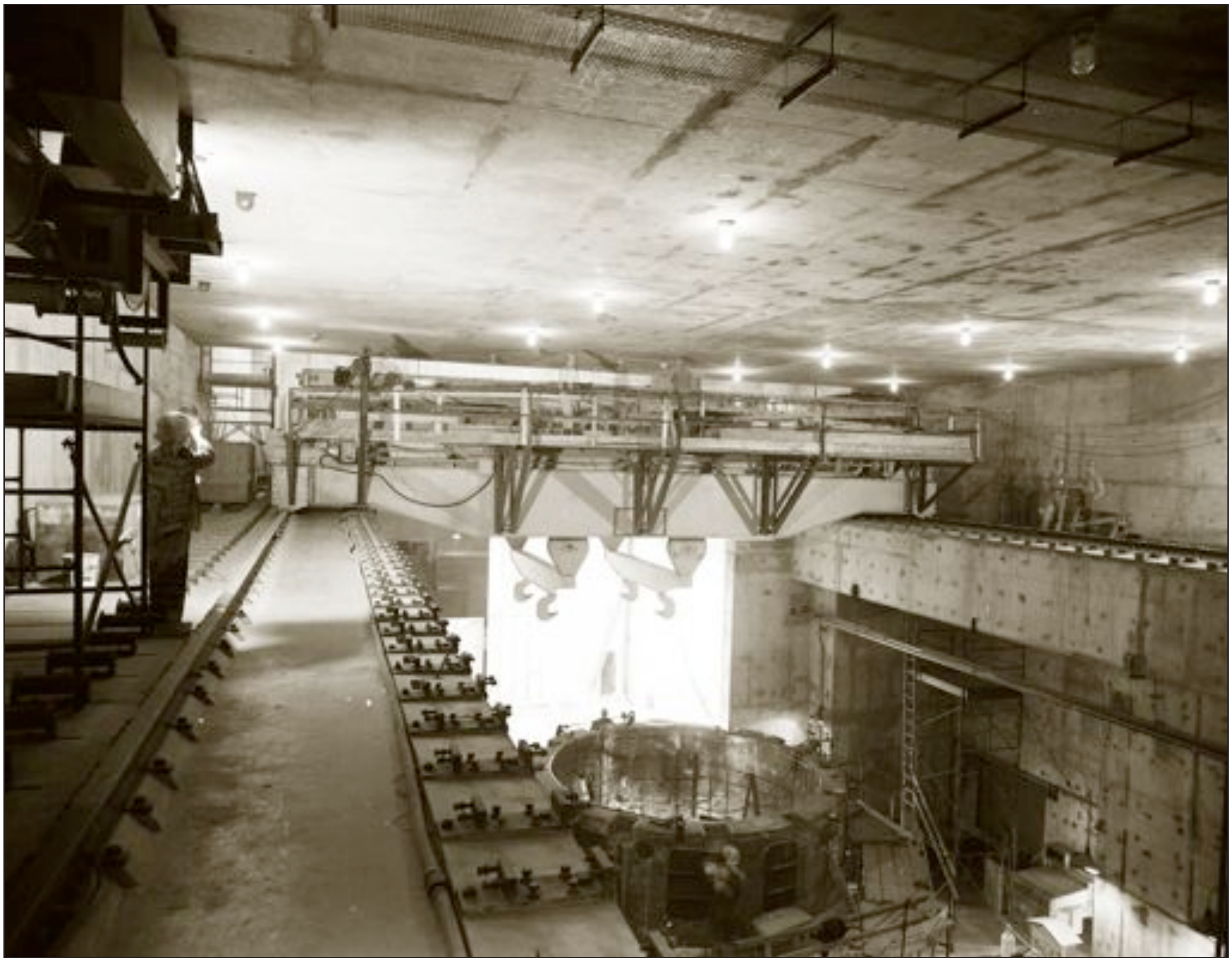


4



5

In addition to the C and D machines, there was also a 120-ton crane for each reactor building. This crane was designed to service the reactor tank itself, and traveled on the same rails that served the C and D machines. Labeled E.P. 174, the 120-ton crane had two 60-ton twin hook trolleys, a 48-foot span, and a lift of 32 feet.[22]

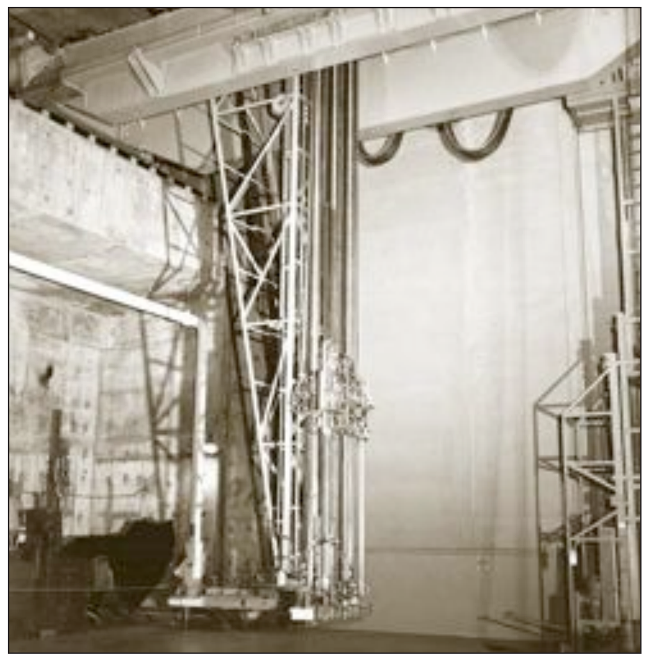


Haunches and 120-ton crane, SRS Negative No. 1664-01.

Other pieces of equipment were located in the Reactor Room. Among them was the Reactor Tank Robot, which was carried by the 120-ton crane. Also known as the Internal Robot (E.P. 168), it was comprised of various devices, such as grapplers, lights, and periscopes, which could be put into the Q-foil positions by the C machine in order to remove loose objects. In addition, there was a General Purpose Robot (E.P. 177), which was a lift truck with dual telescopic booms, equipped with mechanical tool holders and a TV camera. The Reactor Room also contained a holding rack (E.P. 179.1) for the intermediate holding of elements either before or after going into the reactor tank. This rack was generally used to hold elements that were about to be charged to the reactor tank, but were found to be defective at the last minute.[23]

When not in use, the C and D machines and the 120-ton crane were removed from the Reactor Room for cleaning and storage. These areas, the Crane Wash Area and Crane Maintenance Area, are separated from the Reactor Room by eight-inch thick steel doors designed to block radiation leakage from the Reactor Room. These massive doors, which were raised and lowered vertically, were manufactured by the Dravo Corporation of Pittsburgh, Pennsylvania, a prominent World War II shipbuilding firm. The doors were given the E.P number 180.

The door measurements were irregular, since the area it had to cover was also irregular, with notches to accommodate the haunches and rails on either side of the Reactor Room. Even so, they were huge: about 44 feet high, they were around 63 feet across at the top and 27 feet wide at the bottom. Each door weighed 292 tons, and was moved up and down by cables on motor-driven sheaves on a 55-foot high gantry, located on the roof of the reactor building at the 48-foot elevation. The lifting speed was five feet per minute, and almost double that going down. There were two of these doors in each reactor building: one between the Reactor Room and the crane wash area, and the other between the crane wash area and the crane maintenance area.[24]

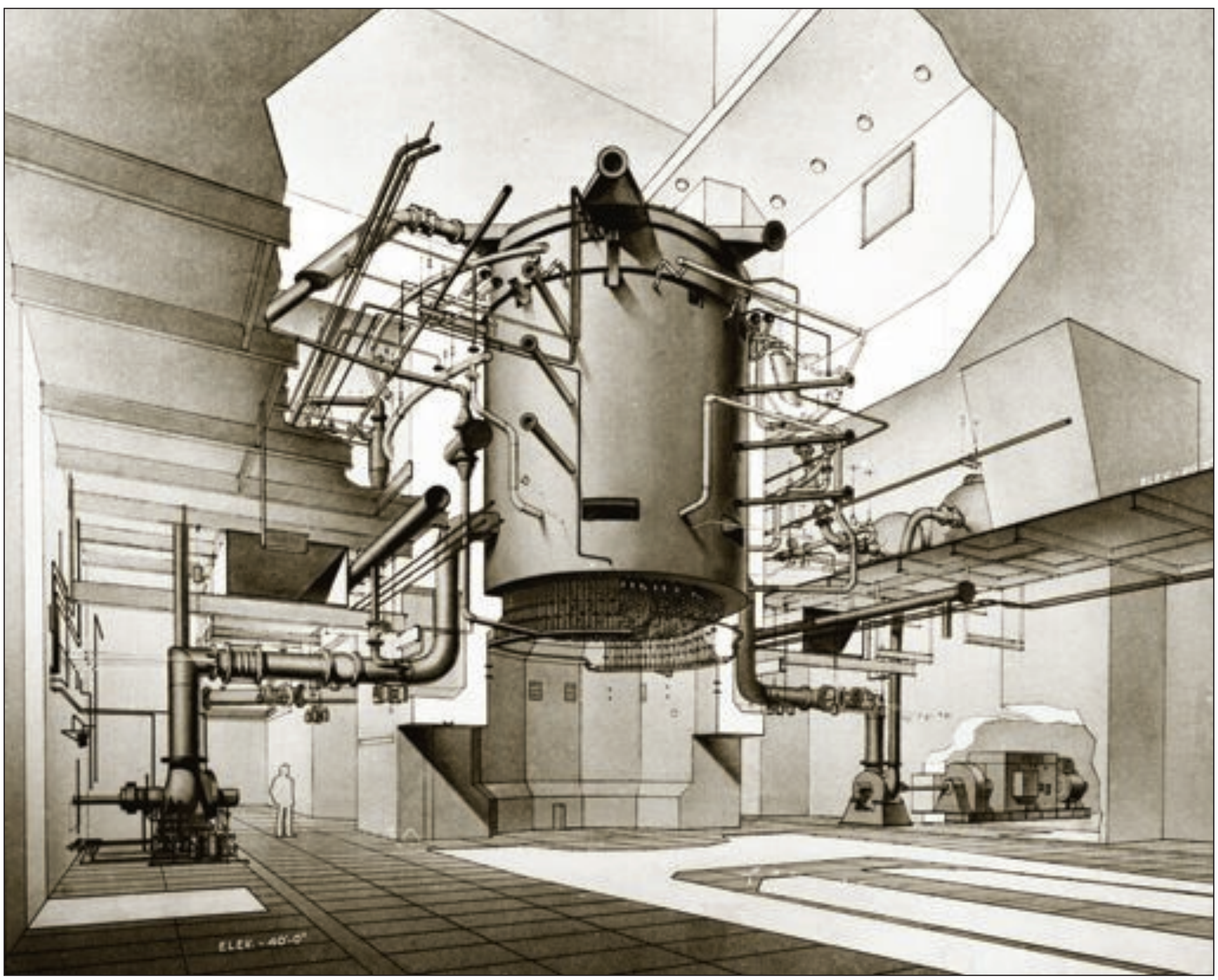


(Left) Vertical Crane Room Doors Manufactured by Dravo Corporation During Assembly, SRS Negative No. 1000-34. (Right) Shield Doors in Place in Background, C and D Machines in Foreground, SRS Negative No. 1229-12.

The Crane Wash Area is normally enclosed on two sides by the two steel shield doors. It was here that the C and D Machines and the 120-ton cranes were cleaned after use in the Reactor Room. The Crane Maintenance Area contained the C and D Machines and the 120-ton cranes, when these were not in use. It also held workbenches and storage cabinets, and a portable platform. It contained a supply fan powered by a 100-horsepower motor, and Elevator No. 2, which ran from 0 elevation to plus-48 feet. These two features, however, are only found in the R and P Crane Maintenance Area.[25]

REACTOR TANK

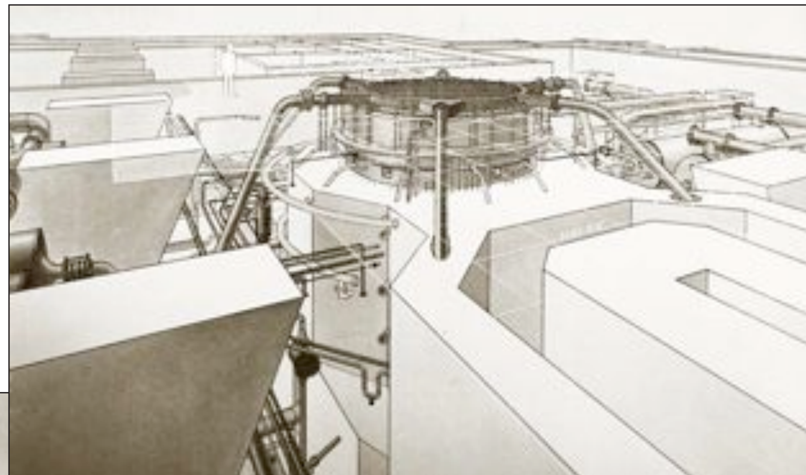
The center of the Reactor Room was the stainless steel reactor tank, identified as E.P. 150. As it was finally constructed, the tank in reactors R, P, L, and K had an inner diameter of 16 feet and 2.75 inches, and a height of 19 feet, 5 inches. The C reactor tank was larger. It had an inner diameter of 18 feet, 6.75 inches, with the same height as the others: 19 feet, five inches.[26] When empty, the tank weighed about 225 tons. The top of the tank was covered by a plenum, which was basically a hollow disk 17 feet in diameter and 1 foot thick. There were six intact pipes into the plenum. It was designed so that water would enter the plenum and then course down through the tank, exiting through six massive channels at the base of the tank. Both the plenum and the reactor tank were designed so that about 850 fuel, control, safety, and other rods could be inserted. More specifically, there were 673 large diameter holes divided into 606 Q-foils and 61 control rods, with the remaining 6 for gas release. There were another 165 small diameter holes for safety rods and instrument rods. All these went through the plenum disk, providing access to the reactor tank.[27] In addition, there had to be elaborate shielding around the tank. The reactor tank and all of its parts were part of a complex whole, and had to be able to withstand industrial and radiological stresses that were literally without precedent.

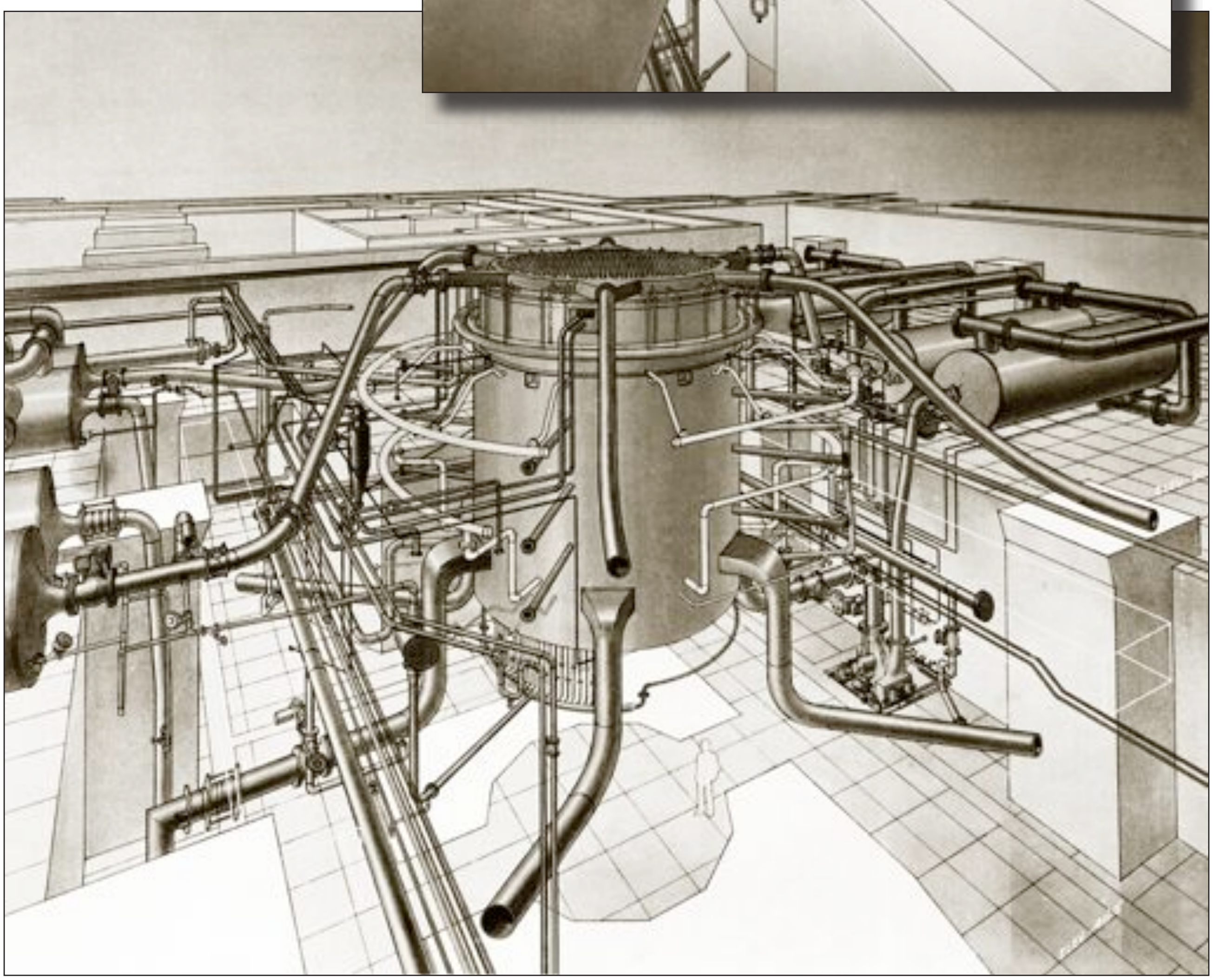


The details listed above were a far cry from the original plans for the reactors first envisioned by Argonne in the fall of 1950. At that time, it was thought that each reactor would have six plenum sectors, allowing mass loading of the vertical elements by means of sector loading. There were also provisions for 30 horizontal control rods at each tank, with six rods on each of five levels. At that time, Argonne also favored a coolant flow that would travel upwards through the vertical channels around the fuel columns, rather than the down flow that was finally selected.[28]

Reactor Tank Diagrams Showing Basic Design, Drawings by Voorhees, Walker, Foley, and Smith at Du Pont's Request, completed about 1951.

(Opposite) Perspective of Reactor Tank From Floor, SRS Negative No. 11046-04. (Below) Perspective of Reactor Tank Looking Down, SRS Negative No. 11046-05. (Right) Diagram Showing Concrete Shielding, SRS Negative No. 11046-11.





In a series of decisions that began in October of 1950, and continued throughout the spring of 1951, the original Argonne plans were greatly modified and changed, as it became clear just how the reactor would have to function within the context of the reactor building and the reactor instrumentation. In October, it was decided that down flow was preferable, due to the problems that any upward flow would pose to the plenum gas system. The main issue of tank size was basically established by December of 1950, even though the design still called for horizontal control rods. Original plans called for a six-inch false bottom at the base of the reactor tank to house the instruments needed to measure temperature and flow at the bottom of each fuel quatrefoil tube, but this idea was dropped in favor of a bottom shield in early 1951 due to the problems envisioned in accessing the instruments in the tank. The sector plenum idea was finally abandoned in early 1951 as well, and by this time it had been decided to use a cooled liquid top and bottom shield around the tank, filled with a combination of steel filings and light water.[29]

Some of the last major design decisions about the reactor tank were made as late as the spring and summer of 1951. The idea of horizontal control rods was finally dropped in April and May of 1951, in favor of vertical control rods. These first numbered 55 per tank, but that number was finally increased to 61 in July. One of the very last major design changes came in summer, when it was decided to use up-flow cooling in the septifoils, to help counter-balance the downward flow elsewhere in the tank. By this time, Du Pont had already selected the firm that would fabricate the reactor tanks for Savannah River Plant.[30]

By the spring of 1951, it was clear that it would not be easy to create the tanks planned by Du Pont. In March, Du Pont contacted the Combustion Engineering Company (CE) for advice on how to proceed with tank development. Combustion Engineering took several days to look over the Du Pont plans. The plans were determined to be basically sound, but CE engineers recommended that there be a complete mock-up of the tank and surrounding facilities to ensure that everything would work as a unit. It was this recommendation that led to the development of the NYX program, conducted by New York Shipbuilding. Even before the concept of all-vertical rods was adopted, New York Shipbuilding was chosen as the subcontractor for this reactor tank work, on April 26, 1951.[31]

The construction of the reactor tank is largely the story of the work at New York Shipbuilding in Camden, New Jersey. New York Ship, as it was sometimes called, was awarded the subcontract by Du Pont to build and test a reactor tank prototype, and produce tanks for each of the reactor buildings, as well as a tank (the Process Development Pile or PDP) for the Physics Assembly Laboratory located in Building 777-M (later designated 777-10A).

New York Shipbuilding Corporation (NYS) was selected as the fabricator of the reactor tanks largely because the firm had the know-how, and the requisite personnel, many of whom already had security clearances due to previous government work. It also had the necessary space to carry out the project. Because of the nature of the work, a lot more was required than merely the construction of a set of tanks. Virtually the entire water system and control system for the tank also had to be created in order to ensure that the tank worked according to Du Pont's specifications. As a result, this would be a huge project, and not many industrial companies in the United States were in a position to carry it out.

Founded in 1899, NYS already had a long history with the U.S. Navy. By 1951, the company had constructed over 600 Navy and merchant ships, including battleships and aircraft carriers, the largest vessels of the day. The physical plant covered 250 acres along the Delaware River in the southern part of Camden, New Jersey. The "South Yard" of the complex had been largely unused since the end of World War II, and proved to be an ideal location for the reactor tank project.[32]

The NYS subcontract was identified as AXC-167½ and was given the name "NYX Project." The first letter of intent from Du Pont was dated April 25, 1951, and there were numerous modifications to the contract that followed. The final scope of work was outlined in a letter from Du Pont dated December 13, 1951. Modifications to the work order continued well into 1952. As outlined in these modifications, there were three parts to the NYX Project: the developmental and experimental work that had to be done first; the making and testing of the prototype; followed by the manufacturing of the production tanks.[33]

To carry out this task, NYS had to work with its own set of subcontractors. Ralph Cornell did the basic construction work for the test facilities, and NYS had to coordinate with American Machine and Foundry for the installation of many of the elements that had to go into the reactor tank. The construction of NYX test facilities began in August of 1951. The initial NYX tank start-up began almost a year later.[34] During that period, the NYX Prototype Unit was constructed with four main parts: the main tank, the plenum chamber, the top tube sheet assembly, and the bottom tube sheet assembly. All of these elements had to fit with exacting precision and had to work without leaks. There were drilling and boring issues that had to be resolved, and welding was a major issue as well.[35]

The other auxiliary systems associated with the reactor tanks also had to be constructed, and NYS had a hand in these, as did Du Pont. These included a fully functioning cooling water system (that used de-ionized water rather than the rare and costly heavy water), heat exchangers, quatrefoils, a functioning control room, and even the "precision cranes" (C and D machines) needed to move assemblies in and out of the reactor tank. NYS also had to develop a "Telescope Actuator System" that would function with the reactor tank. This required a construction 120 feet high, with the lower section resting on a steel frame known as the forest assembly.[36]

It was quickly found in shake-down tests that it was difficult to keep the reactor tank, plenum, and the radiation shields, all lined up for the charging and discharging of the vertical elements. This led to design changes, such as special tongue and groove elements that would tie together the plenum and the top shield.[37] Leak and flow tests led to additional changes in both the reactor tank and the vertical elements.[38]

As it was finally perfected, the NYX reactor tank had a diameter of around 16 feet and a height of 24 feet. There were over 800 vertical components that had to go through the plenum and a 3.5-foot thick radiation shield, then into the tank, and finally engage with the individual receptacles at the bottom of the tank. Below this was another 3.5-foot thick radiation shield at the bottom.[39]

All of the Savannah River reactor tanks followed this basic form. As they were finally fabricated, the reactor tanks for R, P, and L, were all basically the same. The NYX prototype tank and auxiliary equipment was modified to form the reactor tank for K. Only the C reactor tank was a truly different vessel: the main tank was made larger, with room for more control rods, with a different sized plenum, and better flow features in the nozzles at the bottom of the tank.[40] This led to the development of the "knuckle," located between the C reactor tank and the outtake pipes.

The fabrication of these tanks began in the fall of 1951 and continued until January of 1954. They were basically finished in the order of the reactor buildings themselves.[41]

Table 13. Fabrication of Reactor Tanks and Prototypes

Reactor/Prototype	Construction Dates
NYX Prototype	September 1951 – March 1952
R Reactor	November 1951 – May 1952
P Reactor	February 1952 - July 1952
L Reactor	May 1952 – January 1953
K (refurbished prototype)	November 1952 – July 1953
C Reactor	May 1953 – January 1954

"River Landing Barge and Package," Photo series showing the arrival of R Reactor's vessel at the SRP river landing. The vessel fabricated by New York Shipbuilding was shipped by barge up the Savannah River and then transported via truck to its reactor site, August 1952. James Hughes Inc. Barge and Tugboat on the Savannah en route to Plant, SRS Negative No. M-1227-12.

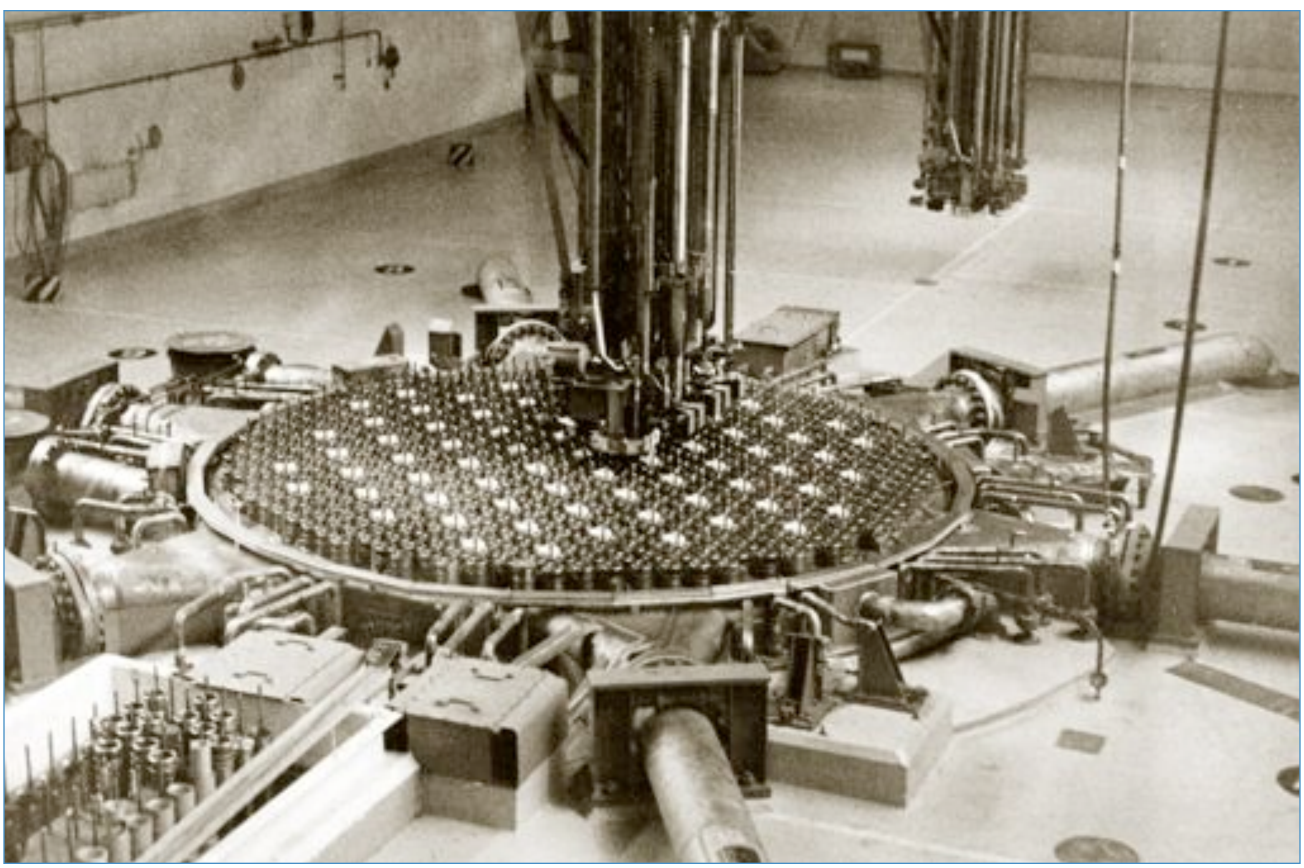
1. Barge Nears Dock, SRS Negative No. 1227-6. 2. Barge Docked and Ready for Offloading, SRS Negative No. M-2957-8. 3. Tarped Reactor Vessel Components Being Prepared for Loading on Truck, SRS Negative No. M-1227-09a. 4. Truck and Motorcade for Delivery of Tank to Reactor Site, SRS Negative No. M-1250-10.

As these tanks were made ready, they were shipped by barge to Savannah River Plant by James Hughes, Inc. In all, between 1952 and 1954, seven barge trips were made from Camden, New Jersey, to the dock at Savannah River Plant.[42]

In addition to the main reactor tanks, NYS also constructed a very similar tank, having the same basic size, but without the extensive water flow features, for the Physics Assembly Laboratory in Building 777-M. They also constructed the "grid beam assembly" that was designed to fit over this tank. NYS made the holding racks for each reactor building, after the previous vendor failed to make them to Du Pont's specifications.[43]

As it was finally constructed, each reactor tank came with features that were essential for the function of the tank itself. Certainly one of the most visible of these was the plenum. This feature, together with the top nozzles, was in fact the only part of the tank visible above the floor of the Reactor Room.[44] A hollow disk, about 17 feet across and 1 foot thick, it had 838 openings to accommodate rods of various sizes (the C reactor tank had even more openings). Most of the openings (673) were for rods with an outer diameter of 5.25 inches, with the remainder (165) for rods with an outer diameter of 2 inches, within the plenum a tube extended through each opening and was welded to each face. These plenum tubes were known as "permanent sleeves." It was into these sleeves that the vertical assemblies were inserted into the reactor tank. The cooling water, which also served as the moderator, entered the plenum and the reactor by means of six large nozzles situated at 60-degree intervals around the plenum disk.[45]

Plenum, SRS Negative No. DPSPF-11395-9.



Not as visible in the final arrangement of the tank was the shielding for the reactor tank. When the first designs for the reactor tank shielding were compiled, in early 1951, the reactor power levels were set at 368 megawatts (MW). Even then, it was understood that future power levels might be increased to around 650 to 680 MW. As a result, the thermal shielding around the reactor was based on anticipated power levels of around 700 MW.[46]

The idea of the thermal shield went through a number of mutations in 1951. The first idea was to have a wall around the reactor tank that was a combination of 4 to 6 inches of lead and 6 feet of concrete. The second idea called for a single concrete shield. Finally, by late 1951, the thermal shield was designed to be an hollow annular (circular-shaped) tank filled with Raschig rings or iron grid blocks. Raschig rings are pieces of tube cut into small segments and packed into a bed. The annular tank, which was in sections and designed to form a ring around the reactor tank, was made 20 inches wide inside, so that workers could enter the annular tank sections in order to pack the metal.[47]

After packing, the annular tank sections were then filled with light water, which circulated around the packed metal from top to bottom. The same arrangement was employed for both the top and bottom thermal shields, so that the reactor tank was completely surrounded by shielding material. The combination of half iron and half light water inside the thermal shields was considered optimal to absorb most of the radiation coming off the reactor tank.[48] For the first four reactors (R, P, L, and K), the thermal shield around each reactor was in three sections; in the last reactor (C), the thermal shield was comprised of 12 sections.[49]

In order to monitor the temperature of the reactor tank, some 311 thermocouples were installed in various places around the tank, and its shields and supports. The readings could then be read in the Main Control Room on the Tank Temperature Panel, also labeled E.P. 480.6. Among other features, there were also three internal periscopes to allow reactor operators to view inside the main tank.[50]

Mention has already been made of the permanent sleeve located in the plenum. By late 1951, there was also the development of the semi-permanent sleeve, which came to be considered part of the reactor tank, since it usually stayed there. The semi-permanent sleeve helped guide the Q-foil into the tank. As a rule, only the Q-foil was processed after irradiation, unless the fuel cladding was compromised and the fuel swelled, making it necessary to remove the semi-permanent sleeve as well.[51]

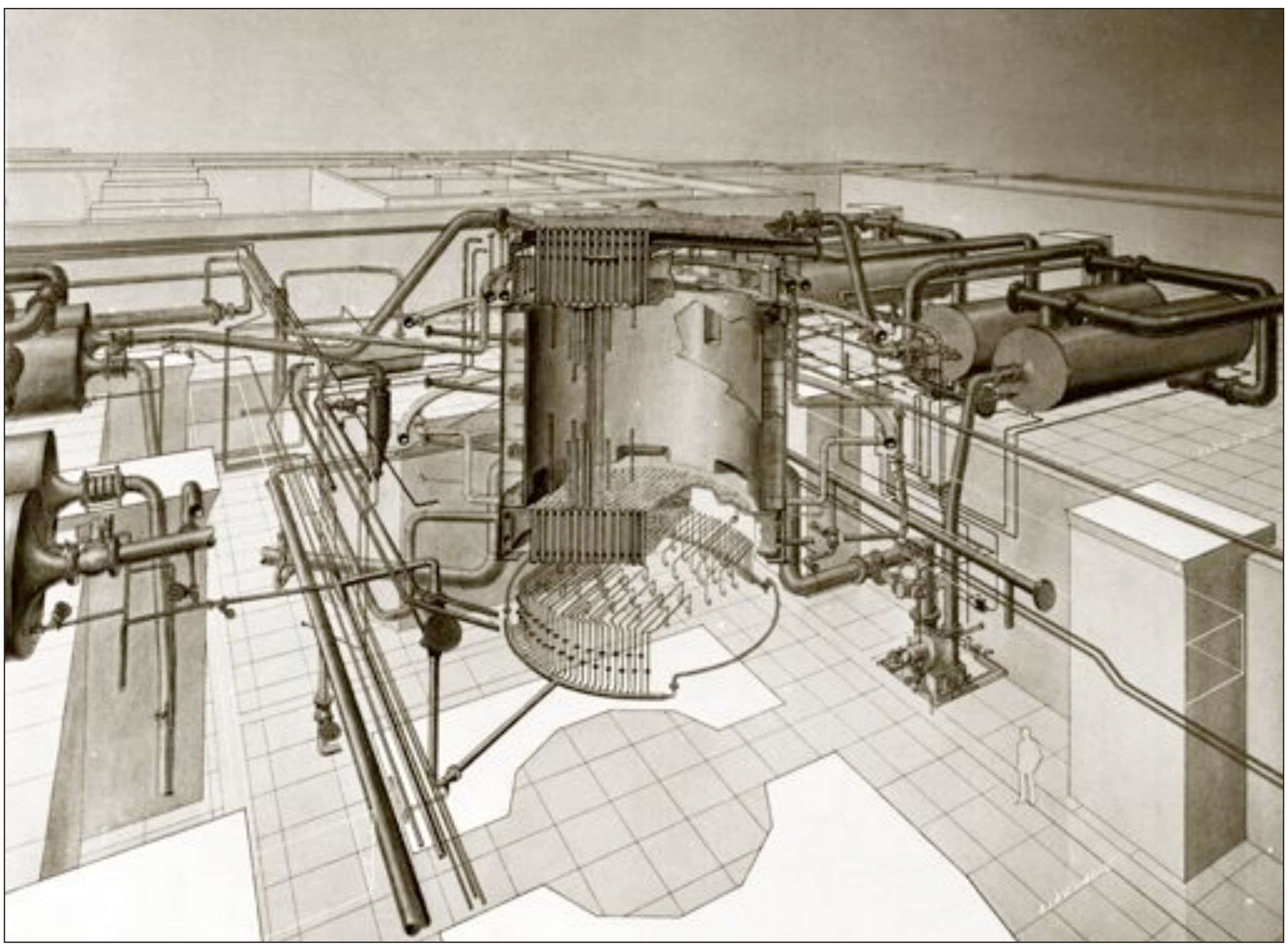
WATER AND GAS SYSTEM FOR REACTOR TANK

The water system that was essential for the cooling and the moderation of the reactor was perhaps the most crucial aspect of the entire operation. The system involved was fairly complicated, and there were engineering hurdles to be resolved at almost every turn. Most of this section will deal with the issues posed by the water system. By comparison, the Blanket Gas System is fairly small and relatively uncomplicated. The gas issue will be presented at the conclusion to this section.

As we have seen, the reactor tank top is basically level with the floor of the Reactor Room, located at 0 Level. The plenum, and the six large nozzles that enter the plenum, are the only portions of the reactor tank water system visible above the level of the floor. These six nozzles feed cooled heavy water into the reactor tank. Each nozzle has an opening of six square feet, and connects to a pipe with an outer diameter of 20 inches.[52] The rest of the tank, and the water system that serves it, were located on the levels below the Reactor Room, specifically the minus 20-foot level and the minus 40-foot level, the two lower levels of the reactor building.

The movement of the heavy water was a closed circular system. It started at the reactor tank, the top of which is at 0 Level and the base at minus 20. As we have seen, the heavy water entered the tank through nozzles at the top, and exited the tank through similar nozzles at the base. The heavy water then travels downward through pipes called suction lines to the pump, which pushed the water through the entire system. The pump, and the generator that actually powers the pump, are both located at the minus 40-foot level. The pump then forced the water back up to the minus 20-foot level, where it entered the heat exchangers. At this point, the hot heavy water comes into close contact, but not direct contact, with the much cooler river water, pumped over from Building 190. River

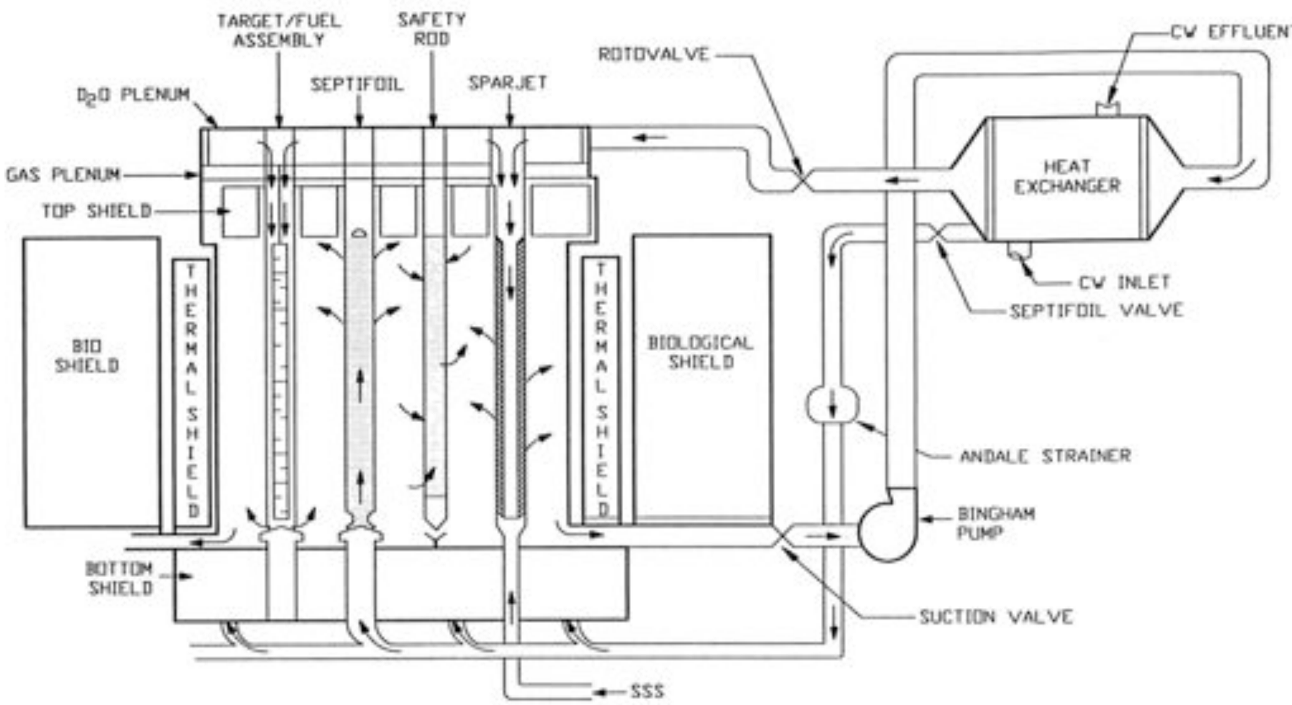
Diagram of Reactor Piping and Pumps, Drawings by Voorhees, Walker, Foley, and Smith at Du Pont's Request, completed about 1951, SRS Negative No. 11046-02.



water entered the system only at the heat exchangers, and its sole purpose was to cool the heavy water. The river water then cooled the heavy water, and simultaneously the hot heavy water heated the river water, which was discharged back to the outside. After leaving the heat exchangers in a relatively cooled state, the heavy water then continued on its way to the 0 Level and back to the reactor tank.

Each reactor was served by six pumps and pump generators, six (later 12) heat exchangers, and six sets of pipes for the entire system. It was originally conceived that these six systems would be arranged around the reactor tank in a circle, just like the nozzles themselves, but it was later decided that it would be easier and far cheaper to design a building where the pumps and heat exchangers were arranged in two lines on either side of the reactor, with three systems to a side.[54]

Process Water Flow in Reactor System. Source: Process Water, Savannah River Site Training and Procedures, General Central Section, SRS Document No, CS-GEN IR-GENERAL – 0102-OJT (1990:23).



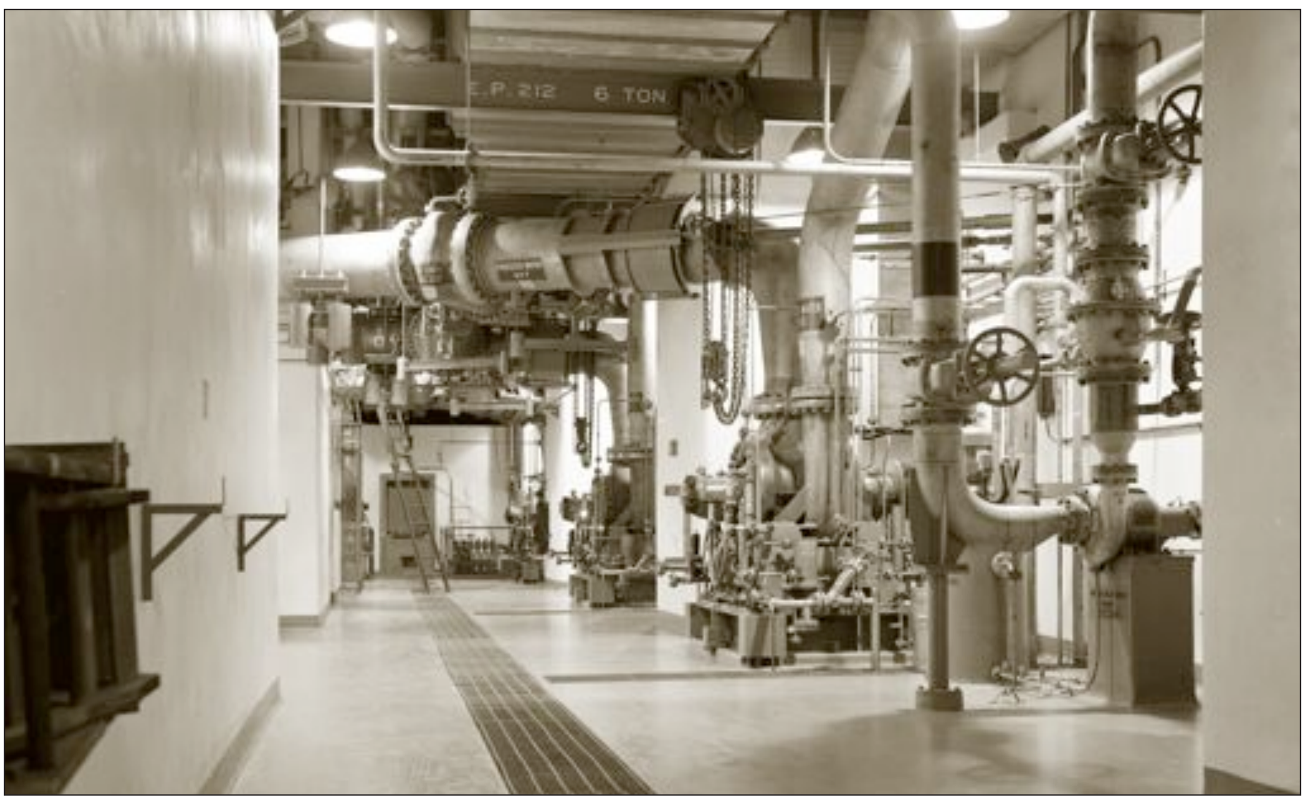
The heavy water system had to be a closed system, if only because the raw material was so costly and difficult to manufacture. Even so, with all of the piping associated with the six systems, more than one half of the heavy water in the reactor building was actually outside the reactor tank at any one time. In the first four reactors (R, P, L, and K), the distribution of the heavy water throughout the system was identical and is listed below.

Table 14. Distribution of Heavy Water Throughout System

Location	Tons
Reactor Tank	94
Fuel and Target Elements	10
Plenum	7
Heat Exchangers (12)	53
Pumps (6)	3
Pump Suction Piping	19
Pump Discharge Piping	14
Purification Area	8
Overflow and Drain	5
Monitoring, etc.	1
Total Tons of Heavy Water	214

The heavy water figures for C were different only because the reactor tank was larger, and the nozzles going in and out of the tank were larger too. In C Reactor, the tank held 126 tons; the pump suction piping contained 30 tons; the pump discharge piping, 23 tons. The rest of the figures were the same, for a total of 266 tons.[55]

Pump Room General View, SRS Negative No. M-4090-08.



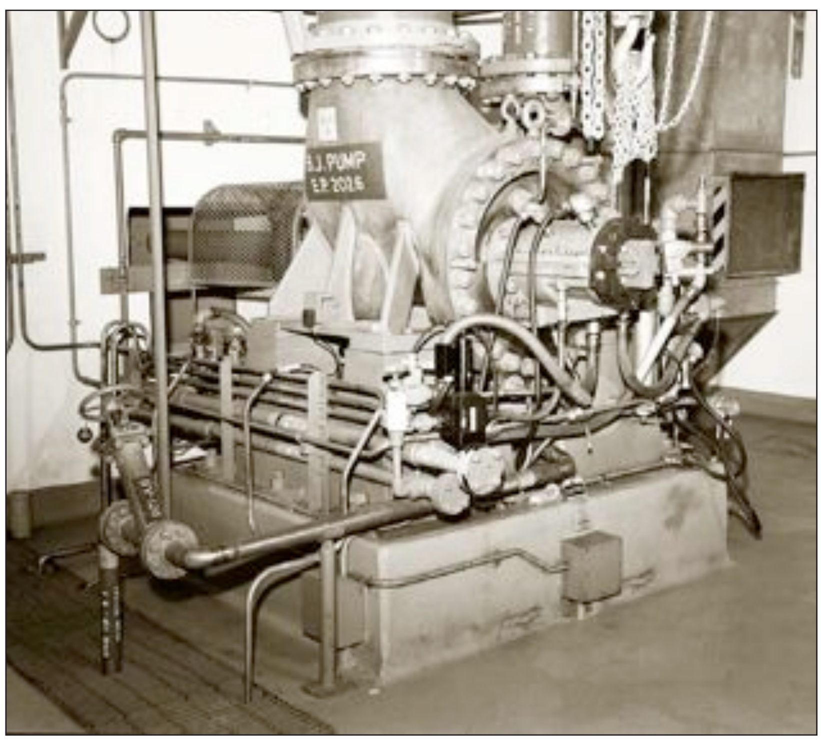
PUMPS AND MOTORS (Minus 40- Foot Level)

The six pumps (E.P. 202) at each of the reactors, as well as the lines that go into the pump (suction lines) and the lines that go out (discharge lines), are the focus of the circulating heavy water system. From the beginning, it was estimated that the six pumps, working in parallel, would have to push some 70,000 gallons per minute (gpm) through the system. Each of the pumps would have to be equipped with flywheels or something comparable to keep the flow going for at least a while after any power failure. In case of a power failure, there had to be back-up power capable of at least 10 percent of normal flow.[56] The pumps were located in the pump room; the motors in the adjoining motor room. Although other pieces of equipment were also found at this level, the pumps and the pump motors were by far the most important.

PUMP ROOM

One of the first ideas, considered in late 1950, was for a "canned motor" pump, where the pump and the motor were housed together in one casing. This would eliminate the need for any sort of long shaft and shaft seal between the motor and the pump. Eventually, this idea was dropped in favor of what was eventually adopted: a pump and a motor, each separated by a wall but connected by a shaft. As a result, there was a pump room separate from the motor room. In the case of a major spill from any of the pumps, the water could be kept away from the motor areas. With this in mind, the pump room itself was designed to serve as a watertight basin. Bulkheads at the doorway could be raised to a height of three feet above the floor to create a spill basin to a height of three feet. Sumps were provided to remove this potential spill.[57]

By early 1951, the pumping needs of the reactor system were better defined. The process pumps would have to have adequate mechanical seals. Sleeve bearings were considered more reliable than ball bearings, especially in the case of water flow failure. It was also estimated that all reactor areas would require a total of 32 pumps: six in each area, plus two spares. Each pump would have to provide at least 11,500 gpm "at a 700-foot total dynamic head." Other early considerations included having a two-stage pumping arrangement, with an 18-inch diameter suction line, followed by a 14-inch discharge line.[58]



Detail of Byron Jackson Pump, SRS Negative No 2347-40.

After some consideration, it was decided to use Byron-Jackson pumps, and the order was placed with in June of 1951. Because of the unusual features required for these pumps, company representatives had to work closely with Du Pont engineers in the design and manufacture of these pumps. They had to have, for example, double mechanical seals and fluid injection between the seals. All had to be tested by Byron-Jackson. Because the reactor tanks were still under construction, the first six pumps had to be sent to NYS as part of the reactor mock-up. It was there that they were tested between July and November of 1952. From this, it was worked out that the pumps would be horizontal and single-stage, with a 20-inch diameter suction pipe and a 12-inch discharge pipe capable of high volume.[59]

Another problem that had to be resolved was an issue common to all parallel pumping systems, but in this case complicated by the fact that there were six parallel pumping systems. There had to be some sort of valve installed at each pump to prevent back-up in case the pump failed. After considerable study, the decision was made in April of 1952 not to use "check valves," which might provide too much shock to the piping. At that time, it was decided to use "non-reversing clutches." These would prevent counter-rotation of the pumps in case the main AC motors failed.[60]

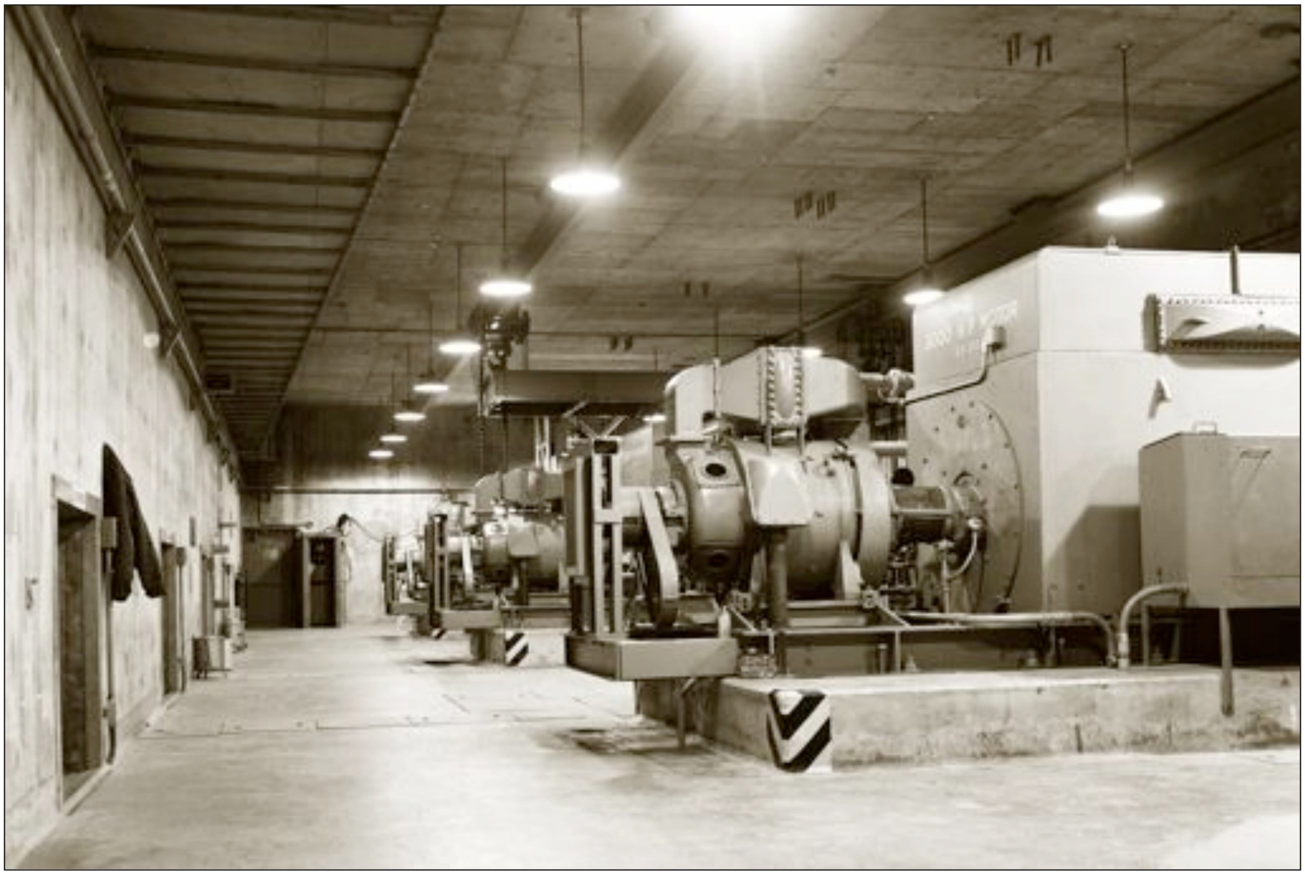
Formsprag clutches were tested as part of the NYX program at NYS, and it was these that were installed in the early reactors. Later, in May of 1954, one of these clutches failed in R Reactor, followed by another clutch soon after. All were replaced until it was discovered that they had built up friction as a result of impurities in the oil lubricant. After modification, they were re-installed.[61]

In addition to clutches, there was also a pump seal supply system installed at every pump to prevent the loss of heavy water due to leakage. There were two mechanical seal assemblies at each pump, and they were first tested during the NYX program. This system changed over time. R and P reactors had supply and leak collection pots associated with the seal system. Subsequent reactors relied more on rotometers and sight glasses.[62]

Other features found in the pump room included the main support base for the reactor tank, the pin room found directly underneath the reactor tank, the instrument room containing the transmitters for flow and temperature monitoring, and the shield cooling water pumps.[63] The shield cooling water pump was capable of 1,000 gpm in R, P, L, and K reactors; and was increased in capacity to 1,500 gpm for C Reactor.[64]

MOTOR ROOM

Motors were required to power the pumps, and there were two sets of motors for each pump. Both motors were positioned in the motor room that adjoined the pump room. Due to the positioning of the pumps on either side of the reactor, there were two motor rooms on either side of the reactor, and each covered an area of around 35 by 145 feet. There was a central lubricant system to serve the equipment in the motor rooms. The main pieces of equipment in each motor room were the AC motors. Generators at the powerhouse and/or the main electrical grid supplied the power. In case of a general power failure, there were also back-up DC motors designed to provide enough force to keep cooling water flowing through the reactor tank.[65]



Motor Room, SRS Negative No. M-4090b-10.

As for the main AC power, each of the six pumps in each reactor building was powered by its own 3,000 horsepower motor.[66] Each of these six motors was identified as E.P. 202. The adjoining DC motors, which were rated at 120 horsepower, were identified as E.P. 202.1. The DC motors were equipped with a non-reversing clutch to keep the motors from going backwards during operation.[67]

Both the AC and DC motors were installed in the Motor Room. Like the Pump Room, the Motor Room was located at the minus 40-foot level. A shaft connected each set of motors with its pump, and this shaft likewise connected the motor room with the pump room. Aside from the motors, the main pieces of equipment within the motor room included a 10-ton chain trolley hoist (E.P. 211) designed to deal with the motors during maintenance operations.

There was a six-ton chain trolley (E.P. 212) for maintenance work on the pump motor flywheel. A truck with a capacity of 18 tons for moving pumps and motors and motors for shield cooler pumps were also present.[68]

OTHER FEATURES AT MINUS 40-FOOT LEVEL

There were other important features located at the minus 40-foot level, aside from the essential pumps and motors. There were monitoring instruments to check reactor flow and temperature. There were facilities for heavy water storage, scram tanks, and related operations, and there were facilities for miscellaneous services and maintenance. There was also a ventilation area to deal with the requirements for the below-ground central portion of the reactor building.[69]

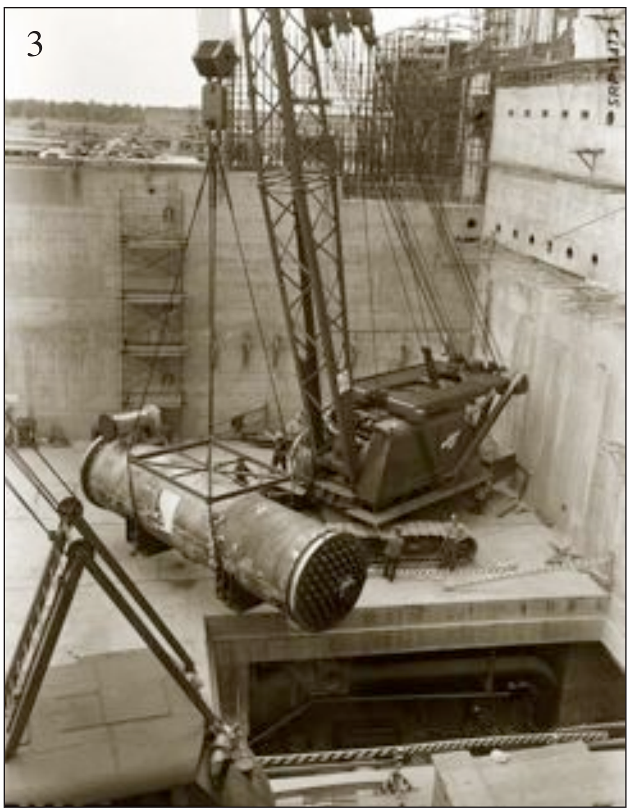
The ventilation area at minus 40 covered an area of around 80 by 100 feet. It had an airshaft that extended up to the ground level, and was equipped with fans for the supply and the exhaust of air for the lower levels of the reactor building.[70]

There were a few differences between R and P, on the one hand, and L, K, and C, on the other, in the arrangement of the auxiliary features found on the minus 40-foot level. R and P both had large fan rooms and cooling water areas. L, K, and C did not have these features, at least not at minus 40. In the later three reactors, the fan rooms were moved to the ground level, and the 42-inch headers for the cooling waters, were moved to the minus 20 foot level. Also there was no observation room at the minus 40-foot level in L, K, and C. In those later reactor buildings, the observation windows and periscopes were located in the instrument room. Also, in C Reactor, the storage and scram tank was larger than the others to compensate for the larger reactor tank.[71]

HEAT EXCHANGERS AT MINUS 20-FOOT LEVEL

After the process heavy water leaves the pumps at the minus 40-foot level, it is pushed upward to the minus 20-foot level, where it enters the massive heat exchangers. It is here that the heated heavy water from the reactor meets the much cooler river water piped from the Savannah River. The river water first collects in the reservoir (Building 186) before being pumped from the adjoining building (Building 190) into the reactor building. It is at the heat exchangers that heat from the reactor moderator water is transferred to the river water, which then is pumped back out of the reactor building and into exit canals. Most of this heated river water would make its way back to the Savannah River by means of natural creeks located near the reactor areas.[72]

Since the reactor heavy water system is a closed one, the heavy water does not come into direct contact with the river water. Even so, the indirect contact had to be extensive in order for the heat transfer to work. Basically, the heat exchangers are large, horizontally-positioned tanks, each about the size of a railroad car. Inside each tank are literally thousands of small-diameter hollow tubes that extend through the tank. Each of these tubes is completely sealed off from the rest of the interior space within the tank. The heated heavy water is pushed through the tubes; the river water courses through the rest of the tank. To prevent any loss of heavy water in the event of a leak inside the tank, the river water is kept a higher pressure than the heavy water. As a result, light water would have to be removed from the heavy water, but were it the other way around, the heavy water would be irretrievably lost in the river water.[73]



1. Heat Exchanger In Transport to Reactor, SRS Negative No. M-3683-04. 2. Transferring Heat Exchanger to Pit, SRS Negative No. 3462-07. 3. Easing Exchanger into Position on Rails, SRS Negative No. 1000-25. 4. Heat Exchanger Positioned in Chamber, SRS Negative No. 1042-01.

This provides the basic concept of the heat exchanger system, but as with so much at Savannah River Plant, there were technical issues that had to be worked out at almost every step in the developmental process. From the first serious design work on the heat exchangers, which began as early as the fall of 1950, it was considered optimal for the heat exchangers to hold a minimum of heavy water, so that the loss from any leaks could be kept low. It was also considered optimal to use stainless steel double-tube sheets. It was not clear whether it would be better to use one-quarter inch diameter or half-inch diameter tubes. These and other issues would be tested at the CMX facility at Savannah River Plant, and at NYX.[74]

The quarter-inch outer diameter tubes were found to be potentially more efficient at heat exchange than the half-inch tubes. A prototype of the quarter-inch tubes was prepared by the Alco Products Division of the American Locomotive Company; a second by Babcock and Wilcox Company. Both prototypes leaked. The half-inch tubes fared better in this regard, and were furthermore more readily available commercially. By early 1951, the half-inch tubes were recommended for use in the heat exchangers by the Heat Exchanger Fabrication Committee.[75]

In May of 1951, Foster-Wheeler won the low bid contract for the manufacture of the first heat exchangers for the reactors at Savannah River Plant. Foster-Wheeler was contracted to produce 12 "shell and tube" heat exchangers for R Reactor. There would be a total of 8,800 tubes per heat exchanger, with each tube to have an outer diameter of one-half inch and a length of 27 feet, 2.75 inches. Inside each tube would be a core rod having a diameter of 0.294-inch. The first of the final Foster-Wheeler heat exchangers was tested at NYX in January of 1953, with satisfactory results.[76]

Du Pont requested another 50 heat exchangers in October of 1951. With the original order of 12, this new order brought the total to 12 heat exchangers per area, plus two spares. In December of 1951, this order for 50 was split between Alco (12) and Foster-Wheeler (38), with the total cost estimated to run around $420,000. Throughout this period, there were improvements made to the heat exchangers. Many of these changes are too varied to explore in any detail, but some tube ends were welded, as well as rolled into an outer tube sheet; "O-rings" were added to the stay-bolts; the heat exchangers themselves were mounted on railroad car trucks; and the tubes increased in number from 8,800 to 8,981. Tube length was also increased from 27 feet, 5.75 inches, to 29 feet, 2.5 inches.

By the end of the fabrication process, Du Pont and the manufacturers came to prefer seamless tubing to the earlier seamed tubes, but both types were installed in the heat exchangers. By 1953, it was estimated that 65 percent of the heat exchanger tubes were seamless; the remainder were either welded-drawn or welded-swaged. To reduce any potential problems, only one type of tube was ever installed into any one heat exchanger; the tubes were not mixed.[77]

From the beginning of the Savannah River project, it was always planned to have two heat exchangers for each of the six pumps, for a total of 12 heat exchangers per reactor building. It was also planned to connect the two "in series," where water would go through the first heat exchanger, and then go through the second. As a result, two heat exchanger bays were constructed for each pump and piping system, to allow for two heat exchangers, and this was done from R Reactor to C. If only one heat exchanger was installed per pump in the first years of the reactors, it was only because of the dearth of heavy water during those first years.[78]

The decision to install just six heat exchangers in each reactor building, one per pump, was made in April of 1951.[79] This decision was confirmed in January of 1952 for the reactors at R, P, L, and K. When the heat exchangers were installed in R, each had 8,981 tubes and a dry weight of around 90 tons. Each was also mounted on 70-ton railroad trucks. They were given the E.P. Number 201.[80]

C was the only reactor where two heat exchangers per pump were installed from the very beginning. Here, the two heat exchangers were installed "in parallel," which was considered a better arrangement for higher flow. Here, a "Y" splitter was used to access the two heat exchangers, after which the lines were merged back into one line before entering the reactor.[81]

Due to the huge volume of water that had to enter the heat exchangers, provisions had to be made for cleaning the tanks and tubes. For general maintenance, oxalic acid was added to the river water during operation. The acid was introduced into the system from an 800-gallon dissolving tank by means of a 15-gpm pump and small pipelines installed into the heat exchangers.[82]

For other occasions, when the heat exchangers had to be scrubbed or replaced altogether, a means of moving and removing the heat exchangers had to be built into the reactor building. In the case of the first reactors, R and P, transfer cars (E.P. 210) and a four-wheeled transfer table were installed to move the heat exchangers whenever necessary. This took place in what were called heat exchanger transfer pits, located at the minus 40-foot level.[83] This transfer area was eliminated in the subsequent reactor buildings (L, K, and C). There, the heat exchanger area was covered by a series of concrete slabs. Located just outside of the reactor building, the slabs could be removed and the heat exchanger lifted out of position by massive cranes.

OTHER WATER SYSTEMS AND GAS FEATURES (Minus 20- and 40-Foot Levels)

Described above are the major features of the Savannah River reactor water system inside the reactor building. There are, however, a number of other smaller water systems essential to the safe operation of the reactors. One feature was the "upflow cooling system" used for the control rod clusters. While the main water flow in the reactor tank was downward from the plenum, an exception was made for the control rods. There, cooling water went up through the tubes of the septifoils and spread out into the tank just below the top shield. This obviated the need for seals at the control clusters and it helped eliminate hot spots in the tank.[84]

Another small system was called the Shield Water System. It had facilities for cooling the water that circulated in the annular tank around the reactor tank itself, as well as the top and bottom shield. Control for this water system was found on the instrument panel identified as 480.8 in Section D of the Main Control Room.[85]

There was also the Overflow System, which was used to keep the heavy water level constant within the reactor tank. This was done by continuously adding a stream of heavy water from the overflow tank, allowing the excess to flow over a fixed weir located one-half inch above the upper plate of the top shield. The excess would then return to the overflow tank. The original overflow tanks had a capacity of 600 to 800 gallons, which was thought enough to accommodate volume changes in the reactor tank levels that would arise from the temperature flux in the reactors. In late 1953, these tanks were replaced in all reactor areas by new 2,300-gallon tanks.[86]

The possibility for leaks was always present, and leak stations were established at around 60 different locations throughout the heavy water system to measure the amount of any potential loss. As already mentioned, the entire pump room at the minus 40-foot level could be used as a water basin in the case of major leak. At each doorway into the room, a three-foot high dam was designed to rise from the floor in the case of a spill. This spill water could then be pumped to Building 106, an underground tank with a capacity of 60,000 gallons.[87]

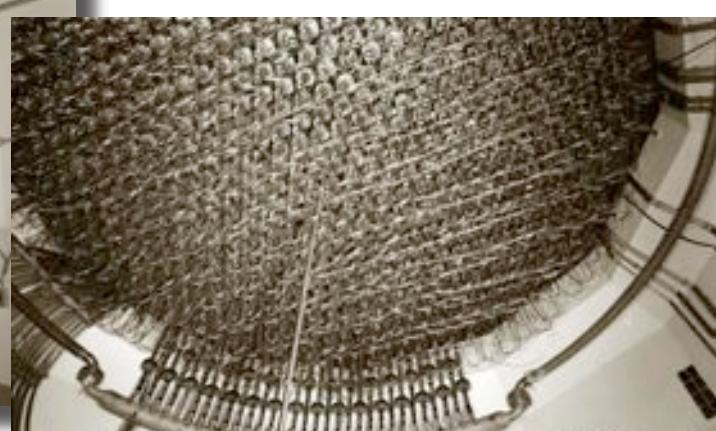
Still other water systems were created to deal with other possible emergencies. The Emergency Cooling Water (ECW) system was designed to flood river water directly into the plenum and the reactor in the case of the massive heavy water leak. Once activated, the ECW could be released into the reactor at the rate of 2,000 gpm.[88]

The scram and storage system consisted of a tank large enough to hold all of the heavy water in the reactor system, about 250 tons, in the case of a nuclear scram (an emergency reactor shutdown). The original idea here was to have a single scram tank directly under the reactor itself, but this idea was later dropped in favor of two separate tanks at the minus 40-foot level: one for the scram and another for storage. In the case of a scram, the heavy water would be moved to these tanks by means of gravity flow. The system could be activated from the heavy water panels in the main control room: valves would open in auxiliary six-inch lines affixed to each of the six suction lines between the reactor tank the pumps. Using these lines, the heavy water could be drained out of the main system in 2.5 minutes.[89]

Another safety feature was the Supplementary Safety (SS) Facility. This water system was designed to supplement the control rods and the safety rods, which were the first and second line of defense against a runaway nuclear reaction. As it was originally conceived, the SS system could inject 100 gallons of borate solution into the moderator though the control septifoils. First proposed in August of 1951, this idea was later abandoned. A number of other ideas were considered, but the system that was finally implemented in 1954 was to inject the nuclear poisons gadolinium and samarium into the moderator by means of spargers (an instrument used to inject one liquid into another). This system consisted of a 20-gallon storage tank for the nuclear poisons, three spargers, and the associated piping.[90]

The last system to be discussed, the Blanket Gas System, was not a water system at all, but was associated with the other water systems featured in the reactor tank. The Blanket Gas System, which used

(Left) Pin Room, SRS Negative No. 3600-02. (Below) Detail of Pins, SRS Negative No. 1000-27.



helium, picked up decomposition products given off by the heavy water in the reactor tank. This helped keep the heavy water clean and prevented the build up of potentially explosive compounds. The blanket gas operates in a 12-inch wide gas plenum located between the top of the heavy water and the "bottom of the water plenum chamber." The helium flows through the gas plenum at a rate of around 1,000 cubic feet per minute, with a pressure of 10 inches of water above atmospheric level. The gas then goes through a cyclone separator to remove any heavy water vapor picked up, and the returns to the Purification Area for processing.[91]

OTHER AREAS AT MINUS 40-FOOT LEVEL

There were other areas at the minus 40-foot level that were not directly associated with any of the water systems or the Blanket Gas System. Foremost of these was the Pin Room, a small chamber located directly underneath the reactor tank. The pin room was 16 feet, 8 inches high, with the floor of the pin room located at the minus 40-foot level. The room was named as the result of the many "pins" located underneath the tank and visible on the ceiling of the Pin Room. These pins represented thermocouples used to register temperature and water flow for each of the assemblies inside the reactor. The wires from these pins were bundled into large ribbons of wires that were fed directly into the instrument panels within the Main Control Room. The main machinery in the Pin Room included the Pin Extraction Machine (E.P. 169.2) and the Pin Cask (E.P. 169.3).[92]

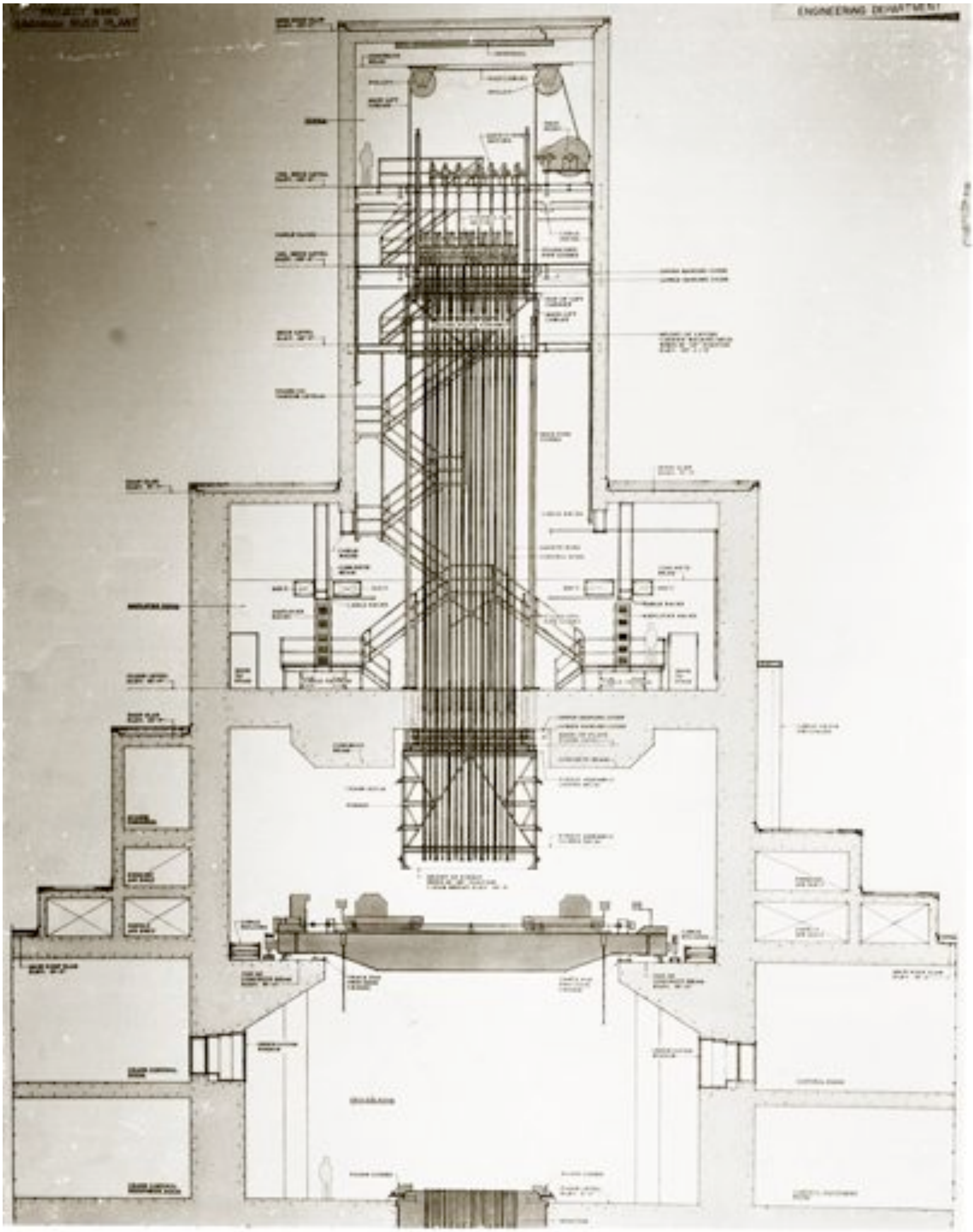
Another room at this same level was the Instrument Room, which contained transmitters to relay information about flow and temperature to other instruments in the Main Control Room at the 15-foot level.[93] On the opposite side of the reactor building from the Instrument Room was the Observation Room, also located at the minus 40-foot level. This allowed the observation of the Pin Room via periscope (E.P. 230), and the pump room by means of shielded windows. It also contained various pump monitoring instruments.[94]

Another room at this level was the Fan Room, which was adjacent to a deep well at the south end of the R Reactor building. The fan room had two fans, each capable of 135,000 cubic feet per minute. Only one fan operated at a time; the other was a spare.[95] As mentioned previously, this fan room was only found in the R and P reactors. It was moved to another level in the other three reactors.

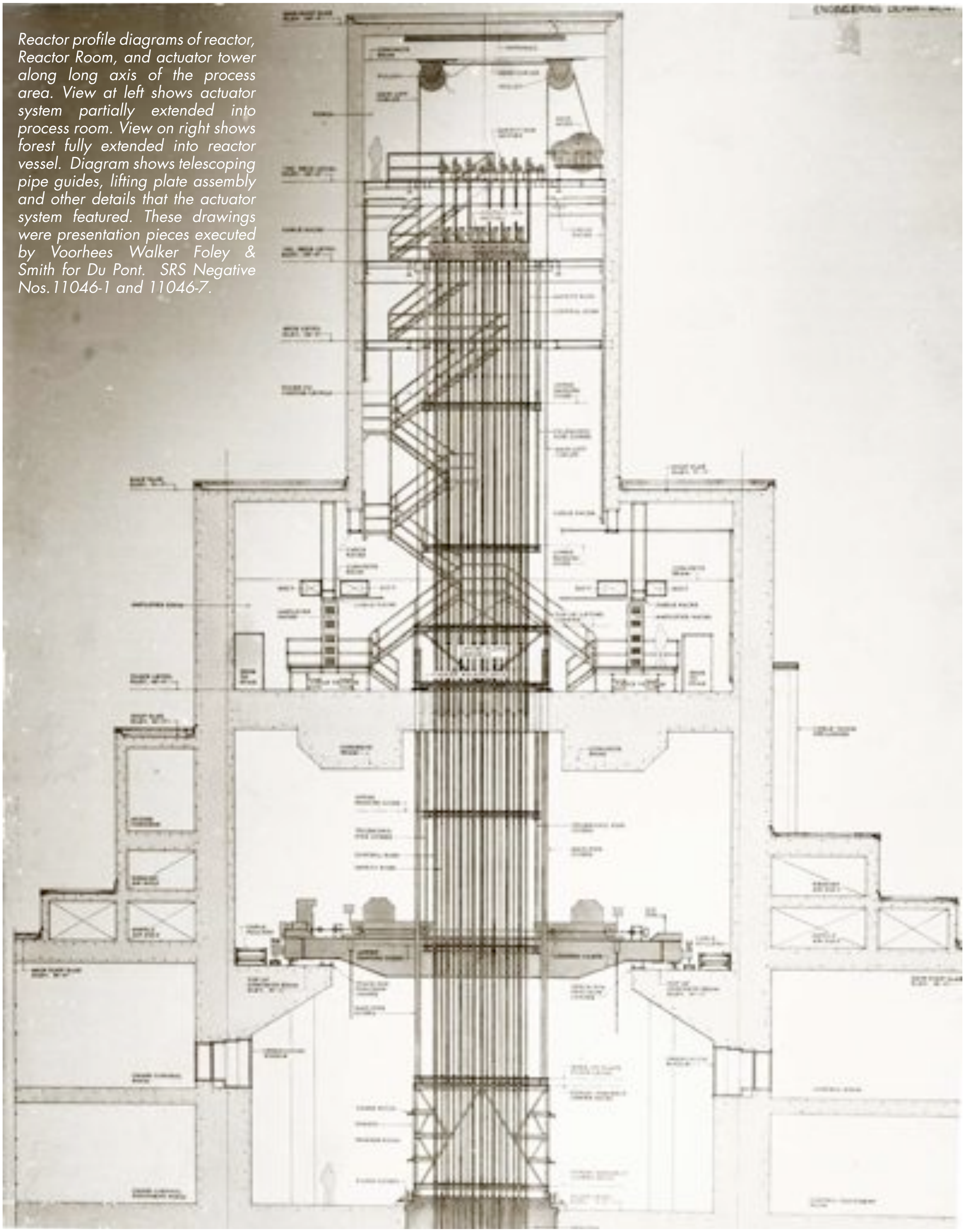
ACTUATOR SYSTEM

The area directly above the reactor, while not as massive as the giant water systems below it, is no less essential for the proper functioning of the reactor. This is the realm of the control rods and safety rods. The first is essential for the control of the nuclear reaction when the reactor tank is in operation, and the second is needed to shut down the reaction at the end of the operation, or end of a reactor cycle, as it is called. The system that controls these two types of rods was usually referred to as the actuator system, and it rose above the ceiling of the Reactor Room to levels 48 feet, 66 feet, 120 feet, 130 feet, and finally 149.6 feet above ground level. Level 48, which was effectively just above the ceiling of the Reactor Room, held the actuators. The T-amplifier units (used to amplify an electrical signal) were on the 66-foot level. The hoist for the four cables that lifted the forest, were found on the levels at 120 and 130. A final small hoist was located at the 149.6 foot-level, the very top of the actuator tower.

Actuator Tower Profile Not Extended, SRS Negative No. 11046-01.



Actuator Tower Extended, SRS Negative No. 11046-07.



Reactor profile diagrams of reactor, Reactor Room, and actuator tower along long axis of the process area. View at left shows actuator system partially extended into process room. View on right shows forest fully extended into reactor vessel. Diagram shows telescoping pipe guides, lifting plate assembly and other details that the actuator system featured. These drawings were presentation pieces executed by Voorhees Walker Foley & Smith for Du Pont. SRS Negative Nos.11046-1 and 11046-7.

Tower Extended with 90 Degree Turn, SRS Negative No, 11046-14.

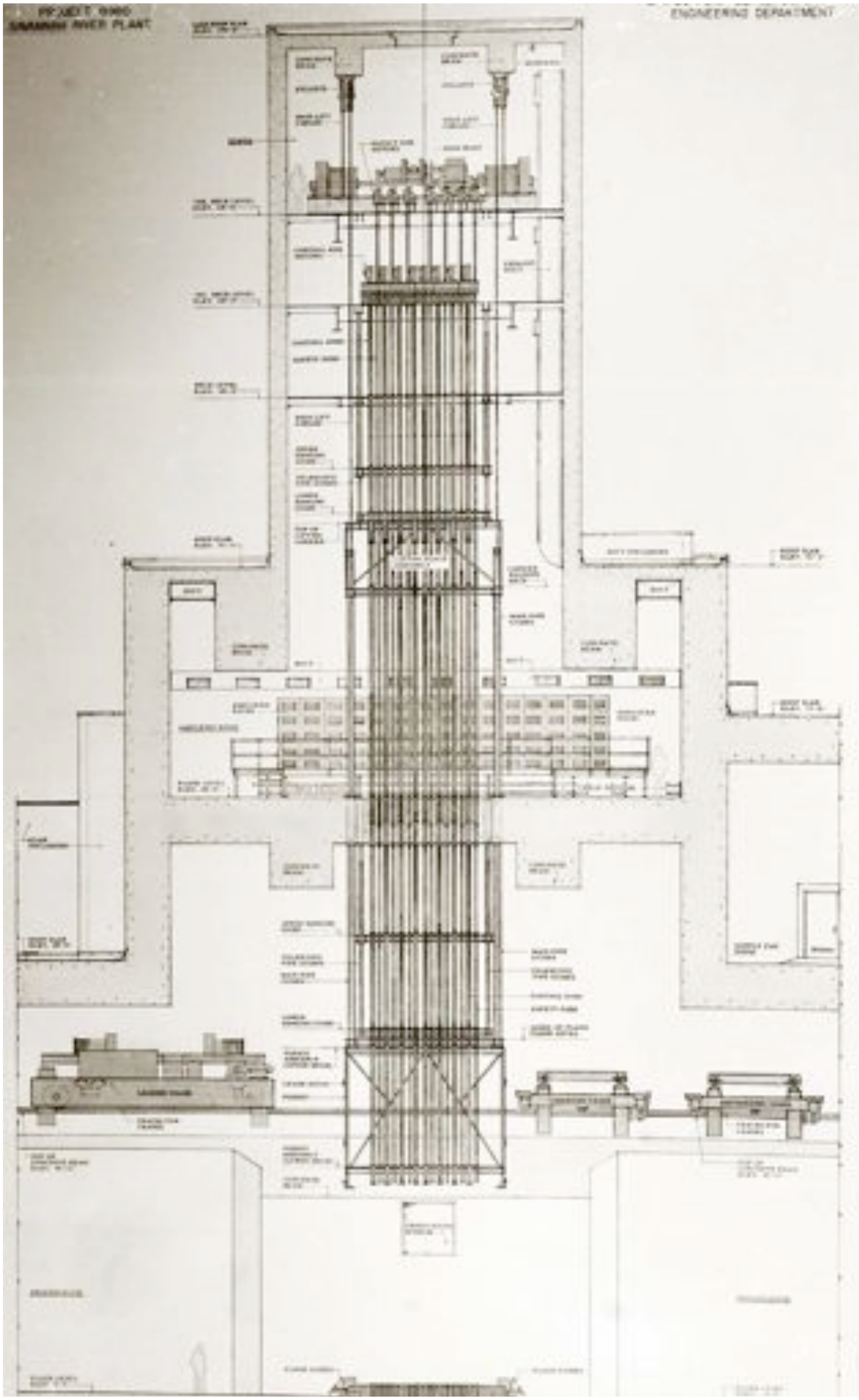
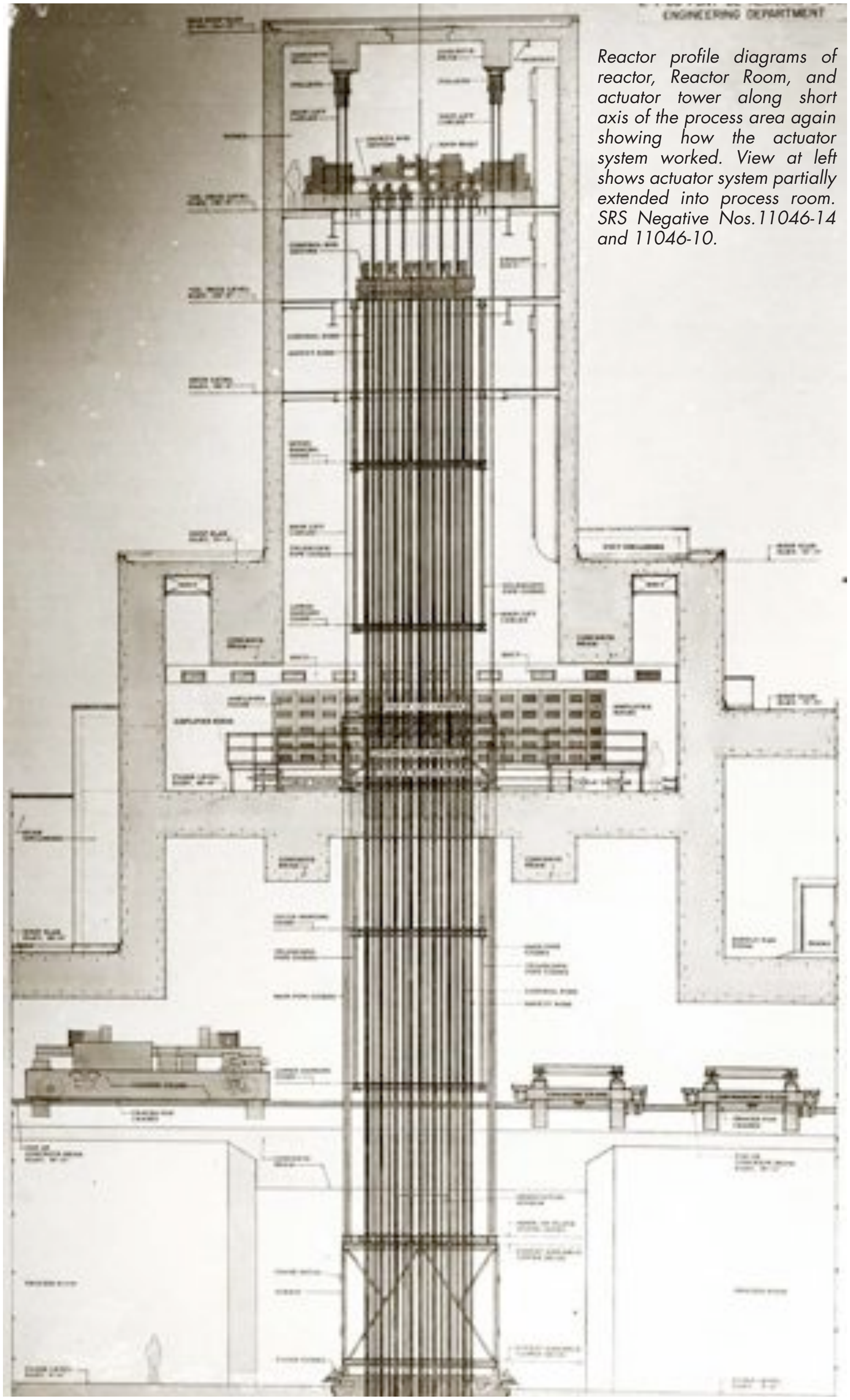


Diagram Showing T-Amplifiers, SRS Negative No.11046-10.



Reactor profile diagrams of reactor, Reactor Room, and actuator tower along short axis of the process area again showing how the actuator system worked. View at left shows actuator system partially extended into process room. SRS Negative Nos.11046-14 and 11046-10.

The control rods were bunched in clusters of seven rods per cluster. As a rule, the rods were either half-length lithium-aluminum (Li-Al) rods or they were full-length rods. Each cluster of seven rods was called a septifoil, and there were 61 septifoils for each reactor tank. The septifoils were positioned so that each was always in the center of a hexagon of fuel rod (quatrefoil) positions.[96]

The control rods are essential for the nuclear reaction. During the operation of the tank, the control rods had to be adjusted constantly to keep the nuclear reaction in what was called proper "nuclear trim," as well as to avoid nuclear hot spots within the reactor tank. Sometimes this operation was made more complicated by the presence of "producer elements" within the control rods, which were inserted to make use of the neutrons present in the reaction.[97]

The control rods were designed to control or limit the rate of nuclear chain reaction so that the operation would remain within the bounds of safe operation. Alternatively, the safety rods would be dropped into the reactor tank in order to shut the reaction down in the event of a scram or other accident. There were 66 safety rods for each reactor. There were two types of scrams, or incidents in which the safety rods were employed. The first and most serious, Scram I, required all safety rods, and all full control rods, to drop at the same time, at full-speed. The second, Scram II, was less serious, and only required the full control rods to drop into the tank.[98]

There were two parts to the actuator control system: the AG system that managed the control rods; and the AH system that controlled the safety rods. The two were basically independent of each other. The AG system was based on a servo system for the positioning of the control rods, which was done by means of position commands usually set by hand in the Main Control Room. The AG control was powered by Motor Package "A" drive, located on the 120-foot level.[99]

The AH system associated with the safety rods was powered by Motor Package "B." This was located on the 130-foot level, and was basically a pushbutton for the release of the safety rods, which would free-fall into the reactor tank. To prevent damage to the rods and the tank, the motors would serve to brake the fall just before reaching the bottom of the tank.[100]

During the early days of the project, there were at least two basic designs considered for the operation of the actuator system, and they were referred to as R1 and R2. The R1 method called for a structural unit or "forest," that would be carried into the Reactor Room by the 120-ton crane. This unit or forest would be 16 feet square in area, but 28 feet high, with three decks. The center deck would contain the 61 control rod actuators and their motors. The R2 design called for a smaller forest, 16 feet square with a height of 15 feet. This forest would only have guide tubes for the control and safety rods. All rods and their motors would be located above the Reactor Room. In this design, the forest could go up or down in place above the reactor tank, or be removed by the 120-ton crane.[101]

By the middle of 1952, when the construction of R Reactor was well underway, the decision was made to drop R1 and concentrate on R2. The first reactor, R, was initially to be equipped with the R1 system, but this was replaced by the R2 before the building was finished. All the other reactor buildings also used R2. As a result, the forest was designed to move up and down in place, but could also be removed by the 120-ton crane if necessary.[102]

(Above) Control Room Layout, SRS Drawing No. 10526-02. 1. Observation Window, SRS Negative No. 9776-03. 2. Graphics Panel, SRS Negative No. 1000-01. 3. Detail of Console, SRS Negative No. 1000-07. 4. Reactor Room in Operation, SRS Negative No. 9244-01.

As finally constructed, the actuator tower consisted of a number of levels, up to a height of almost 150 feet above grade. The 48-foot level, basically above the ceiling of the Reactor Room, contained the control and safety rod actuators, and the electro-mechanical means of raising the actuator structure (forest) off the reactor top during the charging and discharging operation. The 66-foot level contained a 1.5-ton electric monorail hoist, the "T" amplifier units, and (in L, K, and C) a "seal liquor tank." The "penthouse levels," 120 and 130 feet, contained the muscle for moving the forest. The 120-foot level contained the A Motor Package, while the 130-foot level contained the B Motor Package. There was also a 60-ton hoist with a four-cable lift for the forest, located above that level while a 1.5-ton electric monorail hoist was located at the very top, at 149.6 feet.[103]

CONTROL ROOMS AND PERSONNEL AREAS

The operations within the process area were monitored carefully, and this required trained personnel and the facilities for these personnel. Foremost among these facilities were the two control rooms, located at the 15-foot level and overlooking the operation of the process room. The main control room, also known as the Central Control Room (CCR) and more informally as the "brain center," was the location for the control panels for every aspect of reactor operation in the process area. This room was 43 feet by 108 feet, and had an observation window, with a periscope and hoist, overlooking the Reactor Room. The other control room, known as the crane control room, was where the movements of the C and D Machines, the 120-ton crane, and the huge vertical steel doors, were supervised. The crane control room also had an observation window.[104] In the first two reactors, R and P, the crane control room was located on the opposite side of the process room from the CCR. In the later reactors, the two control rooms were located side-by-side. Adjacent to the main control room, and also on the 15-foot level, were the other personnel areas, such as locker rooms, lunchrooms, and fan rooms placed close to the control room for obvious access reasons.

It took a large number of people to run the reactors, and it has been estimated that, on average, there were between 400 and 450 people at each reactor area to ensure the safe and efficient operation of each reactor. This sum included people from at least three different organizations during the 1950s: Operations; Reactor Technology; and Maintenance.[105] Naturally, these people were spread over the reactor area; not everyone worked in the reactor buildings. Among those that did their primary work in the reactor buildings, were Operations personnel and Reactor Technology personnel. Operations people actually ran the reactor: they controlled the dials in the control rooms. The Reactor Technology people supervised the operation of the reactor and made recommendations for any improvements or other changes to Operations, but they did not touch the dials themselves. This was a safeguard implemented by Du Pont, and it remained in place throughout the life of the Savannah River reactors.

The Operations people were part of the Reactor Department that was charged with the actually running of the reactors. Most operators had rather limited technical training and were simply taught to follow procedures, which could be long and complicated. The operators were managed by supervisors, who were still part of the Reactor Department. There were around 10 operators at each shift at each reactor, and around 3 to 4 supervisors. In the 1950s and 1960s, reactor operations went on around the clock, with three shifts per day. All operators and supervisors were required to work the graveyard shift (midnight to 8 a.m.) once a month, for seven days in a row.[106]

1. Locker Room, SRS Negative No. 4464-10. 2 and 3. Lunch Room Views, SRS Negative Nos. 3437-33 and 3437-38. 4. Foot and Hand Radiation Counters, SRS Negative No. 1943-08.

A handful of Reactor Technology people were also on hand for every shift. These were the people with formal training in nuclear engineering, and they provided technical support for Reactor Operations. They also checked for reactor safety, and they basically monitored the operations of the Reactor Department.[107] Based on what they saw, they also helped the Savannah River Laboratory design new fuel assemblies that would go into the reactor tank.[108]

The focus of the whole personnel area was the central control room. There were procedures written up for every aspect of the operation of the reactor, and virtually every aspect was supervised in the CCR. Basic reactor control requirements were written up by C.W.J. Wende as early as 1951,[109] and this work was reflected in the various start-up manuals created in 1952-53 that covered virtually every aspect of reactor operation. The creation of these manuals was overseen by the Atomic Energy Division (AED) Process Section in Wilmington, Delaware, and by the Savannah River Plant Instrument Department.[110] The goal was to take as much of the guess work out of reactor start-up and operation as it was possible to do in the early 1950s, before the advent of control computers. And much of the guesswork was taken out. As one Reactor Technology staffer said, "operating a reactor was much like being a fireman. Unless there was an emergency, there wasn't much to do."[111]

As established in the early manuals, there were three basic categories of reactor control: 1) the basic nuclear instruments; 2) the instruments that allowed operators to run the reactors at maximum capacity; and 3) the instruments associated with the auxiliary functions of the reactor: the pumps, the pipes, and the heat exchangers. There were also additional instruments to measure health physics data.[112]

Within the CCR, all of this information was organized and presented on panels that literally covered the walls of the room. These panels, fabricated by the Panellit Company, were assigned E.P. numbers just like any other piece of equipment. They were part of the 400 series of numbers, the series assigned to "instrumentation."[113] In the reactor control room, most panels were identified as E.P. 480, plus some fractional variation, such as 480.18 or 480.3W.

The CCR control panels were divided into two broad categories: the graphics panels, located in one half of the control room; and the nuclear or physics panels, located in the other half. The graphics panels show the entire water system for the reactor, the gas system, and the electrical arrangement graphically, with panels that actually depict the entire water and gas systems. They provided a summary of reactor operations at a glance. For example, the Process and Cooling Water Panel (E.P. 480.8) is actually comprised of six panel sections. Each of the heavy water pumps and heat exchangers are represented by an icon on this panel. Measurements are taken at each of these locations, and there are three separate systems for water activity measurements. The first system of water measurements deal with the process water (the heavy water) and is designed to find any leaks in the slug cans being irradiated in the reactor tank. The second system deals with the cooling water, and is designed to locate any leaks in the heat exchangers. The third system deals with the de-mineralized water found in the top and bottom shields, and the annular shield around the reactor tank.[114]

The nuclear half of the control room contained panels that show details of the nuclear operation. The main control panels were the partial rod trim panel and the full rod trim panel, and the X-Y Board. Temperature monitors used to detect the beginning stages of any slug failure are included.[115] There were also neutron counters to measure neutron flux distribution within the reactor core. These measure the number of neutrons that travel though a given area inside the tank within a set time.[116] A Q-foil flow monitor recorded the flow of process water through each quatrefoil. It would annunciate any pre-set drop (1 to 10 percent) from the normal flow found in any quatrefoil. If the drop reached 20 percent, it would both annunciate and initiate a scram, releasing control rods and safety rods into the reactor tank.[117]

There were other control features located in the nuclear or physics half of the control room, above and beyond the usual control features. Foremost of these were the reactor safety and emergency systems. The oldest, and the one built into the original system, was known as the "bull ring" or the "ring." By yanking on this ring, set into the wall of the control room, safety rods would automatically fall directly into the reactor tank, halting a nuclear reaction. Other more elaborate safeguards included the Emergency Cooling System (ECS) and the Supplemental Safety System (SSS). In the case of the SSS, nuclear poisons could be conveyed by means of small pipes that actually went from the control room to the reactor tank.[118] The first computers were installed in the control rooms beginning in the 1960s, and these were put in the nuclear half of the room. By the 1980s, these were powerful control computers that did much of the work required of manual operators during the 1950s.[119]

The very center of the CCR was the console, an elaborate three-sided desk located in the center of the nuclear side of the control room. The console, also identified as "Console M" in the early days, was the focal point of the entire reactor operation, for it was here that reactor data was organized and presented to a single person. This person had the means to control many of the operations of the reactor, including the actuator controls.[120] The other data systems within the reach of the console operator included the power calculating system, the temperature monitoring system, the power level systems, and the safety circuits and annunciators.[121]

As an example of some of the types of data available to the console operator, there was neutron flux, which had to be constantly monitored by the console operator while the reactor was critical. There was also the power calculator system, which measured the heat levels of the heat exchanger cooling water system, and recorded those power levels on a circular chart recorder. The Veeder-Root counter was the principal means of determining reactor power, and it was located on the console.[122]

Another, more isolated part of the control room was known officially as the Office and Record Room, but was known informally as the "fish bowl." This was a small glass-paneled room located immediately adjacent to the control room. In fact, this room jutted out into control room so that observers there could observe the operation of the control room. This area was usually reserved for supervisors, and it was where the operational logs were kept. In the R and P reactors, the fish bowl was situated near the middle of the central control room, on the side opposite from the Reactor Room. In L, K, and C reactors, the fish bowl was situated more to the side of the control room.[123]

A second control room, the crane control room, was adjacent to the CCR. Here were the power and amplifier panels that controlled the C and D Machines and the 120-ton crane. A good operator could work the controls so that an old quatrefoil could come out, and a new one be inserted, in two to four minutes. As mentioned earlier, the crane control room in R and P was situated on the opposite side of the Reactor Room from the central control room. In the later reactors, both control rooms were put adjacent to each other on the same side of the Reactor Room. The Crane Equipment Room was situated directly below the crane control room.[124]

There were other personnel and service areas located around the main control room. These were located either on 0 level or on 15-foot level, and included various offices, the power transformer room, the telephone room, the instrument shop, and what was called the welfare area. This included the locker room, with a capacity of 140 men, and a lunchroom equipped with 12 tables.[125] Also situated in this general area were the various health-monitoring devices, foremost of which were the four head-and-foot counters (E.P. 438-C) used to check for the presence of beta-gamma materials on the body's extremities (Instrument Start-Up Manual 1953:1001-2). These counters were positioned near the main personnel entrance for the reactor building, located near the center of the reactor buildings. There were, of course, other entrances available for the Assembly, Disassembly, and the Purification areas, but the main entrance was associated with the personnel area.[126]

VII. DISASSEMBLY

The basic function of the Disassembly Area was to receive and process reactor materials after irradiation. Such irradiated materials were "aged" to allow the excess radiation to dissipate, then disassembled to expose the main radioactive materials to be further processed. After the appropriate machines disassemble these materials, they were put into casks for shipment to Separations. Due to high radiation levels, most of these operations were performed underwater with remote-controlled equipment.

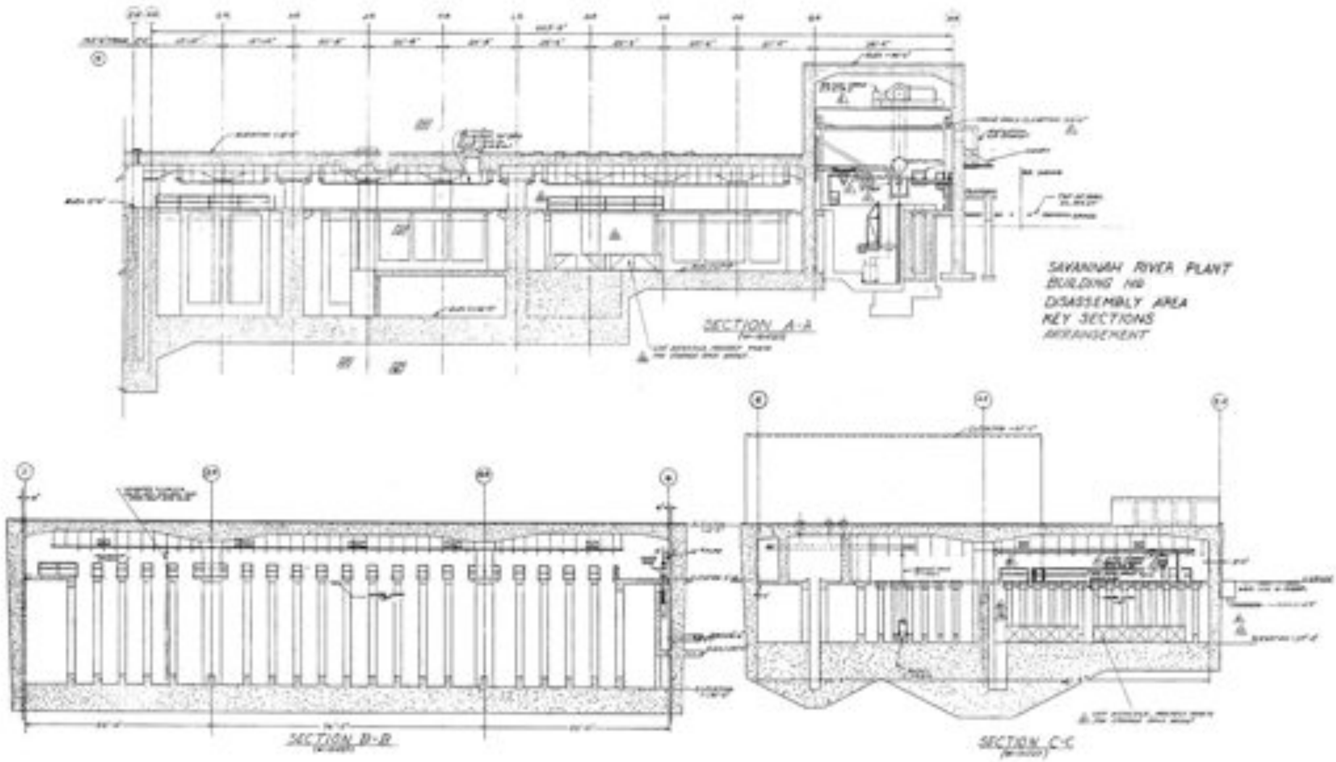
The Disassembly Area was able to process a wide array of vertical elements—virtually everything that could be inserted in the reactor tank. The most numerous and most important of these elements were the quatrefoils (fuel assemblies), but there were many other elements besides. These included instrument rods, safety rods, target control rods, non-target type control rods, thimbles, as well as full and empty septifoils. There also had to be facilities for the emergency handling of sleeves, plugs, spiral shields, and muffs. Spiral shields were spiral-shaped openings designed for each four-inch hole in the top shield of the reactor; they fit over the fuel and targets and allowed water to enter, but were baffled by means of spirals to provide a shield against the radiation in the tank.[1]

The connection between the Reactor Room and the Disassembly Area was the Deposit Point and the Exit Conveyor. It was by means of the Deposit Point and the Exit Conveyor that the Discharging Machine transferred the vertical assemblies from the reactor tank to the Disassembly Area. It was in Disassembly that the irradiated vertical elements were cut open from the outer tubes and cladding, in preparation for the transfer of that material to the Separations areas. Due to high radiation levels, this operation had to take place underwater. In addition, all irradiated materials were stored underwater until their removal to Separations.[2]

The Deposit Point is where the discharge machine dropped off each assembly for processing in Disassembly. At the Deposit Point, a machine called the "carrier" grasped each component. The carrier was positioned at the end of a large conveyor arm, that pivoted the component underwater into the Disassembly Area. This whole devise, the carrier, the drive, track, and the controls, was generally referred to as the Exit Conveyor. These actions occurred underwater in a channel that connected the reactor room with the Disassembly Area.

DESIGN PROGRESSION

Like every other part of the reactor building, the Disassembly Area went through a number of transformations in the design phase. Like most of the other areas, the main requirements for Disassembly were known from the beginning. The Disassembly details, however, were changed over time, and the details in each of the five reactor buildings were altered as well. This has tended to make any generalizations of the Disassembly Areas more problematic than is perhaps the case with any other single area of the reactor buildings.



Disassembly area shown in cross-section.

The basic design requirements of Disassembly were simple. There would be one story at ground level, with a large water basin below grade. All operations and storage had to be underwater, with the water shield kept at a minimum of 10 feet. Since the amount of water involved would be great, it was always understood that this would be regular light water, not heavy water. Within the huge water basin, there had to be internal walls to isolate any problems that might arise within a given area. There had to be a lot of storage, since many elements required a lengthy "cooling off" time before they could be processed. Fuel slugs, for instance, might require 90 days; lithium-aluminum slugs, 30 days.

There were at least three different historic designs for the Disassembly Area in R Reactor alone. The first detailed plan, drawn up in April of 1951, called for a Disassembly chamber covering an area of 186 by 325 feet, all of Class I construction. This large area was required when it was still assumed that the fuel assemblies would go into and come out of the reactor tank as a gang or sector of assemblies. When this idea was dropped, new plans were drawn up in May of that same year to accommodate the handling of single components. The monorail system was made more comprehensive, and the building size was reduced to 144 by 315 feet. Also, part of the Disassembly Area was constructed according to Class III building standards.[3]

The third and final design, the one that was basically used in construction of Disassembly in R Area, was prepared in July of 1951. This third set of plans called for an area 187 by 316 feet, a return to complete Class I construction, and the inclusion of a dry cave for the disassembly of the producer rods. Storage capacity called for 2,030 hangers. Provision was made for sleeve disassembly and storage, but this extra space was not needed after the development of the semi-permanent sleeve. This extra space was used for other general storage. The basin for bucket storage was originally designed for 800 buckets, but was soon increased to 1,870 buckets. Each bucket was designed to hold 250 fuel slugs or the equivalent in aluminum scrap.[4]

BUILDING DETAILS

As built, the Disassembly Area for R Reactor was a Class I construction that covered roughly 187 by 326 feet, only 10 feet longer than called for in the third set of plans. It consisted of one story above ground with a water basin underneath most of that area. The roof height from floor to ceiling was 15 feet, except for the southwest corner, which was 40 feet. The basin varied from 17 feet to 30, depending on the area. The foundation below the basin consisted of reinforced concrete resting on a pattern of concrete mats, each mat measuring 7.5 by 5 feet. Being Class I construction, the exterior walls and the roof were also reinforced concrete. The interior partitions within the water basin were also made of concrete.[5]

The Disassembly areas within the other reactor buildings were different. The one in P Reactor was smaller than the one in R, and somewhat more irregular in shape, measuring only 235 by 187 feet. The Disassembly areas in L and K were smaller still: 219 by 159 feet. And C Area's Disassembly Area was even smaller: 193 by 135 feet.[6]

The basins may have varied in size, but otherwise were similar. As a rule, they had depths that ranged from 17 to 30 feet, always providing an average shielding depth of 13 feet of water. The 30-foot depths were devoted to the machine areas and temporary tube storage; the 17-foot depth covered most of the other underwater areas. Concrete walls divided the underwater basin into seven areas to provide discrete work and storage areas. The canal leading into the Disassembly Area connected to one of these seven. The interior basin walls had vertical openings to permit the movement of materials from one area to another. These openings allowed for continuous flow throughout the basin, at a rate of 1500 gallons per minute. In the case of R Reactor, water entered through three supply lines in the south wall of the basin, and exited via five lines in the north wall, as well as one in the canal. This flow system helped remove excess heat from the basin. The basin capacity in R Reactor was 7.5 million gallons, and 1.5 million of these could be diverted to the emergency pumps in the 108-2 building for use as emergency cooling water. In the case of a slug leak or some other similar emergency, the wall openings could also be closed with portable bulkheads called "stop logs."

GENERAL AREAS AND EQUIPMENT

There were a number of specific areas within the Disassembly Area, largely based on the functions that were performed within those areas. Each area had its own special equipment, and some of the most important of these had a number of design changes over time. As might be expected, there were certain preconditions for all major pieces of equipment in Disassembly. The equipment had to be able to operate underwater. Such equipment could not use standard oil or grease, since this would obscure visibility in the water. It also had to be as simple as possible, in order to keep breakdowns and repairs to a minimum.

For the irradiated vertical assemblies to reach Disassembly, they had to enter the exit canal, which extended 148 feet from the transfer point in the reactor room, to the temporary tube storage basin inside Disassembly. On the way, the canal passed underneath the wall between the reactor room and Disassembly. This long canal, which connected the exit conveyor with Disassembly, was found only in R and P. It contained four lanes: one lane was for loaded hangers, one for the return of empty hangers, and two for storage.[7]

One of the most important pieces of equipment in Disassembly had to be the monorail system, the only major piece of equipment in Disassembly not located underwater. Featuring hangers from which the elements were suspended, the monorail system was in concept like the monorail system at a drycleaners. The monorail system connected the storage hangers in the canal, with those in the Temporary Tube Storage, and finally brought the irradiated materials to the Machine Areas No. 1 and 2. In fact, the monorail system extended throughout the basin area of Disassembly. The rails themselves were located at the 7-foot level. In R Reactor, the movement of the vertical elements on the monorail system generally went from east to west on fixed rails. Any movement between the rails in a north-south direction was effected by monorail transfer cranes that were operated manually.[8]

One of the largest of the Disassembly areas was the Temporary Tube Storage. Irradiated materials were placed here in order to "age," allowing some of the more deadly and unstable isotopes to wear off. The Temporary Tube Storage consisted of 40 storage lanes, each about 46 feet in length. This at least was the situation in R and P. In L and K, there were 48 lanes; in C, only 25 lanes. These lanes contained storage hangers that would be placed in the lanes by means of an electric crane. These hangers would be stored in the Temporary Tube Storage before continuing on to the various disassembly machines.[9]

Most of the work in Disassembly was done in Machine Areas No. 1 and No. 2. At least this was the case in R and P. The two machine areas were combined into one in the later reactors L, K, and C. Machine Area No. 2 contained the vertical fuel tube (quatrefoil) disassembly machines. These were the standard disassembly machines. Here, the irradiated fuel slugs were extracted from the quatrefoils and taken to Bucket Storage. Machine Area No. 1 was devoted to cutting up the empty foils so that they could be stored in underwater buckets as scrap metal. In addition to the foil presses and shears that dealt with the scrap metal, this area also contained rod shears capable of dealing with safety rods, cadmium rods, and rod extensions.

The most critical machine in Disassembly was located in Machine Area No. 2 (at least in R and P). This was the vertical tube disassembly machine. In R Reactor, there were two such machines in this area, with the possibility of a third, if needed. These machines operated at basin depths of between 17 and 30 feet underwater. The vertical tube disassembly machines were essential components in the entire operation of the reactor, and a number of variants were tried before it was decided to go with a hydraulic double-acting cylinder with a solid piston and an attached 17-inch ram. Other machines in this area included the foil rod extractor, and the rod extractor tongs. Machine Area No. 1 contained the foil press used to cut and press the aluminum casings or foil scrap from the vertical assemblies so it would fit into the bucket storage. The rod shears (E.P. 326), also found in this area, were designed to cut the various rods into short lengths for bucket storage. These rods included safety rods, thimbles, cadmium rods, and rod extensions.[10]

Bucket Storage in R Disassembly was comprised of 22 lanes, each with a length of around 143 feet. These were for underwater buckets that contained fuel slugs or scrap metal, kept at a depth of at least 17 feet below the surface of the water. Bucket storage was basically the same in the other reactors, except for C. There was no bucket storage area in C Disassembly; this facility was replaced there by a "final storage area" of around 18 by 185 feet.[11]

An area available for slug inspection was the Monitor Basin.[12] Here, a turntable was provided for underwater examination of fuel slugs, which could be rotated on the turntable for remote examination with a binocular microscope. The operator sat at a desk at ground level, above the basin. The microscope in the Monitor Basin was found only in R and P; in L, K, and C, no equipment was installed in the Monitor Basin, even though it was designed for such installation if needed.

Another important zone was the Emergency Disassembly Area, located downstream from the rest of the Disassembly basin. This made it easier to isolate any contamination, and it guaranteed that any contamination that might escape in this area would be carried out of the building to the basin overflow area. The Emergency Disassembly Area contained equipment only in R and P, and that consisted of a tipping device and a horizontal fuel tube disassembly machine, known as a "plow." These machines and this area were designed to deal with quatrefoils and tubes that might be damaged and could not be processed in the normal vertical disassembly machines.

The most important piece of equipment in the Emergency Disassembly Area was the horizontal fuel tube disassembly machine (E.P. 322). This was also known as the "plow" or "plow machine," named after the manner in which this machine opened up a quatrefoil. It was designed to process quatrefoils that were damaged or for some other reason could not be recovered with the vertical machines. The horizontal fuel tube disassembly machine was normally used with a tipping device (E.P. 357) that would take the vertical quatrefoil to a horizontal position. There was also an Emergency Sleeve Remover, to be used whenever an assembly sleeve was damaged and had to be cut up and removed.[13]

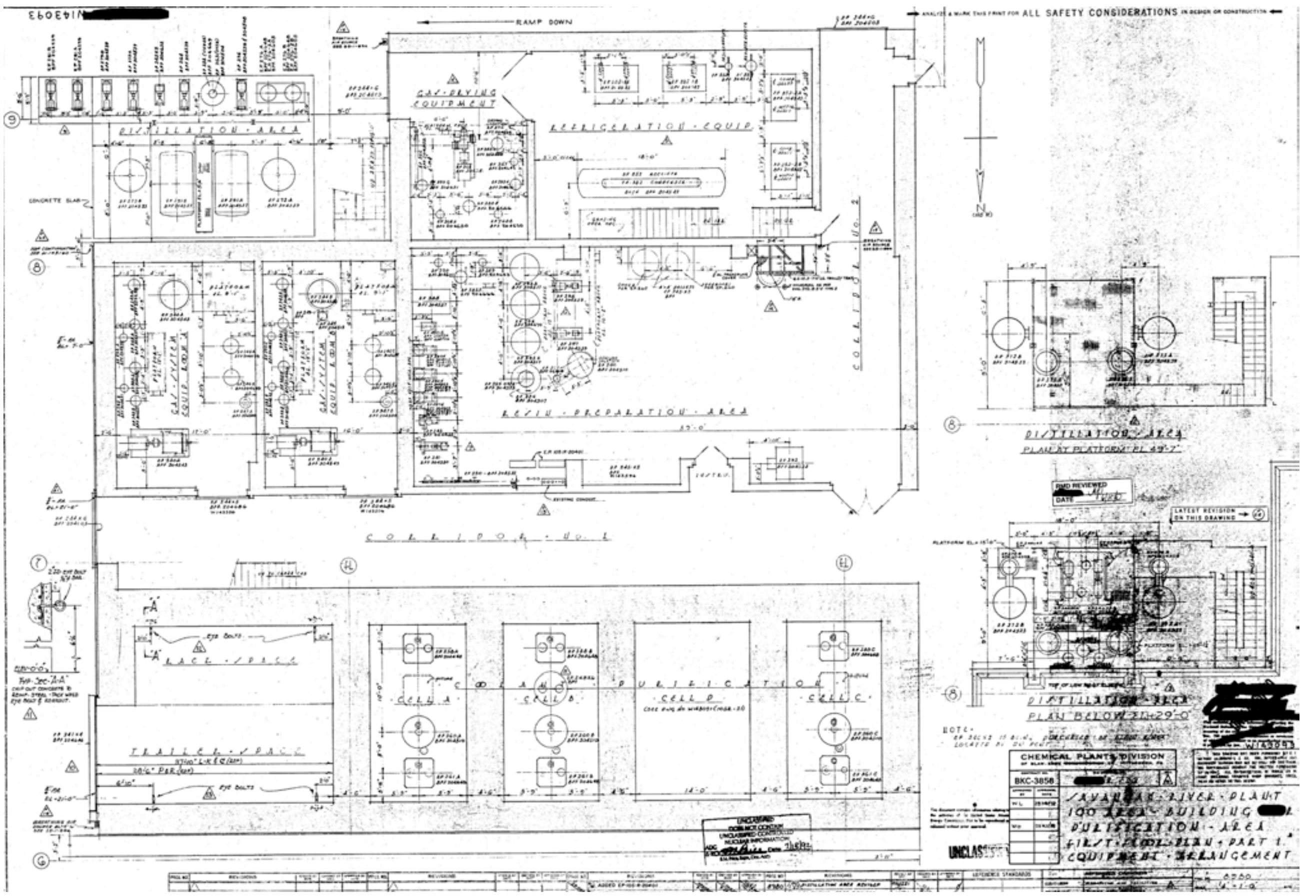
Another important area was the Dry Cave, located at ground level above the basin. The purpose of the Dry Cave was to receive loaded septifoils where they could be unloaded and delivered to the rod disassembly machines. These machines were designed to deal with radioactive materials other than uranium that could not be processed with the quatrefoil disassembly machines. In R, the Dry Cave covered an inner area of 76 by 15.5 feet, surrounded by 30-inch thick concrete shielding walls and four shielding windows. It was equipped with two rod-disassembly machines, identified as E.P. 321. Materials to be handled in the Dry Cave were brought into the area from underneath.[14]

Inside the Dry Caves of the R and P reactors was a separate enclosed room called the "Hot Lab." This was located in the corner of the cave and was equipped for remote measuring, such as weighing dry fuel slugs with master-slave manipulators. There was also an underwater periscope for examining canned fuel slugs after extraction from the quatrefoils. This arrangement was different in the later reactors. The dry caves in L, K, and C were smaller than those in R and P, and they were constructed without hot labs.[15]

One of the last areas of Disassembly was the Transfer Station, where there were platforms to assist with car loading. Slug buckets were brought to this area from the basin and were placed in shipment casks. Scrap metal was also loaded in this area for removal to the burial ground. Radioactive materials in need of further processing were shipped from this point to the Separations areas.[16]

VIII. PURIFICATION

The main reactor process began in the Assembly Area, went through the Process Area, and came out in Disassembly. The Purification Area was not directly a part of this line, but was still an essential part of the whole operation. Even though the Purification Area was located in its own section of the reactor building, it can be considered part of the Process Area, since it helped regulate what went on in the reactor tank. The main purpose of Purification was to constantly check and purify the heavy water moderator that was so vital to the operation of the reactor. It also sampled and purified the helium blanket gas in the plenum. Both of these functions helped keep the reactor running at optimum capacity.



View of Purification Wing, R Reactor, First Floor Plan, Part 1, SRS Drawing No. W143093.

Specifically, the function of the moderator purification system was to prevent the accumulation of foreign elements in the heavy water. This included the cleanup of any materials left in the heavy water moderator as the result of slug failure in the reactor tank. It also maintained isotopic purity of the heavy water. All this was done by a combination of filtration, deionization, and distillation, with the water treated through an average flow of 30 gallons per minute, which was sufficient for a daily turnover of all the moderator in the reactor system. This flow was diverted to the Purification Area after going through the heat exchangers; after purification, it rejoined the main flow on the suction side of the circulating pumps. The smaller blanket gas system also cleaned the moderator. Using helium as a blanket gas, it swept over the surface of the moderator inside the plenum, and took away any oxygen and deuterium. Those elements were then salvaged from the helium and returned to the heavy water moderator.[1]

DESIGN ISSUES AND BLAW-KNOX

From the beginning, considerable attention was devoted to the Purification Area. To a large degree, this was because of the high cost of the heavy water moderator, and the need to keep the heavy water free from ground water contamination, light water vapor, and other impurities that would affect its moderating abilities in the reactor tank. Other design requirements called for the area to have Class I construction, thick concrete walls to shield from potentially high levels of radiation, and the necessity of remote handling. Also, the continuous operation of the gas system required the presence of stand-by gas purification facilities in case of emergency.[2]

Du Pont began the first design work on the Purification Area in the summer of 1951. Even at that stage of the design work, there was recognition of the need for remote handling and cell-type construction as a means of protection from radioactivity. The cell principle and other remote methods of operation had been previously used to great effect by Blaw-Knox at Hanford, in Washington State. Blaw-Know was already under contract at Savannah River for design work in the 200/Separations areas. Because the work required in Purification was similar to what was going to be required in 221-F, Blaw-Knox was tasked to design the Purification Wings of all the reactor buildings. This decision was made in September of 1951, and it was the only instance in which Blaw-Knox was used in any of the 100 Area designs.[3]

Working with Du Pont, Blaw-Knox prepared the first design layout of the Purification Area in late 1951. This layout featured labyrinth cells, a central pipe alley, and two cranes. After some study, this design was found to require too much space. One of the cranes was determined to be unnecessary, and the outside loading of the casks for Purification was found to be too close to the receiving area for Assembly.[4]

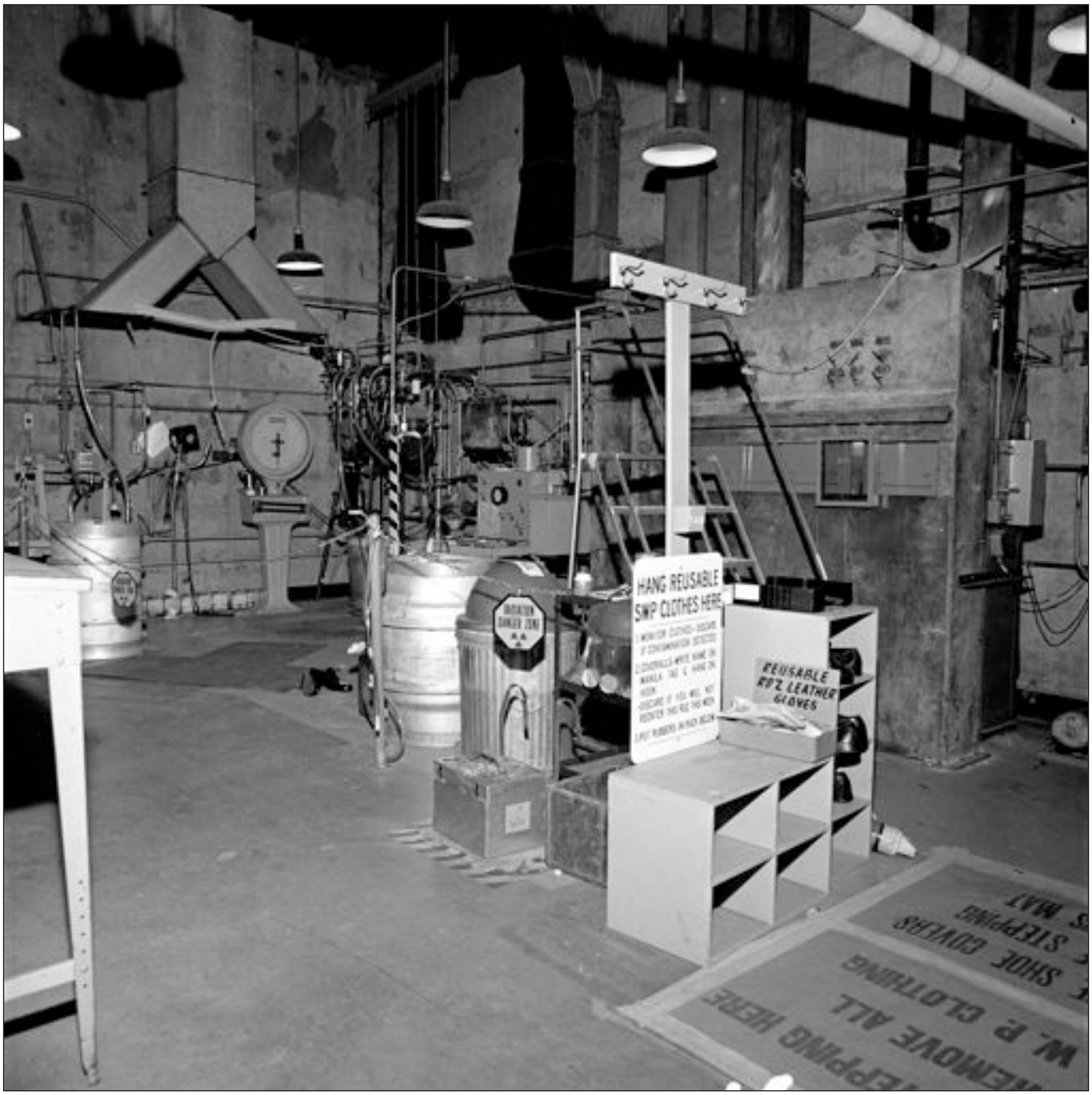
The second design layout for the Purification Area was prepared in early 1952. This called for two floors: the main floor at the 3.5-foot level, and a basement at minus-9.5 feet. The operation cells were located on the main floor; the basement contained the cell tunnels and other facilities. The concrete cell walls were 4.5 feet thick. Other features, depicted on the first plans, were dropped, including a labyrinth entrance to the four cells, and observation windows into the four cells. A remote optical system was added instead. Also, a five-ton crane was added to assist with any repair work on the cells.[5]

The second layout was basically what was adopted for both R and P. Each reactor had four cells, each remotely-operated, labeled A through D. The D cell was basically a conduit. It could detain any moderator that was deemed too impure to forward to the other three, but usually the heavy water it received was pumped to cells A, B, and C through parallel systems. Each of these three contained moderator purification units—pre-filters, deionizers, and after-filters, connected in series– located inside of the cells. In case of emergencies, there were two units on stand-by. Each of the three cells received a flow of 30 gallons per minute, and moderator was processed through a combination of filters and deionizers. There was a special filter found only in B that would remove any radioactive contamination in the gas used to dry equipment in A, B, or C. The last three reactors, L, K, and C, had Purification Areas that were smaller than those in R and P. Each of the later reactors were only equipped with two cells, identified as E and F. Neither of these cells was equipped with pre-filters.[6]

Building Details

The final engineering drawings for the Purification Area in R Reactor are listed in the Blaw-Knox history of work at Savannah River Plant, compiled in 1954.[7] As these plans make clear, the as-built Purification Area was a Class I construction that covered an area 97 by 158 feet. There was a main floor and a basement, with the roof elevation found at the 22-foot elevation. The foundations and exterior walls were of reinforced concrete. Interior partitions were of poured concrete, with some rooms formed by metal studs and cement asbestos boards such as Transite.[8]

Main Floor, SRS Negative No. 12843-16.



The cell area, containing four moderator purification cells, was located on the main floor. There was also a 30-ton crane located overhead for placing and replacing equipment in the cell areas. Essential to the operation of the cells were the distillation towers. These were columns located just outside the Purification Area, and were 83 to 88 feet high. These towers processed the system's heavy water, bringing it back to the required purity as needed. Returning to the inside of the building, there were a number of other work areas within the Purification Wing. These included the counting room, offices, the electrical control room, the instrument control room, the mass spectrometer room, the chemistry lab, the refrigeration equipment room, the gas drying equipment room, the gas purification system equipment rooms, the resin preparation area, change room, and toilet facilities. All of these facilities were made operational in R reactor. Even though these same facilities were constructed in P, many were not made operational since it was determined they were not needed. In P Reactor, the chemistry laboratory, the mass spectrometer room, the laboratory and counting room, were all left empty.[9]

The features common to all five Purification Wings were the purification cells and the distillation towers. As mentioned above, the first two reactors, R and P, contained four cells (A-D), while the later three had just two (E-F). These cells were the center of the purification operation. In the case of R and P, the moderator heavy water first entered Cell D, which was considered a "deep cell." Thirty feet deep and covering an area 14 by 22 feet, the D cell was equipped with a temporary storage tank. From D cell, the heavy water was pumped to the other three, A, B, and C. These three were "shallow cells," 12 feet deep and covering an area 12 by 22 feet. Each was equipped with the pre-filters, deionizers, and after-filters needed to purify a stream of moderator.[10]

View of Cells, SRS Negative No. D2 x 2100.

In those cases where the purity of the heavy water had to be improved, the water was sent to the two distillation towers immediately outside each Purification Area. These towers were mounted outside the building and were exposed to the elements, since they did not require any shielding.

The Purification Wing also contained the blanket gas purification system. Here, helium gas passed over the surface of the moderator in the reactor plenum, and was cleansed of any oxygen and other unwanted elements before returning to the plenum. There were two identical gas purification systems in each reactor, with one always on stand-by.[11]

The helium gas was circulated through the system by means of blowers. To purify the gas, the first stage in the operation was to send it to the Gas Purification System Equipment Rooms "A" and "B." Each of these rooms had an area of around 17 by 27 feet. In these rooms, the gas went through a catalyst bed of palladium, supported on alumina pellets in the catalytic recombiner. In the recombiner, deuterium and oxygen were combined into deuterium oxide vapor. The gas then went to the gas cooler for condensation of the heavy water vapor. A gas spray separator then removed the condensed moderator. At this point, there was a difference between the operation in R and P, on the one hand, and L, K, and C, on the other. In R and P, the vapor was refrigerated to prevent the loss of any heavy water. Ammonia was used as the refrigerant. In L, K, and C, a desiccant system of drying beds was used in lieu of refrigeration. There were other minor differences as well. In L, K, and C, the blanket gas piping was simpler.[12]

In R and P, the Refrigeration Equipment Room measured 23 by 34 feet, and contained two ammonia compressors, two booster compressors, and a condenser receiver tank. The Resin Preparation Area, also found in R and P, was a room that measured 29 by 50 feet. This room had equipment to perform several functions, foremost of which was charging resin into a new deionizer. The Gas Drying Equipment Room, also found in R and P, measured 14 by 23 feet, and had a gas blower for drying spent filters and deionizers in position in cells A, B, and C. Heavy water vapor was then recovered from the drying gas.[13]

Many of the areas or rooms discussed above were only found in reactors R and P. This was the case for Refrigeration, the Resin Preparation Area, and the Laboratory Room. Alternatively, there were storage and "make-up areas" that were found only in L, K, and C.[14]

The final room to be discussed is the Purification Control Room. This room, which covered an area of around 20 by 30 feet, contained a "U"-shaped

Control Room, SRS Negative No. 12843-04.

Control Room Operator, SRS Negative No. 4378-09.

instrument control panel that had an overall measurement of 28 by 10.5 feet. This panel was divided into three sections, two wings and a center. This panel provided control over temperature, pressure, and flow rate within the purification cells and distillation towers, as well as similar controls over the gas system. There were also leak detection devices and health monitoring units, such as Kanne ion chambers.[15]

IX. REACTOR DIFFERENCES

As we have seen, there were a number of differences in the layout and composition of the reactor buildings and the reactor areas, from R, the earliest of the Savannah River reactors, to C, the latest. Many of these differences have been discussed in the previous chapters, but much of this discussion was incidental. The emphasis in the previous chapters was usually on the design and construction of R reactor, since it was the first, and therefore the subject of considerably more study than the others. In the Savannah River Plant literature from the 1950s, it was always assumed that R was the baseline, the one that was always described in detail as the Savannah River reactor. There was a tendency to discuss the others only as they varied from this baseline. Up to this point, our discussion of the reactors has followed this pattern.

Reactor design, however, did not stop with R, and new improvements were made every step of the way in the design and construction of the later reactors. As these improvements were made, they were incorporated into the overall design, and this included changes to the reactor building as well as the surrounding buildings in each reactor area. As a result, there were both numerous substantial and minor changes to each of the reactors, making each reactor building and even each reactor area unique. This chapter is an attempt to correct some of the over-emphasis on R reactor, by describing in more detail the differences among the other four reactors at Savannah River.

As has been pointed out both here and in other sources, the five Savannah River reactors can be divided into two main categories, based on layout and size. R and P comprise the first general category, while L, K, and C constitute the other. As an example, take the process rooms in each reactor. The process room itself in L, K, and C is wider than it is in R and P. The long transfer canal, used as the exit point in R and P, is not found in the later three. Also, there was a fan room in L, K, and C, where there was not one in the older R and P.[1]

Aside from these general categories, however, there were features within each reactor that also make each unique. The basic progression of this development went something like this: R reactor was overbuilt out of necessity, to ensure that the facility would work and that could be constructed safely. As a result of constructing R, it was found that many of the features in that first reactor were superfluous. By the time the overall plans had been changed, P was too far along to be altered, except in various details; the layout was already basically frozen. The big layout change came with L. The subsequent reactors, K and C, followed this model. Further economies in design led to a few other changes in C, the last reactor. As a result, C Reactor, especially the reactor tank itself, is a unique construction.

The size of each reactor building is different, regardless of category. As can be seen from the chart below, there was size differences found in each area of the different reactors.[2] The following measurements are given in thousands of square feet:

Table 15. Reactor Comparative Measurements in Thousands of Square Feet

	R	P	L	K	C
Assembly Area	39.9	30.6	31	31	31
Process Area	344	344	296	296	297
Disassembly Area	94.8	67.9	61.8	61.8	68.2
Purification Area	23.6	23.6	16.8	16.8	16.8
Total	502,374	466,183	405,476	405,476	412,922

P REACTOR

P is the reactor that is closest to the original R baseline. It has the same basic reactor building layout, a layout that would change radically with the later three. Even so, there are a number of differences that separate P from R.

Even though P Reactor is like R Reactor, P is slightly smaller, by the elimination of some 14,000 square feet. The main differences were in assembly and disassembly, where one bay was eliminated from the former, and three bays were eliminated from the latter. Most of this change was made due to the elimination of storage space for the sleeves. The decision to make this change was made in January of 1952.[3]

Specifically, one of the Assembly bays was deleted from the plans for P reactor when it was decided to eliminate one of the Assembly crane systems and the associated transfer rail car, and use a crane to unload the supply trucks instead.[4] This redesign of the Assembly area for P was worked up in January and February of 1952 in the form of eight new engineering drawings. Similar work was done in Disassembly as well.[5]

In the reactor area, outside the Reactor building, the biggest change by far was the elimination of the 183 Clarification Plant from P area, and from every subsequent reactor area. By March of 1952, about the time that design changes were being made to the Assembly and Disassembly areas in P, it had been determined that the clarification basins were not needed—untreated raw river water could be run through the 186 Reservoir and the 190 Pump House, directly into the heat exchangers inside the Reactor buildings. This was the result of research conducted at the pilot plant facility known as CMX, which had been in operation since the summer of 1951. After extensive testing at CMX, it was found that silt and film deposition was not a problem within the river water cooling system, especially at the velocities anticipated in the reactor heat exchangers. In fact, it was found that the occasional dose of chlorination was all that was needed.[6]

L AND K REACTORS

Spurred by the changes made to P reactor, Du Pont determined to do a complete design overhaul of the next series of reactors. This included a new layout for the reactor building, as well as additional changes to the Assembly, Disassembly, and Purification areas. Initially, when the first ideas for a new design were being explored in early 1952, it was assumed that they would only affect C reactor, the last to be constructed, since so little had been done on this reactor at that time. However, the new arrangements looks so promising that by April it was decided to scrap existing plans for L and K, and go with the new layout for these reactors as well.[7]

Even before this period, it had been recognized that there would have to be some changes to the reactors constructed after R and P. For the most part, this was due to the need for higher power levels, extra shielding from radiation, and the possibility of using enriched and/or depleted fuel, in addition to the usual natural uranium.[8]

As a result of all these issues and others, the basic layout of the Reactor buildings was altered to reflect the new ideas of reactor economy. The reactor buildings themselves were designed to be smaller. Now, rather than having an appearance that looked like an indistinguishable mass of building blocks, the new designs called for Reactor buildings that had a "small waist" in the middle. The waist contained the Reactor Room, and it was "narrow" because the method of removing the heat exchangers had changed. The heat exchanger transfer cars were eliminated. With the new arrangement, large ground-level panels could be removed on either side of the waist, to effect the removal of the heat exchangers, which could be hoisted up by a boom crane.

There were other changes as well. Alterations were done in the Assembly and Disassembly areas, fan rooms, and personnel areas. Du Pont provided the general drawings of the changes they had in mind, and these were finalized by Voorhees,Walker, Foley, and Smith in the form of 60 full-sized "W" drawings. These also became the basis for L, K, and even C reactors.[9]

This was a sea change in the construction of the reactors, and it explains the big differences between R and P, on the one hand, and L, K, and C, on the other. Some of the main changes are listed here. The large canal that connected the exit conveyor in the reactor room, to the Disassembly area, was eliminated. Some 44,000 square feet of floor space was eliminated from the lower levels of the process area. The reactor room itself was made 36 feet shorter. As mentioned already, the heat exchanger transfer cars were eliminated. The main control room and the crane control room, previously separated, were brought together in the new layout. The Assembly area went from blast proof Class I construction, to more expendable and cheaper Class III. One of the reasons for the unusual flow arrangements of the first two reactors, was the possibility that an extra reactor might some day have to be installed on the side. This need for future reactors was eliminated by the time these plans were finalized, and this also made it possible to eliminate the heat exchanger transfer cars.[10]

In the Assembly area, the bays for receiving, storage, and assembly were done as Class III construction, while the older Class I category was retained for the final storage and the Presentation Point. The layout of the Assembly area was also modified from what it had been in R and P.[11]

Another change in overall design was the location of the Reactor control rooms. The main control room and the crane control were basically put together, and located above the Disassembly Area. There was also a single observation window located at an angle to provide a complete view of the reactor room.[12] There was also some alteration in the design of the new stack.[13]

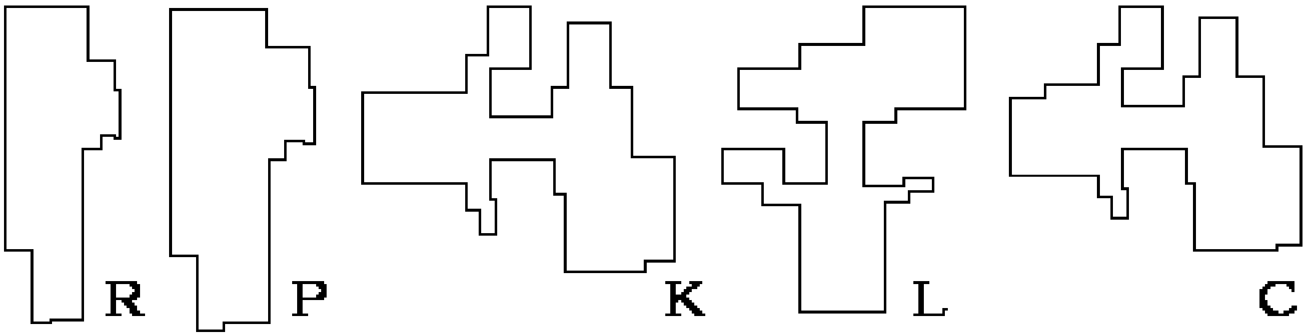
The location of the Disassembly Area was really altered in the new plans. Without the need for a second reactor at each of the Reactor buildings, it was now possible to shift Disassembly to line up with the discharge side of the reactor room. This put the Process Area and Disassembly in a more direct alignment. In the case of L reactor, the Assembly Area was located to the north, off to the side, followed by the Process Area (with the heat exchangers located underground on both sides of the reactor area), with the Disassembly Area to the south. The two 108-buildings were located on either side of the Disassembly Area. Purification was situated on the west side of Process Area. The new line-up, especially from Assembly, through Process, to Disassembly, was more efficient than the old arrangement, and led to a more direct route for materials from the reactor room to Disassembly. This of course did not eliminate the need for the Discharge and Exit Canal, also know as the D & E Canal, which still connected the Process Room with Disassembly in all five reactors. It did eliminate the need for the right-angle turn and the long canal that connected the D & E Canal with Disassembly in R and P.[14]

Another Reactor building area that went through a number of changes was the Purification Area, also known as the Purification Wing. The Purification Area in L, K, and C was made smaller and simpler to operate than the older system used in R and P. The dimensions of the new Purification Area were around 114 by 72 feet. It was comprised of a basement and a first floor, with a crane-way area, just like in R and P. One big difference was that there were just two cells, E and F, in the new Purification. Both were shallow cells, equipped with deionizers and evaporators. E cell measured 23 by 17 feet in area, with a depth of 13 feet. F cell was identical, except that the width was 14 feet rather than 17. The cells were still served by a 30-ton crane, but it was made easier to use. No provision was made for some of the facilities found in R and P, such as the resin preparation facilities, and the laboratory facilities, the mass spectrometry lab, and the counting room. In those cases, it was found adequate to simply use the facilities already in operation in R and P. The distillation towers, located outside, were similar in size and function to those already in use in R and P.[15]

Another major change in the Purification Wing was the use of desiccant beds rather than refrigeration in the gas-drying operations. There was still a Gas Drying Equipment Room, as there had been in R and P, but now there were no refrigeration facilities. There was, however, a Pump Room, measuring 23 by 13 feet, not found in either R or P. This room contained equipment related to the desiccant system.[16]

Another facility found in L, K, and C, but not in R and P was the Make Up Room, 29 by 20 feet. This contained a sampling vacuum pump, a sampling sink, oxygen manifolds, and two platform scales. This was similar to what was in the resin preparation rooms in both R and P. Another feature unique to the later three reactors was the Crane-way Operating Aisle. This measured 13 by 87 feet, and contained two stationary consoles for crane operation; only one would operate at a time, the other was held in reserve in case of problems. There was a special window of shielded glass, measuring 6 by 3 feet, which allowed the console operator to see the crane in operation.[17]

Comparative Reactor Plans



C REACTOR

The last of the five reactors, and by most criteria, the most efficient, was C. It had the advantage of changes made to all of the previous reactors, and it had some features unique to itself. The most formidable attribute was that it could run at higher power levels than any of the other reactors.[18] It was also the most prestigious of the five reactors, since the headquarters for all of Reactor Operations was located in C Area.

Design work on C Reactor began in September of 1952 and continued until February of the following year. The overall objective of the new reactor was to be able to operate at a 2,000 mega-watt capacity, with a moderator exit temperature of 95 degrees Celsius, and these changes alone required new design elements, not only in the reactor building, but also in the reactor tank itself. To effect this change, a number of alterations were made. The cooling water supply line from the river was increased to a 66-inch diameter pipe that could handle 96,000 gallons per minute—with a possible future flow of some 140,000 gallons per minute. Moderator flow was increased to 85,000 gallons per minute, with the possibility of future expansion to a flow of 120,000. To accommodate this greater flow, offset expansion joints were added to the piping. The tank itself was made bigger, from a diameter of 16 feet, 2.75 inches for the other tanks, to 18 feet, 6.75 inches for C. This was to accommodate the integral heavy water reflector at the sides of the tank A curved knuckle was added between the tank wall and the bottom shield. Pipes were added to the bottom shield for more cooling water. Baffles were added within the bottom shield, and a second deflector plate or "poison plate" was added below the top shield.[19]

One element of the C design work that did not pan out were the adaptations to the handling of flat plate fuel assemblies, then thought to become the leading technology by the time C reactor was in operation. These flat plate assemblies, such as Mark III, did not work as hoped. That was not the fault of the new reactor design, but rather problems in the design of the vertical elements themselves.[20]

Some of the last changes made to the new tank design called for the addition of more control rods. For this reason, the C reactor tank has 73 control rod positions, while the other tanks have just 61. Unlike the other four reactors, C reactor was installed with 12 heat exchangers from the first; the other four began with just six, with the other six added later. Also, the moderator flow was increased to 90,000 gallons per minute.[21]

The new reactor tank was fabricated at New York Shipbuilding between April of 1953 and May of 1954, at which time it was shipped to Savannah River Plant. The new larger reactor tank also demanded new thermal shields around the tank. These were in 12 curved vertical sections that fit around the walls of the tank. It was also stipulated that the metal filler used in the thermal shields had to be stainless steel, which would serve to limit the amount of radioactive corrosion.[22]

The increased size of the tank, and the extra number of control rods, meant corresponding changes in the actuator tower. With the addition of another 25 actuators and motors, extra support had to be added to the tower.[23]

Another unique feature to the C Disassembly Area were the adjustments made to accommodate the new long fuel elements that were already on the drawing boards.[24]

In the Purification Area, the system for cleaning the moderator was changed. Only two cells were needed now, instead of the five that had been installed in the previous reactor areas. As a result of this changes, a smaller Purification Area was installed in C than in the other reactor areas. Some of the changes first used in C Reactor, were later installed in L and K, and this included the two cell system, in lieu of the five.[25]

Outside of the Reactor building, C Area was also different from the other reactor areas. The 184-1C Boiler House and Coal Storage facility was smaller than in the other areas, since it was determined unnecessary to produce electrical power at the fifth reactor.[26] Perhaps because it was the last reactor area to be constructed, C Area was designated the site of reactor headquarters within the whole Savannah River Plant complex. Many of the offices found in 704-C were not duplicated in the other 704 buildings. Another office building, 706-C, was set up as office space for Reactor Technology personnel. This was a former "temporary construction" building, No. 8300, re-assembled at C for the Reactor Technical Group.[27]

X. OPERATIONS HISTORY, 1953-1989

The first of the five Savannah River reactors, R Reactor, went critical on December 28, 1953. The others followed in relatively quick succession: P on February 20, 1954, L on August 11, 1954, and K on October 14, 1954. The last of the five, C Reactor, went critical on March 28, 1955.[1] All five reactors operated for a decade, until the first, R, was closed down on June 17, 1964.[2] This was followed by the closure of L in 1968.[3] L Reactor would later be refurbished in a massive reconstruction campaign in the early 1980s; it was restarted on October 31,1985. C Reactor, plagued by numerous heat exchanger leaks, was closed in September 1986.[4] The remaining three reactors, K, L, and P, were shut down in 1988, in April, June, and August, respectively. These closures coincided with the departure of Du Pont from Savannah River Plant in April of the following year.[5] A new contractor, Westinghouse Savannah River Company, entered the scene and the name of the facility was changed to Savannah River Site. K Reactor was refurbished in the early 1990s, and was started up for a test run on June 8, 1992.[6] It was shut down almost immediately, and none of the reactors has been in operation since that time.

During this period, from the mid-1950s to the late 1980s, the reactors at Savannah River produced almost half of the plutonium and almost all of the tritium needed for the nation's nuclear arsenal (most of the rest was made at Washington State's Hanford facility, which had been in operation since the Second World War). As was commonly said among employees at Savannah River, "we didn't dig uranium out of the ground, and we didn't make the bombs, but we did almost everything else in between." It was a remarkable achievement, and the many processes used to achieve this end were constantly being scrutinized and improved. The development of tubular fuel and target elements was perhaps the single greatest development in a whole array of developments and improvements to the working of the reactors during this period. By the 1970s, the fuels, targets, techniques, and processes had been improved to the allowable heat limits of what the reactors themselves could stand. One supervisor in Reactor Technology has stated that running a reactor was a lot like being a fireman: there wasn't much to do until there was a problem. This comment, though, masks the huge amount of work that went into the reactors and their safe and effective operation—an operation of astonishing complexity.

The Du Pont Company, which had a culture of safety, was perhaps uniquely qualified to design, build, and operate the reactors. Their idea was to operate the reactors through two organizations: one to actually operate the reactors, called Reactor Operations; and the other to monitor the results, known as Reactor Technology. This latter organization was also the interface between Operations and the Savannah River Laboratory.

Reactor Operations ran the reactors from day to day. Operations personnel sat in the control rooms, pushed the buttons, and turned the levers. For every operation within the reactor area, there was a procedure to be followed. All of this was closely monitored by Reactor Technology personnel, who could not push any of the buttons, but could write up reports that would eventually change the procedures used throughout in the reactor areas. This gave Reactor Technology a great amount of power, though at a level removed from the daily operation.

Alfred Anton Johnson. A.A. Johnson directed the Reactor Technology Section from its inception to 1961. Source: Savannah River Plant News, Volume XVI. No. 25, January 10, 1969.

The man who really put Reactor Technology on the map was Alfred Anton Johnson, commonly known at Savannah River Plant as A. A. Johnson or "A^2." A. A. Johnson was one of a number of young Du Ponters who began work at Hanford during the Manhattan Project, and went on to even greater achievements in the company later in life. This list included, but was certainly not limited to, Crawford Greenewalt, Charlie Wende, and Dale Babcock. With the exception of Greenewalt, who was president of Du Pont by the early 1950s, most of the others found themselves at Savannah River Plant.[7]

At least one fellow associate at Reactor Technology has referred to A^2 as "SRP's Admiral Rickover," and claimed that he ran the reactors at Savannah River more than any other single person.[8] He was superintendent of Reactor Technology from the beginning of the plant, and ran the organization until at least the mid-1960s, when he was made Assistant Director of the Savannah River Laboratory. His headquarters, at least in the early years, was in the 703-A building, but at least one source[9] has claimed that he had an office in the old construction pipe shed in C Area, probably what was later designated the 706-C building. This was a place with concrete floors, bare I-beams, and window air-conditioning units that barely worked. Everybody there had to work hard, and the building was set up with glass-partitioned cubicles to help ensure that.[10]

Reactor Operations, originally headed by Bill Church, actually ran the reactors on a daily basis, but A^2 Johnson effectively ran the reactors at one step removed by means of the "Reactor Technology Memorandum," or RTM. He read all of the field reports submitted by Reactor Tech personnel, most of which were hand-written, coalesced the findings, double-checked the figures, and issued an RTM to cover the results. These were mailed to his higher-ups within the Savannah River hierarchy. It very quickly developed that whatever was recommended in the RTM's, was effectively put into practice. It has been estimated that A^2 Johnson issued between five and six thousand of these memoranda, and it was through these that he effectively ran the reactors.[11]

And there was a lot to run. Before each reactor could be started, there was a dummy run with quatrefoils loaded into the reactor tank without uranium, so that they could be tested hydraulically. This was done with deionized water. The reactors and assemblies were then cleaned and loaded with heavy water for the first real load.[12]

For the first year or so, the first loads within the reactors consisted of solid slugs comprised of natural uranium, with aluminum cladding. Natural uranium (U-238) absorbs a neutron to produce plutonium-239. Tritium was only produced within the control rods, comprised of lithium-aluminum alloy, also clad in aluminum. The lithium would absorb neutrons, and split to form tritium. Only after the first year was tritium produced as part of the regular reactor cycle.[13]

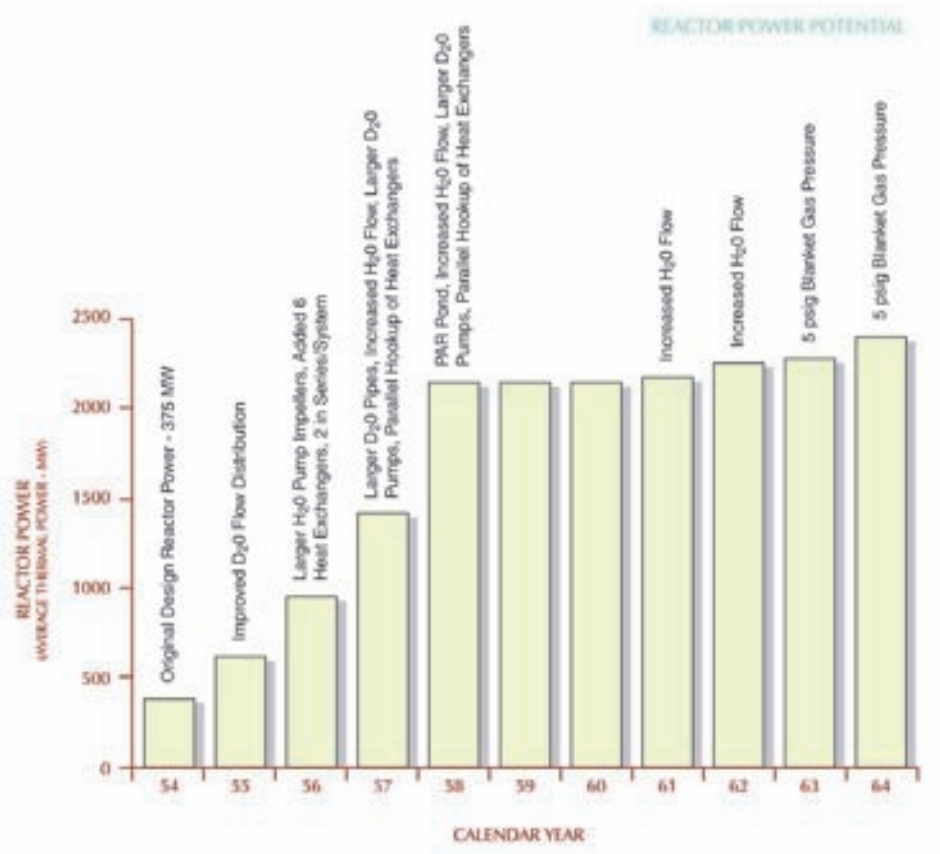
Each reactor run with a full complement of fuel elements was called a reactor "cycle." A cycle was completed when all of the fuels elements were replaced with new fuel.[14] A sub-cycle was where the targets were removed or replaced, and the fuel or most of the fuel was left in place. This usually occurred in the production of plutonium. Tritium production usually had no sub-cycles.[15] Alternatively, tritium required a cycle of relatively long duration. Plutonium only required a cycle of medium length.[16]

Almost immediately after start-up, there was a push to raise the reactor power levels. Originally rated at a power level of 375 megawatts (MW), the reactors began their power level ascension in 1955, right after C went critical.[17] In 1956, six additional heat exchangers were installed in the first four reactors, bringing the number of heat exchangers in each reactor up to 12.[18] A year later, the average power level had reached 1750 megawatts. The Bingham pumps began to be installed in late 1956 and throughout 1957, and where they operated in 1957 (in L, K, and C reactors), the average was already 2000 MW.

Power ascension really jumped in 1957 and in 1958. The Bingham pumps made this possible, as did the construction of Par Pond, completed in 1958 along Lower Three Runs Creek. Par Pond made it possible for R and P reactors, the two furthest from the river, to use recycled cooling water, freeing up more river water for the other three reactors.[19]

Power ascension continued, albeit at a slower, more uneven rate, until the peak of reactor capability was reached in the mid-1960s. By 1959, average power levels had reached 1825 MW in summer and 2200 MW in winter, with the maximum that year (2350 MW) reached in C. By 1961, average power levels in R, P, L, and K were at 1725 MW in summer and 2525 MW in winter, with C reactor reaching 2575 MW.[20] Between 1962 and 1964, the helium gas pressure within the plenum was increased to five psig to allow the reactors to operate at higher power levels.[21] By 1963, the summer and winter averages were up to 2060 MW and 2260 MW, with the maximum in C at 2600 MW.[22] The reactors did not operate much above this level, even though the highest power recorded at any Savannah River reactor was 2915 MW at C reactor in 1967.[23] That same year saw the introduction of the Universal Sleeve Housing (USH) for the reactor's vertical assemblies, an innovation that reduced the cost of each reactor load.[24]

Reactor Power Potential in Megawatts. Source: William P. Bebbington, History of Du Pont at the Savannah River Plant *(Wilmington, Delaware: E. I. du Pont de Nemours & Co. 1990).*



During most of this period, there was an even split between the production of plutonium and tritium. In 1955, there were 14 production loads discharged from the reactors.[25] This jumped to 42 loads in 1956.[26] Thirty-one loads were discharged in 1957.[27] In subsequent years, the average would generally fall lower, around 25 production loads annually. This did not represent a reduction in the production of plutonium and tritium, but rather the greater efficiency of higher power, and improvements in the fuel assemblies so that more fissionable materials could be produced in each reactor load. It also has to be remembered that the production of tritium required a longer reactor cycle anyway, and tritium was not made in the first year or so except as a by-product in the control rods.[28]

Higher power led to shorter reactor cycles, speeding up the creation of plutonium and tritium, which was the ultimate goal. It was this demand for higher power that led to the first serious problems with the old uranium solid slugs, the fuel shape that had been used in reactors since the days of the Manhattan Project. Uranium fuel pieces, called "slugs," each one an inch in diameter and eight inches long, were encased in thin skins of aluminum, to protect the slug from the effects of the heavy water moderator. If the slug got too hot and the casing was compromised, the heavy water would react with the uranium to create a swelling that could block up the fuel assembly. As the water flow declined, the slug temperature would increase, until boiling occurred. Not only could an entire column of fuel slugs be damaged or destroyed, but also damage could occur to the entire tank.[29]

To prevent this from occurring, new tubular fuel elements were created in the later 1950s and early 1960s that were capable of withstanding the higher temperatures. In fact, the designs of fuel elements were experimented with all the time. Mark I, the original Manhattan Project-era fuel slug of solid uranium, was quickly replaced by Mark II, Mark III, and so on. And this was just in the 1950s. By the early 1960s, tubular elements had completely taken over, replacing quatrefoils altogether.[30] It was not until 1972, after almost two decades of experimentation, that the best marks were discovered for the production of plutonium and tritium. For plutonium, it was found to be Mark 16-31; for tritium, Mark 22.[31]

Naturally, these changes to the fuel elements led to changes in other equipment as well. Constant improvements were made to the C and D Machines, so they could handle the heavier fuel elements in use by the 1960s.[32]

During this period, as the fuel elements were being improved, and as all of these elements were being tested in each of the reactors, some reactors came to be known as better plutonium makers, while others became associated more with tritium. According to reputation, R and P were better suited for the production of plutonium, while L, K, and C were known as the "tritium" reactors.[33] It is important to remember, however, that too much can be made of this distinction. Each of the five reactors could make either product – and more besides.

The production of plutonium and tritium was a constant at Savannah River Plant during this entire period, but there was time for other projects as well. Almost from the beginning, there were breeder reactor programs that featured thorium and uranium-233. There were special irradiations for food preservation, and there were early programs to prepare cobalt-60 and other isotopes, like plutonium-233 and plutonium-238, as heat sources for use in the Arctic and in outer space.[34]

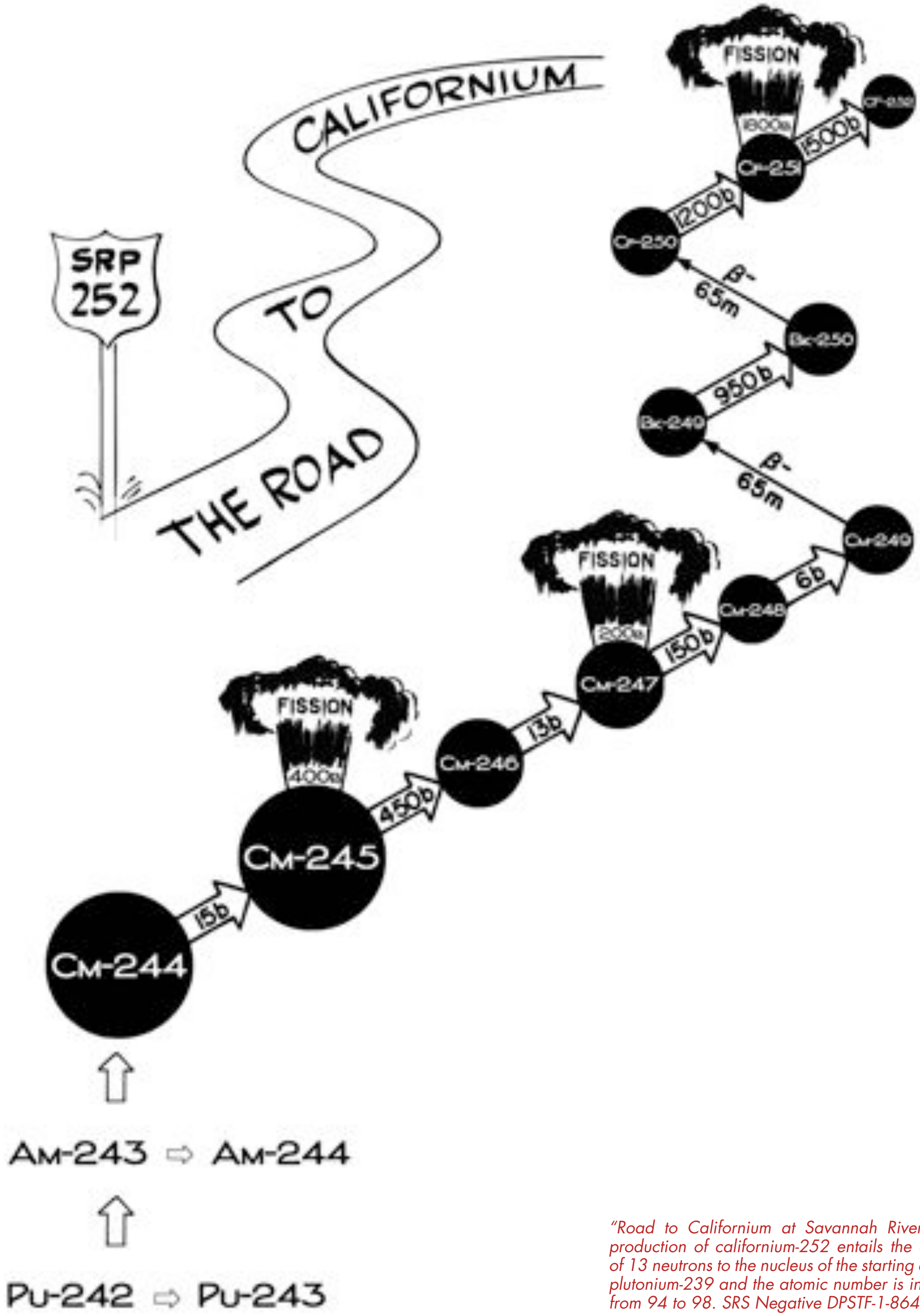
Another early extracurricular program at Savannah River was the search for neutrinos, conducted at P Reactor. This research was first done by Drs. Clyde L. Cowan, Jr., and Frederick Reines in the mid-1950s under the auspices of the University of California. The goal of this research was to determine the existence of neutrinos, which had hitherto only been postulated. Cowan and Reines succeeded in actually discovering neutrinos for the first time ever, and this event took place at P reactor in June of 1956.[35] Further studies into the nature of neutrinos continued in P reactor for many years afterwards. After Cowan and Reines concluded their research, the neutrino program was continued locally under the direction of Dr. Henry Gurr and others at P Reactor.[36]

Dr. Clyde L. Cowan, Jr., left, and Dr. Frederick Reines, leaders of the Los Alamos Scientific team that confirmed the existence of the neutrino at SRP's P Reactor, SRS Negative No. 3016.

Another much more massive program was begun in the early 1960s at the behest of Glenn Seaborg, who was chairman of the Atomic Energy Commission (AEC) from 1961 to 1971.[37] Seaborg, while a physicist at the University of California, had been one of the discoverers of plutonium, back in 1940, and he had a profound interest in the creation of other man-made elements heavier than plutonium. While AEC chairman, he was in a position to make those "transplutonium" elements, an operation best achieved in reactors. So began the Transplutonium Programs at Savannah River Plant, which went on from the early 1960s to the early 1970s.[38]

The Transplutonium program began rather slowly in 1961 and 1962, but began to take off with the Curium I program in K reactor in 1963-64. The Transplutonium work was a series of processes, each step building on the other, with each transplutonium element, like curium, used to create the next, more heavy, element. This was done by bombarding the new element with neutrons. This would create a still heavier element, after some atomic adjustments and beta decay. The process would then be repeated, until the next new heavy element would be formed. All of these new elements were dubbed "special products."

It appears that the production of special products really got going in 1966-67, as the reactors produced curium, then americium, and finally californium. The program to produce californium really began in August of 1969, and was continued until the early years of the 1970s. The year 1970 was the peak of the Special Products work at Savannah River. That year witnessed a record 81 reactor cycles. Sixty-six of these were in K reactor, and were associated with the production of californium.[39]



"Road to Californium at Savannah River." The production of californium-252 entails the addition of 13 neutrons to the nucleus of the starting element, plutonium-239 and the atomic number is increased from 94 to 98. SRS Negative DPSTF-1-8641.

Although the Transplutonium programs succeeded in producing californium-252, one of the heaviest man-made elements ever created, the program was less successful in marketing the product. Californium, a neutron-emitter, was marketed to a number of medical establishments as a localized treatment for cancer. It was even touted as a prospecting tool for finding gold. None of these applications panned out. The rather limited uses for the element in no way off-set the astronomical cost of production. The program was quietly buried shortly after Glenn Seaborg vacated his AEC chairman's position. The program was much reduced by 1974, and continued on in a much more limited fashion until at least the late 1970s.[40]

One important element of the Transplutonium Program was "High Neutron Flux." The high neutron flux program was first proposed in 1964 and begun in 1965 and concluded in 1966. The high flux program occurred between Curium I and Curium II and took place in both C and K reactors.[41] High flux was achieved inside the reactor by irradiating a small, highly reflected core and a very high flow of cooling water to remove the heat. To effect this, only the central core of the reactor tank was used.[42] Such a set-up in the reactor core was ideal for the production of transplutonium isotopes like americium-243, curium-244, and the ultimate element in the program, Californium-252. High flux allowed the elements within the reactor core to obtain several successive neutron captures and thus override the rate of radioactive decay. It was in this fashion that it was possible to create californium out of plutonium-242.[43]

The reactor most used for neutron high flux was C reactor. As a result of the high flux program, a new record was set for high specific activity in a cobalt-60 source: 700 curies/g in a 1.4 g target. The peak of high flux levels in C was reached in 1965, and measured $6x10^{15}$(cm2)(sec).[44] This is believed to be the highest neutron flux intensity ever achieved anywhere in the world.[45]

There were 25 high flux cycles done in C reactor in 1965, and much of this operation was overseen by a research crew from the University of California Radiation Laboratory that was known informally as the "Wild Men from California." Most of this team (and a lone member from Norway) all dressed and acted in a manner that was highly unorthodox in the conservative setting of Savannah River Plant. Their leader was a character simply known as "Dr. Harry," and one of the main pieces of equipment his team used was known as a "rabbit."[46]

There were two rabbits, and both were built to allow researchers to insert and then quickly remove irradiation samples from C reactor during the high flux charges, without having to shut down the reactor. The first rabbit, built in 1965, was a mechanical device that could insert and withdraw a sample attached to the end of a stiff wire encased in a guide tube. The mechanical rabbit was an integral part of the high flux program in C reactor. After the conclusion of high flux in 1966, it was moved to K reactor. The second rabbit, known as a pneumatic rabbit, was also constructed in 1965. It was used in the C reactor for around 200 irradiations of the short-lived isotope fermium-257. The pneumatic rabbit was plagued with operating difficulties and was retired from service after the high flux program.[47]

One of the many stories that came out of this high flux work was the one about the special wrench and Glenn Seaborg. One evening after the regular day shift, Dr. Harry and his crew were working on one of the rabbits. The crew needed a special wrench, but the maintenance man on duty that night would not give it up without the proper authorization, and there was no one on the evening shift with that authority. An impatient Dr. Harry then cut through several chains of command and called his friend Glenn Seaborg to report that the folks at Savannah River Plant would not give him the wrench he needed to do the job that Seaborg had sent them to do.

According to the story, Seaborg was at a dinner party, but not for long. He called Du Pont's president, Crawford Greenewalt, who was also at a dinner party, and the train wreck picked up speed from there. Within an hour, one of Fred Christensen's Reactor Technology supervisors appeared at his door. He was told to get back to C Reactor immediately and make sure the rabbit people had every tool they needed, and spend the night there too, in case they needed more tools. From that point on, Seaborg's team was granted every convenience and license. A troublesome safety officer who had urged the team to wear proper work boots was packed off to another area, and the team's Norwegian, a reputed speed-demon, was forgiven numerous traffic violations.[48]

Not nearly as exciting, but of much greater importance to the operation of the Savannah River reactors, was the development of the mixed lattice arrangement, beginning in the mid-1960s. Unlike a uniform lattice, where every fuel position around the septifoil was the same, mixed lattices had different fuels in different positions, usually alternating around the septifoil. This arrangement was first proposed in 1966, and the first Mixed Lattice Demonstration occurred in May of 1967. This was done in K reactor, at the end of the Curium II program, which was in turn a part of the overall Transplutonium program.[49]

Mixed lattices of the fuel assemblies became the norm towards the end of the active life of the Savannah River reactors. There were two reasons for this. The first was simply that the production of plutonium had progressed to the point where it was no longer as urgent to make the stuff as had been the case earlier, leaving more room for experimentation. The second was a surplus of fissionable material from the Navy, specifically uranium-235, while Oak Ridge had a surplus supply of uranium-238. Savannah River was instructed to take these materials and process them together, and this led to mixed lattices.[50]

By the time mixed lattices became common, some of the Savannah River reactors were already shut down. The first to go was the oldest, R reactor, which was closed in June of 1964, after President Johnson announced in that year's State of the Union Address that the U.S. would begin to decrease its nuclear materials production. R reactor already had leak problems in the outlet nozzles, which made it a suitable candidate, but others had leak problems too. C reactor, for instance, had stress cracks and leak problems, both at the tank knuckle area and at the heat exchangers, shortly after it first went critical, and was in need of constant maintenance for that reason. The other reactors had problems with the heat exchangers: after January 1961, all the heat exchangers began to wear "diapers" in order to catch any leaking heavy water.[51] Even L reactor, which did not have any major leak problems, was shut down on February 18, 1967.[52]

All of this led to a heightened concern for reactor safety. It just so happened that as the general public became more aware of the dangers of radioactivity (and less concerned about the dangers of international Communism), the reactors at Savannah River Plant were reaching maturity. By the 1970s and 80s, some said they were obsolescent. This situation made the reactors more susceptible to charges that they were becoming dangerous.

In hopes of forestalling this development, Savannah River Plant engineers increasingly turned to the addition of new safety features that would help make the reactors safer and more acceptable to nuclear regulators and the general public alike.

SAFETY FEATURES

As set up at Savannah River Plant, the irradiation process within the reactor tank was a relatively simple process, but one that posed risk. If something went wrong, it could happen quickly and the results could be catastrophic. The fuel and target elements, the control and safety rods, the cooling system, and the various back-up safety systems came together at the reactor tank. Thus careful monitoring was essential. There were no computers installed in the reactor buildings in the 1950s. This monitoring had to be done by a huge array of instruments, all observed by operators in the control rooms.

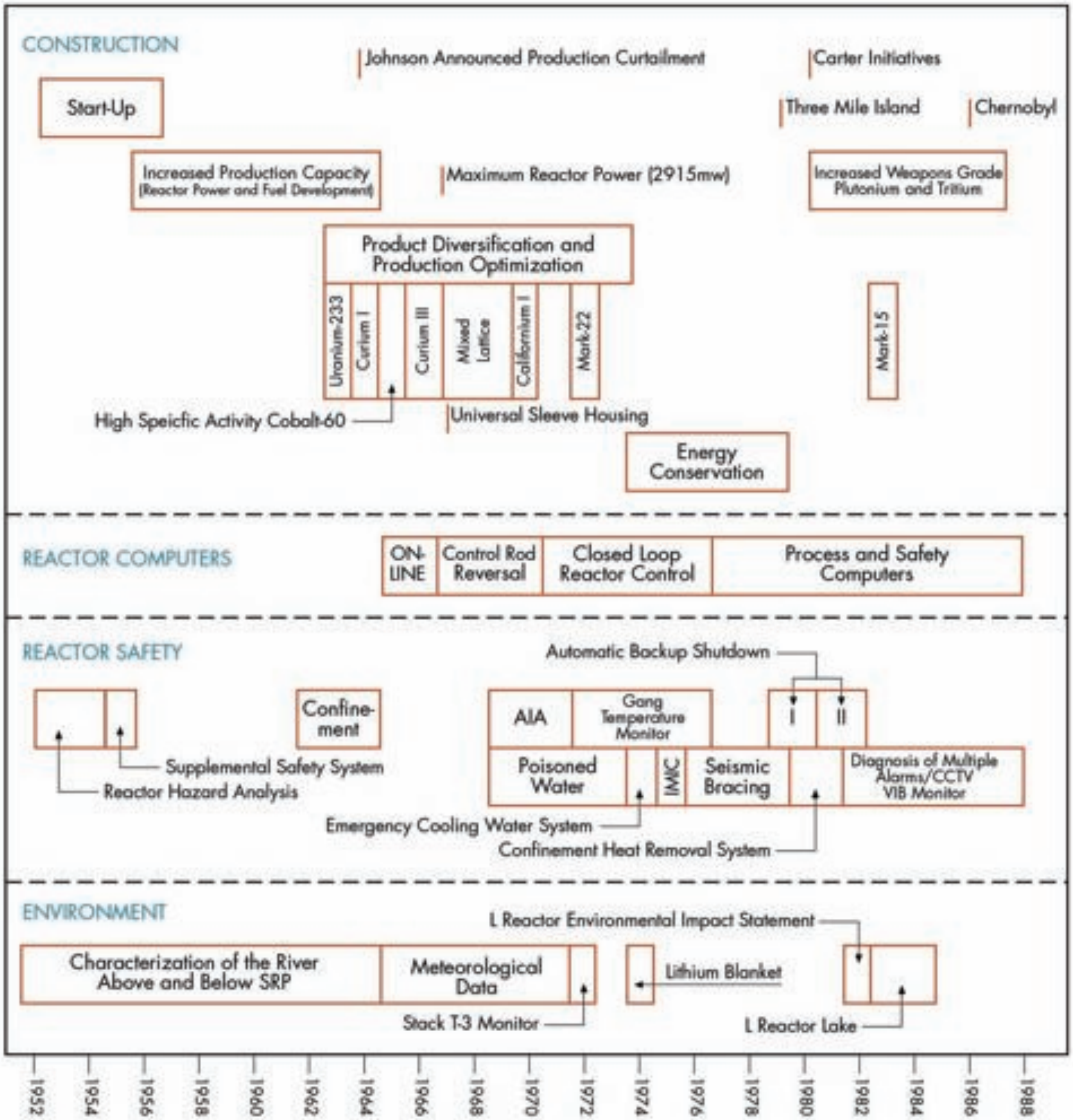
One of the first of the new safety systems installed in the control room was the Supplementary Safety System or SSS, introduced in 1956-57 and improved over the following years. The main feature of the SSS was gadolinium nitrate, a neutron poison that could be inserted into the reactor in case the control rods and safety rods failed to do their job.[53] The Supplementary Safety System was put through the paces at R reactor just before the final closing in 1964.[54]

Monitoring operations in the reactor control room could be a complicated procedure. Most of the operators had little industrial experience, much less nuclear experience. The reactor crews were largely inexperienced, and were especially susceptible to error in case of emergencies. There was a tendency, certainly in the 1950s, that if there was a problem or a gas leak, you just blew the matter out the stack. And that was for small problems; in the case of a large problem, you relied on the huge area set aside for Savannah River Plant to mitigate any unpleasant results. In the 1950s, there was no idea of "containment" for nuclear reactors.[55]

This was not considered a flaw, certainly not in the 1950s. For their time, the Savannah River reactors were state of the art, both in efficiency and in safety. What changed of course was the perception of the threat. Most of the safety features that were added to the reactors in the 1960s, 70s, and 80s, were designed to compensate for this lack of containment, which was considered just too expensive and ineffective to be tacked on to the existing reactors at Savannah River. In fact, everything short of containment was lumped under the umbrella term, "confinement."

When the Savannah River reactors were constructed, there was no civilian nuclear industry of any sort. There were only the nuclear production reactors under the control of the Atomic Energy Commission, and almost all of what they made went to the Department of Defense. Civilian power reactors only began in the late 1950s and early 1960s, and it soon became apparent that for power reactors in populated areas, it was only reasonable that they have "containment shells" that would encompass the whole reactor. The Savannah River reactors were simply too large for a containment shell, so the idea of "partial containment" or "confinement" came to the fore as a means to make the reactors as safe as possible without going actual containment.[56]

Improvements to Reactors Over Time. Courtesy, J.M. Boswell.



This confinement required new filters on the exhaust ducts and on the stacks, and that merely began the process.[57] The first computers installed in any of the Savannah River reactors were safety- monitoring computers known as GE-412's. These were installed in K reactor in 1964, and were placed in the other reactors two years later.[58] A host of other safety features soon followed. Improvements were made to the control rod actuator system.[59] The Emergency Cooling System (ECS), designed to cool the reactor in case regular cooling water shut down, was put in around 1966. A Poisoned Light Water System was installed in C reactor in December of 1969, and was later installed in P and K in the early 1970s. The gang temperature monitor, or GTM, was installed in 1973, along with more reactor computers and the poisoned Emergency Cooling Water System, or ECW.[60]

One of the containment-related issues that became prominent in the late 1960s was the possibility of earthquakes. This might seem rather far-fetched in South Carolina, but there had been a sizable earthquake centered on Charleston back in 1886, and it was understood that such a thing could happen again. A study of the vulnerability of the Savannah River reactors to seismic activity was conducted by Dr. George W. Housner, professor of Civil Engineering at Cal Tech in Pasadena, in 1967. In the initial report, Housner recommended that seismic bracing was needed for much of the outside piping and equipment, and some of the more exposed parts of the reactor building itself. In particular, it was recommended that the top of the penthouse or actuator tower could use extra support.[61] Some of these recommendations were amplified in subsequent seismic reports.[62] The seismic bracing was finally installed in the mid-1970s.[63]

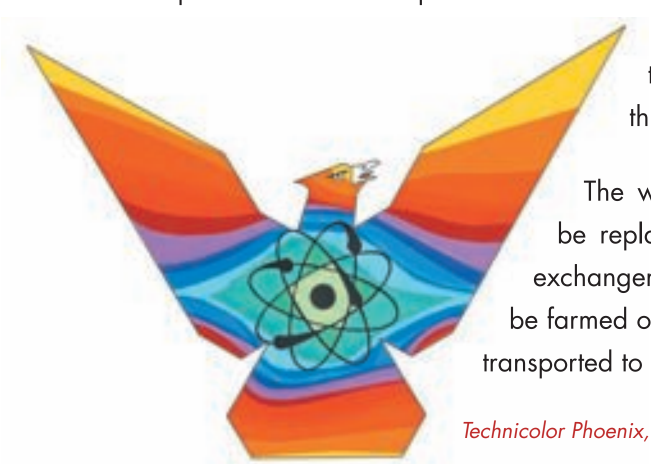
Aerial view of P Reactor showing seismic bracing or buttresses on high hat, 1979. SRS negative No. 3772-79.

One of the last of the confinement improvements made during the Du Pont years was the Confinement Heat Removal System or CHRS. This system was installed in 1981.[64]

L REACTOR RESTART

The story of L Reactor restart has it beginning in the brief flare-up of the Cold War that began in the aftermath of the Vietnam War. The Soviet Union began a period of expansion of influence in Africa, capped by the out-right invasion of Afghanistan in 1979. The election of Ronald Reagan in 1980 was seen by many as a response to this expansion—and in response to Carter's handling of the Iran hostage situation. The new president soon made it clear that there would be a robust military response, a response that would have a nuclear component. At Savannah River Plant, this meant the resuscitating of L reactor, closed since 1967.

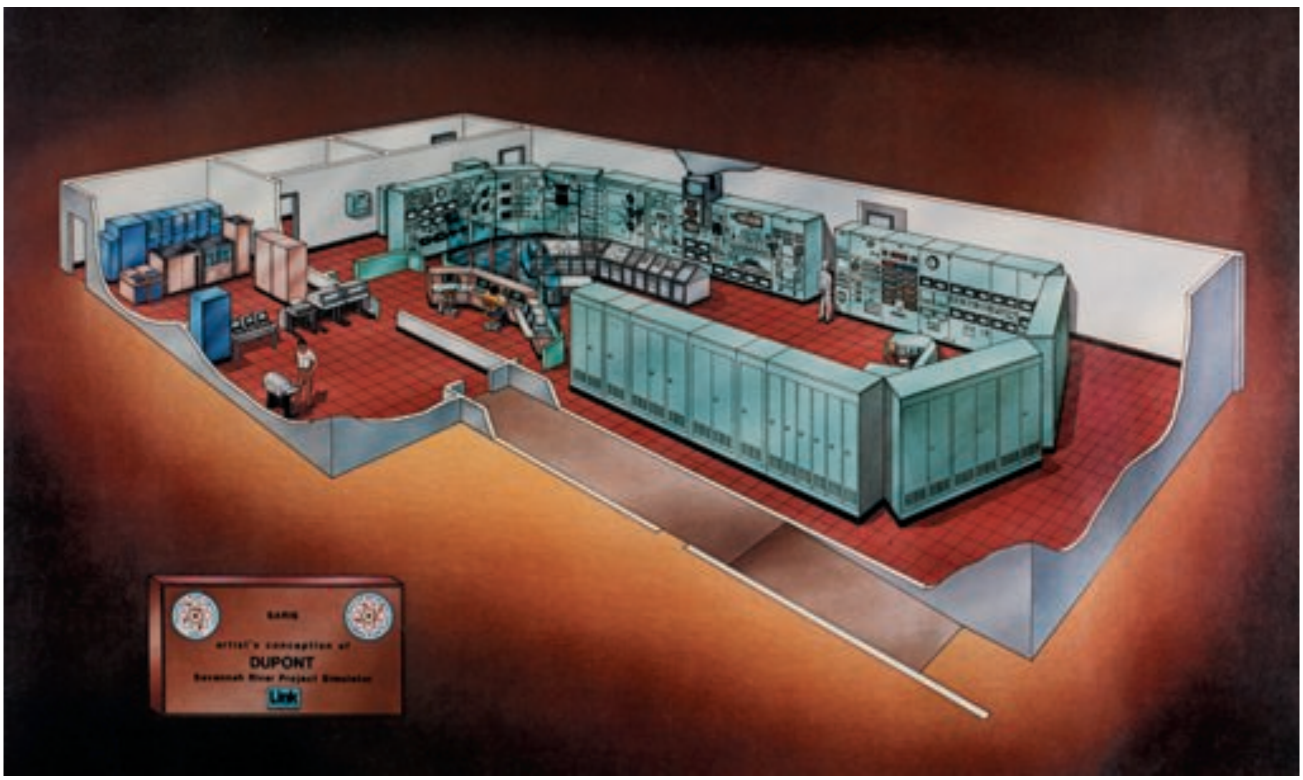
The work at L reactor began in 1981. Much of the piping had to be replaced, as did the heat exchangers. In fact, the enormous heat exchangers could no longer be made in the United States; that work had to be farmed out to a steel firm in Kobe, Japan. The heat exchangers were then transported to the plant by rail.



Technicolor Phoenix, L Reactor Restart Project Logo. Courtesy, J. Walter Joseph.

Even so, L reactor was basically refurbished by the fall of 1983, but the operation of the reactor was delayed by environmental concerns that did not exist in the early 1950s. By the 1980s, there were a number of civilian power reactors, and these had to be operated within strict safety parameters. The release of hot cooling water from the reactor, directly into the environment, acceptable in the 1950s, was no longer customary for the new generation of reactors, now equipped with cooling towers. As a result, the state of South Carolina determined that the old practice of running hot water down the local creek toward the Savannah River, was not acceptable. As a result, the start-up of L was delayed to allow for the construction of L Lake, designed to cool the hot river water coming out of the reactor. This delayed the start-up throughout 1984 and into 1985. L Reactor was finally made operational on October 31, 1985, for the first time since it closed in 1968.[65]

Reactor Simulator or SARIS. Courtesy, SRS.



One of the many changes brought about by the re-start of L reactor was the construction of the Reactor Simulator Building in C area. Designated 707-C, this building was installed in the early 1980s in order to train reactor operators for service in L reactor. It was also used for the other reactors as well. The highlight of this building was the "Simulator Reactor Control Room," formally known as SARIS, an acronym of sorts for Savannah River Simulator. Prepared by Singer-Link, SARIS began construction in 1983 and was completed in 1986.[66]

THE REACTOR SAFETY CONCERNS OF THE 1980s

The restart of L Reactor coincided with the so-called "Neo-Nuclear Age" of the early 1980s, marked by increased tensions between the United States and the Soviet Union. Not only was L Reactor refurbished, but also there was an increase in production at the three operating reactors at Savannah River: P, K, and C. In fact, plant production peaked with a record two million mega-watt days in 1983.[67] And this was in the teeth of increasingly strict environmental regulations and oversight.

The rise of environmentalism in the 1970s led to growing regulation and a heightened concern for reactor safety by the 1980s. Spurred by the Oil Crisis of 1973-74 and the need for greater energy regulation, the old Atomic Energy Commission was abolished in 1975 and was largely replaced by the Energy Research and Development Agency (ERDA) and finally in 1977, by the new Department of Energy. One of the corollaries of the environmental movement was a growing mistrust of nuclear energy itself. In the United States, this came to a head with the Three Mile Island accident of 1979, followed by the much worse Soviet accident at Chernobyl in 1986. By this time, the issue of nuclear waste, its treatment and disposition, had become a major issue not just within the nuclear industry, but also among the public-at-large.[68]

By the 1980s, there was general change in the plant's original stand on reactor safety, which had been based on the use of empty land as a buffer against nuclear accidents as well as occasional nuclear releases. In the 1950s, the streams that drained reactor effluent water toward the Savannah River were sacrificed, so long as the end-result at the river was clean. By the 1980s, this was no longer considered acceptable. By 1987, there were some 70 Nuclear Pollutant Discharge Elimination System (NPDES) monitoring stations scattered throughout the government reservation. There was also a reduction in the permissible maximum reactor power. By 1987, there was a 50 percent reduction in power levels over what had been allowed just a few years before.[69]

OTHER DEVELOPMENTS IN THE 1980s

A number of other developments occurred during the 1980s that marked this as an end of an era. The last of the heavy water production units in D Area was closed in 1982. A couple of years later, the Du Pont Security Patrol was disbanded when Wackenhut Services, Inc., assumed the job of plant security.[70] This marked a shift in overall plant security from an earlier fear of espionage, to a growing concern for terrorism, as patrolmen armed with pistols were replaced by paramilitary units.

In other arenas, progress continued on the Defense Waste Processing Facility (DWPF), which was constructed throughout most of the 1980s. The idea behind the DWPF was to seal radioactive waste into a glass mixture, which would then be placed in a steel canister and buried in concrete. Another project that was completed but barely used was the Naval Fuels Facility, constructed at the behest of the Navy in the early 1980s. This was shut down in the late 1980s by the direction of the Department of Defense.[71]

The biggest change of all occurred during the period from 1987-89, when Du Pont, the principal contractor for Savannah River, decided not to renew its contract with the Department of Energy. Hounded in the press for its "30 Worst Incidents" report, and concerned that the government would no longer indemnify its work, Du Pont decided that it was in the company's best interest to let others run the plant. This decision was announced in October of 1987, to be effective at the end of the last contract in 1989.[72]

Before that time, in 1988, all of the operational reactors were shut down, to allow the new contractor, Westinghouse Savannah River Company, time to take over and restart the reactors according to their system. For reasons that will be explored in the following chapter, these reactors were never put back into production. Du Pont left Savannah River in 1989. In the 35 years that the production reactors saw service, from 1953 to 1988, Savannah River Plant produced 36 metric tons of plutonium, or 40 percent of the nation's stockpile of this fissionable material.[73] Only Hanford, which dates back to the Manhattan Project, has produced more.

XI. SHUTDOWN ERA, 1989-PRESENT

1989 brought a new contractor and name to the Savannah River Plant. Westinghouse, the new contractor-operator, brought in Bechtel National, Inc., and together they set up Westinghouse Savannah River Company (WSRC), as an independent firm for the purpose of running the plant. To signal a change of direction, DOE-SR also changed the name of the facility from Savannah River Plant to Savannah River Site.[1]

The name change was prescient, since Savannah River would soon be more accurately described as a "site," rather than a production "plant." Throughout the 1990s and into the present decade, there was a shift at Savannah River from "production" to "clean-up."[2] Events in Eastern Europe made this shift possible. First, in 1989, the Eastern Block nations became free from Soviet domination, culminating in the collapse of the Berlin Wall that autumn. This was followed in 1991 with the complete collapse of the Soviet Union itself, leaving in its wake Russia and the other former Soviet republics.

During this same period, in the early 1990s, Westinghouse made a stab at starting up K reactor for tritium production. By this time, the stockpile of plutonium was more than enough to halt production for the foreseeable future. With a half-life of over 24,000 years, plutonium was in no danger of disappearing. The same could not be said for tritium, an essential component for a hydrogen bomb. With a half-life of 12.2 years, tritium had to be produced almost constantly in order to provide a reliable supply for the nation's nuclear arsenal.

When WSRC first studied the restart potential for the Savannah River reactors, it found that P, L, and K were all sufficiently intact to permit restart. From the beginning, however, WSRC put its emphasis on K reactor. This entailed some problems. By this point in the evolution of reactor safety, any renewed operation of K reactor would first require the construction of a cooling tower. This was erected at the cost of $90 million. It was also during this period that Savannah River reached a record personnel level, over 25,000, with an annual budget of $2.2 billion, twice what it had been in 1989. Despite the influx of this money, many local political leaders, who had heretofore been supportive of the nuclear industry, were opposed to the restart program. K reactor went critical during a test run on June 8, 1992, but was shut down shortly thereafter. It was never started back up.[3]

The final closure of the Savannah River reactors occurred during the first year of the Clinton administration, which took office in January of 1993. The new administration was not favorable to the huge spending that had taken place at Savannah River during the previous Bush administration. By the end of 1993, not only had the work force been reduced, but also the reactors were put in a situation where any future restart was virtually precluded.[4] After 1993, there was no chance that any of the five Savannah River reactors would ever produce nuclear materials again. This did not, however, end the usefulness of these facilities, as will be showed later in this chapter.

Tritium production has since been allocated to two commercial reactors in the TVA system. The gas, which still had to be processed and packaged, is then shipped to the tritium facilities in H Area for processing and replacement. These facilities, primarily the Tritium Replacement Facilities, have functioned throughout this period, and do so

"When we started using these reactors down here, the commercial nuclear business hadn't been invented yet.
We had five reactors going–
and commercial power reactors were just a gleam in the scientist's eye.
So everything we did was pioneering–
there was no real road map for us."

-Gerry Merz

Source: "Reacting to Change," *The Augusta Chronicle*, November 6, 2000.

today, insuring that viable tritium gas is available for the nation's thermonuclear arsenal. These facilities have been upgraded in recent years by the addition of the new Tritium Extraction Facility (TEF), which began construction in the year 2000.[5]

WSRC brought in other firms for their second contract, which was awarded in 1995 and went into effect the following year. In addition to Westinghouse and Bechtel, the conglomeration now included Babcock and Wilcox Company (later identified as BWX Technologies) and British Nuclear Fuels, Ltd. Each company had their special area of expertise. WSRC continued to operate the nuclear facilities, the Savannah River Technology Center (the former Savannah River Laboratory), and the general administrative functions. Bechtel Savannah River, Inc., dealt with engineering and construction work, plus environmental restoration. Babcock and Wilcox was brought in to run the deactivation and decommissioning (D & D) of surplus buildings left over from years of production work. British Nuclear Fuels ran the solid waste program. By this time, the overall work force had been reduced to around 13,000.[6]

The second contract took effect just at the time that the Defense Waste Processing Facility (DWPF) finally began operation. Waste management work also took place in other areas of the site. The main new area was E Area. Located between areas H and F, E area contains most of Savannah River Site's disposal and storage facilities, in particular the Solid Waste Management Facility.[7]

Environmental restoration got underway on a massive scale. There had been earlier efforts, back in the 1980s under Du Pont, but these had been small affairs, the best known of which was the clean up of the M Area settling basin. By the late 1990s, this was expanded to include environmental clean up at over 500 inactive waste and contaminated groundwater sites.[8]

A very active Deactivation and Decommissioning (D&D) program was established in the 1990s. Initiated to remove the many excess buildings left over from years of nuclear materials production, the D&D program began the clean up of D Area in the mid-1990s. Using an area based approach, D&D efforts have changed the historic built environment of the production plant, with work completed in M Area, D Area, and A Area. This study is a result of the program's move into the reactor areas, particularly, P and R.

One of the more recent missions initiated at Savannah River Site is the program to process "spent nuclear fuels," or SNF. These are fuel production targets after they have been used, and they can come from commercial power reactors, defense material production reactors, research reactors, and even naval reactors on submarines. Savannah River Site has become the destination for this material, which has to be processed before final disposition. The holding facility for all SNF is now the Receiving Basin for Offsite Fuels (RBOF).[9]

A related program is the "K Area Materials Storage Facility" or KAMS. Set aside for the storage of plutonium, KAMS is the first phase of the mixed oxide fuel process or MOX, set up to convert excess plutonium to a mixed oxide fuel suitable for use in commercial reactors. K reactor was chosen as the site for KAMS largely because of the work done on the reactor during the K re-start program in the early 1990s. This had left the K reactor building and its facilities in better shape than most of the others.[10] At present, only K and L have missions as integral parts of the Savannah River Site.

In 2005, Washington Group bought out what remained of Westinghouse's share in the Westinghouse Savannah River Company; the name of the consortium changed to Washington Savannah River Company. In 2007, Washington Group lost its bid to renew the Savannah River contract, which was awarded to the Fluor Corporation, which has allied itself with other firms such as Honeywell, Northrop Grumman, Lockheed Martin, and Nuclear Fuel Services. This consortium, identified as "Savannah River Nuclear Solutions," assumed the overall operating contract for the site in 2008.

The final disposition of the reactor areas is still under consideration. Deactivation and Decommissioning of the Savannah River Site's reactors will be undertaken per the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) consistent with the SRS Federal Facility Agreement requirements. The Department of Energy, which is the lead agency for such SRS activities, has led the development of an Early Action Proposed Plan (EAPP) to address the preferred decommissioning actions that will define the reactors' end state.

All five reactors played a significant role in the Cold War and it is this role that this study has sought to document through photography and research. They also played a major role in the lives of the men and women who worked in the reactor areas. The next chapter talks about reactor operations from their perspectives.

XII. INSIDE PERSPECTIVES

The previous chapters have delved into the architecture and engineering of Savannah River reactors, as well as reactor operations. This chapter will be different. Here will be presented some of the inside perspectives from some of the people that worked in the reactor areas excerpted from oral history interviews. This will be the personal side of the reactors, if you will. The oral history provided in interviews with knowledgeable individuals about reactor physics and operations and through a questionnaire circulated among Reactor Technology members have contributed greatly to this document. All the interview transcripts are located in Appendix B in their entirety and Appendix D contains responses to the questionnaire. This report effectively closes with these excerpts, letting the voices of those who worked in these historic buildings tell their stories.

FRED CHRISTENSEN

The average age of those of us who started SRP in the 1950's was less than thirty. Idealism was rampant. A strong feeling prevailed that the job was vital if we were to survive opposite the Russians. Most people were directly involved in producing something. Many had been at SRP during the just-completed construction phase when some 35, 000 workers has descended on Aiken County and had completed the largest construction job in the history of this country.

My first job at the Savannah River Plant was operating the K reactor; that is, I became one of about twenty supervisors who with some sixty operators ran the reactor around the clock, seven days a week. SRP had five reactors labeled R, P, L, K and C. Each was essentially identical to the others. Each was housed in an immense reinforced concrete fort designed to withstand a near miss by a 1955 Russian atom bomb. The reactors were placed in a circle, each about five miles from its nearest neighbor, so that a nuclear hit on one would not destroy any of the others. An army contingent manned antiaircraft gun at various plant locations to shoot Russian aircraft.

Operating a reactor was much like being a fireman. Unless there was a fire, there was not much to do. Pumps spun. Waters flowed. Neutrons swarmed, produced heat in massive quantities and cooked up elements not seen on earth since the beginnings of time. All this happened while we, the crew, had very little to do, except watch gages and be ready to head off trouble. Compared to the wind tunnel (my previous job at Moffat Field, California), reactor operation was quiet; we lived in our concrete forts essentially isolated from the outside. We never knew if it stormed or if night came or if day broke. On night shifts a good storyteller was popular.

After three weeks apprenticeship, I was made Hydraulics Supervisor on D shift for the K reactor. I was responsible for the pumps and pipes and motors and valves and instruments that made sure the heat from the fuel was dumped safely into the Savannah River. Two operators in the central control room and two operators 40 feet underground in the pump room were under my control. I was weighed down by my responsibilities, in large part because I had little idea of what was expected of me. After years in the safety business I now realize that Hydraulics Supervisor was a parking spot for young engineers, and the main responsibility was to keep the pump room operators awake on night shift. Some of my associates grasped this fact immediately and led relaxed lives. I spent a year pondering what should be done if this pipe should break or if that pump should stop.

The reactor building looms large in floodlights, resembling a very large stacked collection of rectangular children's blocks. Exhaust stacks for various engines stick out here and there. We can tell much about the status of things inside by what comes out of the stacks. Tonight the right three stacks belch diesel smoke; we infer that the reactor is up and all is well. We go through two security checkpoints.

Shift turnover takes ten minutes and the retiring shift is gone shortly after midnight. We supervisors sit around the Fish Bowl, read logs, catch up on what lies ahead and gossip. The Fish Bowl is a glassed off portion of the central control room that is office for the shift boss; from his desk he can see most of what goes on in the central control room. I move off to the lunchroom for coffee, two spoons of sugar and an inch of condensed milk. Raw Hide, the shift electrician is holding court. He tells of his latest adventure with the Plant Manager.

I infer that the Plant Manager has three tasks: to meet production schedules, to avoid hurting anybody and to keep labor unions out. Convincing potential union members like Raw Hide that the Company gives them more without a union than could be won with one is a major assignment for all supervisors of all levels. Raw Hide is well aware of the strong cards he holds, and is an accomplished artist at catching his foreman in the same room with one of the big bosses. He then runs up to the big boss, "Mr. Big, have you met Jim, my foreman. Come here Jim and meet Mr. Big." Foreman Jim slinks over knowing he has been had. Raw Hide makes the introduction with excessive complements about what a fine boss Foreman Jim really is and then regales the big boss with some tale about how Foreman Jim only allows a ten minute coffee break when all the productions operators take twenty minute breaks, all this while Foreman Jim stands first on one foot then the other.

Tonight Raw Hide recounts the pinnacle of his career. He has caught the Biggest Boss in a crowded lunchroom at high noon with his pet peeve, an ex-Navy Chief, now a stickler of a foreman. The whole lunchroom had fallen silent. Raw Hide had played to a packed and attentive house, and the Plant Manager had agreed to have lunch with the two of them while they worked out the fairness of some navy practices that the ex-Chief was attempting to implement at SRP.

Coffee done, I head downstairs to my pump room domain. I have found that my two pump cooperators get called on the building telephone system when I am seen headed their way. This is not all bad. I have but to yawn and mention the pump room and I know that they spend the next half hour alerted. But I must show up part of the time, and tonight I walk down six fights of stairs to the bottom floor of the reactor building 40 feet below the ground. Here six electric motors spin six pumps that remove the hot water form the reactor. The motors are the size of small automobiles and the whole floor hums and whines so that conversation is difficult. My two operators sit at an instrument that monitors all the important things going on inside the pumps and motors.

Last night had been a bad night for me. I had come down at 5 AM when sleep is almost irresistible with the training manual to train the three of us and to keep the three of us awake. We three had propped up against the wall in front of the monitor; I had opened the manual and had started reading to them. The motors had droned. The pen on the instruments had pecked away. The fried eggs and bacon recently consumed at the cafeteria had settled most comfortable into my gizzard. And the three of us had fallen sound asleep, all propped up, three in a row.

Three AM lunch time approaches. We walk a block to the cafeteria and order scrambled eggs, bacon and grits. Lunch over, we head back to the massive reactor building. Dave, the shift boss, patrols the control room. Two instruments that monitor radioactivity levels in the heavy water fuel coolant are inching upward. This is not too unusual, but we begin to worry that one of the thousands of fuel pieces has sprung a leak. These uranium fuel pieces are contained in thin-skinned tight-fitting aluminum cans. If a can springs a leak the heavy water coolant eats away at the uranium. The wound swells; cooling water flows go down and temperatures go up. The swelling accelerates. Boiling might start and a whole column of twenty fuel pieces might be damaged. This would be a first class mess.

Very extensive and complex instruments watch hundreds of flows and temperatures and stand ready to ring bells, blow horns or even automatically shut down the reactor if these unpleasant circumstances appear to approach. We need to be sure that these instruments are working, and we would like to shut down as soon as possible to minimize the mess. But there is the rub. Activity instruments frequently give false alarms. Shutdowns are very costly both to the government and to the carrots of overcautious shift bosses. And we must run until we can locate the leaking fuel piece or we will not know what to replace when we are shut down.

We pace the control room, first to the activity instruments, then to flow and temperature instruments, then back. The activity instruments inch upward; alarms bells begin to ring. Three fuel assemblies begin to look sick; in one the temperature eases up, in another the flow drops off a bit and in the third the temperature goes up and flow goes down. Then the activities ease down, but the third assembly looks sicker. Dave decides to call his boss at home; it is 5 AM. They talk while we pace between in the instruments. The activity instruments ease back up and high temperature alarms begin for the third fuel assembly. Dave and his fresh-waked-up boss decide to shut down.

Roland, the control room supervisor, tells the console operator to slowly drive control rods into the reactor. Long thin aluminum rods containing lithium inch further into the reactor core. The lithium catches and holds neutrons that otherwise would split uranium atoms. Pens on the power instruments draw lines that slope downward. Then horns blow and lighted information plates tell us that the reactor has scrammed, that is, that automatic systems have taken over and have quickly shut down for us. The temperature of the heavy water coolant had decrease and it had contracted. A group of instruments had felt that we had sprung a big leak and had seen the need to take over and shut down quickly.

After five years in Reactor Tech, I am promoted to Senior Supervisor and I am placed in charge of the Reactor Tech group actually stationed in the C reactor building. This was probably the best job that I had at SRP. About five of us were responsible for the safe operation of the C reactor, and during this time we did some very interesting things. We made large amounts of curium for power sources for space exploration, and we achieved the highest neutron fluxes ever produced, $3x10^{15}$ per square centimeter per second.

During this period we had some unusual visitors, sent to us by the AEC. At the very top of the management heap are the Atomic Energy Commissioners. I think there are five of them. One of them, Dr. Glenn Seaborg, is a wall-eyed super scientist from the state university in California where much of the nation's nuclear research is done. He feels that one of SRP's reactors should be diverted for a while and used as a research tool, and what Dr. Seaborg wants, Dr. Seaborg gets. The plan is to load up the C reactor such that we cook up the thickest neutron swarm possible.

The purpose of this high neutron flux is to make new elements that only last a second or so. This is very important and high-powered research, and can be done only by the most potent of nuclear physicists. A crew of these advanced thinkers descends upon staid, conservative SRP. Their leader, Dr. Harry, is an old-time buddy of Dr. Glenn, the AEC Commissioner, and the group includes a wild man from Norway.

The contrasts are startling and refreshing. SRP is ten years old, and we have an average age of about forty. Most of our youthful rough edges have been rubbed off, and we DuPonters walk pretty much in lock step. We all wear big, round-toes, ugly safety shoes. We wear safety glasses almost everywhere we go. Horseplay is strictly forbidden. A pyramided, military-type discipline is very much in force. Conservative dress codes are the unquestioned rule. The California team arrives in open-toes sandals and one mechanic wears no socks. Hawaiian shirts of bright colors are worn with tails outside the pants. The Norwegian team member is want to go barefoot and spring to the top of a file cabinet, flap his arms and crow like a chicken. They are a dedicated, very likable, productive bunch, but they march to a different drum.

The area superintendent welcomes them and gives them a stern lecture about how we do things at SRP. I escort them to their work area and hang around to watch them hook their counters onto our rabbit. Basically, they will stick a small amount to californium into the reactor where the neutrons are the thickest, cook it for a while there, and then snatch it out as fast as possible. The hope is that some of the californium had been transformed into other new elements as yet unknown to man, and if they are quick enough, they may be able to detect the new elements before they disappear. For this work we have made a device like the one that takes your money to the bank teller from your car at the bank drive-in window. A small metal can dashes into a hold in the reactor, rests there for a while and then dashes back out. This machine is called a rabbit.

They work the rabbit area until quitting time. I ask Dr. H if he has what he needs, and I go home. Dr. Harry and his crew work on into the night to be ready for tests the next day when the neutrons will be the thickest at the end of the rabbit hole in the middle of the reactor. At about the time I sit down to supper with my beloved family, Dr. H decides that he needs a special wrench, and asks one of our mechanics to get it for him from a locked cabinet. Now our mechanic has never seen such a wild looking bunch before, and he does not like to see bosses working with tools, such being forbidden at SRP as part of the package to keep labor unions out. The Du Pont mechanic declines to get Dr. H the tool explaining that those tools belong to the day shift foreman and are not available to shift workers. He goes on to lecture Dr. H about how he takes bread out of the mouths of honest American workers be doing their work. He adds that he might feel compelled to call Mr. Bill the next day and report that he had seen Dr. H doing forbidden work.

Such a threat to one of us would have filled us with terror, and would have reduced us to trembling impotency opening visions of sessions with the Plant Manger and ruined careers. Unfortunately, Dr. H has none of our background on the compelling need to grovel when a worker mentions a labor union. In his ignorance of the system, Dr. H calls his buddy, Dr. Glenn, the AEC Commissioner, just in the middle of Dr. G's cocktail hour in Washington, DC. He tells Dr. G that Du Pont won't give him the wrench that he needs to discover new elements at SRP. The Chairman calls the Company President in his Du Pont mansion with sheep on the front lawn in Wilmington, Delaware; he calls the appropriate Vice President, and this message about the wrench tumbles down hill towards me at my supper table in Aiken.

Avalanche-like, the wrench message grows in volume and priority as it rolls down hill through about eight levels of supervision. My first indication of Dr. H's need for a wrench is the appearance of my boss at my front door demanding that I leave for the plant with him immediately.

We arrive in time to find the Superintendent of the Maintenance Department personally unlocking the cabinet in question and delivering the wrench into Dr. H's hands. I am told to spend the night with Dr. H, and to cater to his every wish. I am exposed to the ultimate in naked power. I have but to mention Dr. H's name and whole machine shops stop to build a modification for Dr. H's rabbit. The wild Norwegian looses his security badge and is taken into custody by the local patrol force. One call to the head patrolman springs him free. Our safety engineer makes threatening noises about stopping the rabbit work until people learn to wear the required safety equipment. I make one telephone call and the safety engineer disappears from the rabbit area for a week.*

* These stories were provided by Fred Christensen in lieu of a formal interview.

DANIEL PELLARIN

When I was seventeen, I finished high school and enlisted in the program that the army had, it was called ASTRP, Army Specialized Training Reserve Program. And they send us to college until we reached eighteen. And at that point, they extracted us from the program and fed us into the army, basic training. So I had one year of college in this program at Rutgers University as a general engineering background. Then I spent about a year-and-a-half in the service. The war ended and I was in the adjutant general's department assigned to MacArthur's headquarters, and sent to Tokyo, which was very interesting, to be there very shortly after the war.

When I finished up, I came out in April of '47, and looked over a bunch of catalogs, with the help of my assistant principal, and identified Lafayette College in Easton, Pennsylvania, as a good school. They offered a degree in engineering physics, which was sort of a noncommitment in any one area. I got a B.S. in physics.

And at that time, January 1951, the job market was pretty wide open, there were people interviewing with five and six different companies, shopping around (laugh) for the best offer. I very nearly committed with Eastman Kodak but didn't—wound up hiring on with Du Pont. In those days, they didn't pay your moving expenses and when I finished school I was in debt. So—and I didn't have clearance, and they also didn't take you on board—Du Pont didn't take you on board until you had your clearance.

The very first day I was at Argonne I still didn't have my clearance but they finally, I guess felt sorry for me and at least put me on the payroll. I was in the reception area, spending the whole day just looking at textbooks and trying to educate myself (laugh) as much as I could, when on one occasion I hear this commotion and I look up and hear coming in to the reception area is Oppenheimer with an entourage of people, I guess it was a meeting. I was quite impressed. Well anyway, at Argonne, we did some experimental work that provided data for the people involved in the design of the Savannah River reactors.

I started out in Argonne National Lab as a Du Pont trainee over there, in the Physics group, in preparation for the 305-M reactor, the test reactor. And we were next door to the 777 building because the Lab (laugh) wanted to put reactors as far away from the rest of the business as they could. I guess maybe they always felt something might blow up. Well, the same thing was true at Argonne, that the reactors were at Palos Park, which was a state park that had been taken over by the government, and the very first reactor, CP-1, the one that went critical at Stagg Field, was dismantled and brought out to Palos Park, reassembled, by then they had some more uranium rather than uranium-oxide, and they rebuilt it and that's the one that was very similar to the test reactor in the 300 area.

And so George McManoway and I were involved in some experiments and we taught a [class]. I thought it was so strange. I never had a course in nuclear physics. I graduated in January, just sort of off schedule. And shortly after arriving at Argonne and getting assignment, someone thought, Gee, it'd be a good idea if we gave a course in nuclear, or reactor physics, doing simple experiments using CP-2. And George and I were involved in that thing, and I always felt uncomfortable, [since I] didn't know a damned thing.

[Later, when I was working at Savannah River Plant in Reactor Technology,] certainly the most colorful [co-worker] would be Bob Axtmann. Now, you know what a helmet liner is, [something that goes inside] a hard hat, has a little hooks that go in, fasten in. It's like a sweatband that goes around your head. Bob Axtmann would have one of those hanging on the coat tree in his office. And he would very solemnly pick it up on occasions when he had to talk to Production department, who were running the buildings. Production department was the superintendent and assistant superintendent and area supervisor and senior supervisors and so forth. But Axtmann interacted generally with the superintendent or the assistant superintendent. He would put this thing on. Of course it looked ridiculous. With a great degree of solemnity, he would walk down the hall from where his office was, maybe twenty feet to where the production superintendent's office was. And he would call that thing his "talk-to-Osterdal hat." Osterdal, was at one time or another, assistant superintendent. And he'd walk in there, sit down and relate whatever his business was to Osterdal. And he could do this without cracking a smile.

On one occasion I remember going into his office. I had found something that was amiss, I don't remember the detail. And I was quite excited about it, I guess. And Bob Axtmann was sitting at his desk. He has one foot up. DuPont safety rules would probably frown even on one foot, but he had it, and he had his shoe off. And there was a hole in his stocking, and he had a toe that was protruding. He was— All the while, you know, I'm all out of breath, I'm talking about what's going on, it's not right and we got to do something about it. And he's just looking and wiggling the toe. And then all of a sudden with no other forewarning, he reaches down, puts his finger in the hole and tears the sock, you know, just rips it off his foot, balls it up and throws it into the wastepaper basket. And he turns to me and he says, That'll teach my wife not to darn my sock. But he—I knew him. He was at Argonne. I knew him from Argonne. And he was in Reactor Tech. He was a great guy to work for. He had a running feud with another guy, a Ph.D., in Physical Chemistry. His name was Sid Katz, very confident, he was from Johns Hopkins.

Du Pont had some very, very good, very high-caliber employees that they had pulled together or even out of their commercial plants to feed in. As a matter of fact, I think there were five plant managers at Savannah River. Only one could be a plant manager and the others were extremely knowledgeable. But anyway, he and Sid Katz were sort of forever bantering back and forth, making bets. And I remember one time when Bob Axtmann lost a bet. He made a dollar bet with Sid Katz and lost. So he paid him off with a hundred pennies that were taped down, I mean really taped on a piece of cardboard, so he had to work at it. It was funny.

LARRY HEINRICH

In 1951, the personnel people for Du Pont came through the universities and were hiring people for work, eventually they said [the work was] at South Carolina at the Savannah River Plant. And I talked to them and applied and eventually got a job and clearance, and my first assignment was at Argonne Laboratory at the group in Building 316 that was doing the development work for the production reactors at Savannah River and also for the reactor for the submarine, Nautilus. We were working on both of those. And I worked there for about a year and then transferred down to the Experimental Physics group at Savannah River. The facility at Argonne consisted—that was related to Savannah River - was a two-thirds size mockup of the production reactors. And this was the second test of that. The first one was a sub-critical test of a thermal column of a source that they had out there, doing the design work, and we were looking at the flux shapes around the fuel and getting the general reactivity characteristics of the reactor, then transfer it down.

Argonne did the development work for the reactors, the development work for the reprocessing was done at Oak Ridge, and the development work for much of the other was done at KAPL, Knolls Atomic Power Laboratory. And then it sort of all fed together—the D_2O development was done elsewhere, but then the D_2O plant was built at the site.

After Argonne, my wife and I relocated to Aiken and moved into Crosland Park, which was being built at the time. And there were about three or four hundred homes completed and we bought one and went down to Southern Mortgage and signed the lease and went back and couldn't find it. It was raining cats and dogs. We found it at the top of the hill, and lived there until 1958.

The impetus for the Savannah River Plant itself was to provide material for the hydrogen weapons, tritium. The existing plant at the time at Hanford could make small amounts of tritium, but not large amounts of tritium because the nature of their reactors. They were graphite-moderated reactors and one of the problems that you get into when you try to make tritium in graphite reactors is that you get into positive power coefficient systems, something that you ignore or try to keep out of if you're at all able to do so. It's the thing that killed the Chernobyl reactor. So the reason they went to D_2O was to be able to make tritium and the characteristic that was important was the smaller absorption cross section of D2O compared to graphite, so you could get a higher reactivity of the reactor and make tritium.

The design concerns—the things that drove the design of the reactor, was the lack of heavy water, which we had to make, the known ability to make fuel at that time, the size of the tanks that had to be built at New York Ship. The Savannah River Plant actually consumed the entire stainless steel output of the United Sates for two years when it was built. The reactor tanks themselves were built at New York Ship. And we built the largest tanks that could be floated down the Intracoastal Waterway and up the Savannah River and discharged at the site, so that was a limiting condition there.

The problems that we had to face at that time were knowledge of how to make fuel and how to connect aluminum and stainless steel, which is why we went to a reactor that had both moderator and the coolant all on the same circuit, so to speak. The tubes holding the fuel were aluminum and the bottom plates of the reactor and the top plates were stainless steel, and it was not known at that time how you could bond aluminum with stainless steel. We could do that now, but we couldn't back then. So we went with a single moderator system. They had built or been able to design fuel and get a good contact between the cladding and the fuel using one-inch slugs of uranium that were 8.1 inches long. And so we designed a fuel piece that was called a quatrefoil. It had four columns of one-inch slugs in there. And one of the things that we were doing at Argonne was to measure what was called the Wilkins effect. It was discovered by a physicist by the name of Wilkins, strangely enough, who never worked for Du Pont, but this is a streaming effect of neutrons around the bottom of the gap between one piece of fuel and the next.

Wilkins was one of the few African American physicists at the time. As an amusing sideline, we had a fellow come in and try to hire on to Du Pont and his name was Wilkins too and he claimed that he was one of the guys that discovered this effect, only he was not the right color, so he did not get hired.

In the fall of 1955, I transferred into Reactor Technology, into the Works Technical end of the business, where I did production calculations and reactivity calculations. Back in those days, we didn't have computer codes for the reactor, everything had to be done by hand. And for calculating reactor flux shapes and reactivities, we had to go through the Bessel Function Equations. It was a long and involved process, but it worked nevertheless.

Most of the time when I was out in the reactor area, we ate—we took our lunch and ate it, because we also had a bridge game going or something else like that, and got together and ate lunch together. There was a cafeteria at each area back in those days and you could do that. If you were involved in a project, and there were numbers of times that I was involved in a project, you would work sixteen, twenty-four, thirty-two hours at a stretch and you'd eat at the cafeteria and grab a nap in the ladies rest room, because that was the only couch in the building.

I can remember when I was running a test when they shut down R-reactor. They had decided to close down R and they asked people if there was anything that ought to be done, any tests that ought to be made on that reactor before they shut it down. And I wrote up a proposal for testing the supplementary safety system. That was a system for injecting a solution of gadolinium nitrate in D_2O as the next-to-last safety system before you dump the moderator and put H_2O into the tank. And this system, it was installed and it had been in all the reactors and it was under pressure and—but it had never been tested. So I suggested before we shut down, on our list, do two things—we'll test it to 1) determine how effective it is at shutting down the reactor and 2) if we ever have to use it, can we get it out and restart the reactor? And the bottom line is that we did one hell of a lot of calculations and measurements and set up various monitoring systems in R-reactor and used some high or very fast recorders to record neutron temperatures or neutron distributions at various places in the reactor and outside. And early one morning after I'd been here for probably thirty-six hours or so, we pulled the ring and shut down the reactor, had a lot of management looking over my shoulder. And it worked exactly as we had anticipated it would. And we then ran the separations system out there for the moderator and took the gadolinium out and actually restarted the reactor to prove that we could do that. And after we did that, we shut it down for the last time, and that was the last time R operated.

The only reactor area that I ever worked in before start-up was C-reactor because when the other reactors were starting up, I was in the Technical division. But I visited the areas quite extensively. And it was hectic. There was a great sense of urgency to get the reactors on line. We actually went critical with R reactor in December of '53. And we were doing everything we could. It was a mark of accomplishment, I think, for Du Pont management that this was the only site in the weapons business that started up on time, or before, and under budget. It was brought in under the budget that was actually designed for. And we were operating five reactors, two reprocessing plants, a tritium production facility, and all of the fuel production facility with about between five to six thousand people on the site in production and a thousand people in the laboratory—less people than you have out there today with everything shut down.

Over time the mission of the site changed. The original mission was meshed in with the navy program and with the accumulation of depleted uranium. The whole method of production changed from a single-uniform lattice in the reactor, to a mixed-lattice complex. The reason for that was that Admiral Rickover's submarines required some ultra pure uranium-235 because their time at sea was limited by how long the reactors could operate, and that depended on how much pure uranium-235 was there. Well this uranium-235 has a very large value to it in terms of feed and separative work. And when the navy got through with their fuel, there was a lot of 235 still left in there that had a lot of book value of feed and separative work. The navy didn't want to eat this as part of their budget, so they needed to find something to do with this fuel. At the same time, Oak Ridge had been making the 235 by isotopically separating the 235 from 238, and they had fields full of drums filled with uranium-238. Question was, what to do with that? And the third thing was that we were interested in producing plutonium-238 for use as power sources for the space program.

Well, all three of these came together at Savannah River. And we changed the entire concept of the reactor operation to a mixed lattice that would take the enriched uranium from the navy program and put it into half of the fuel positions, take the depleted uranium from the isotope separations operations at Oak Ridge and put it into the other three, and run the reactor, process the depleted uranium to recover plutonium for weapons, process the U-235 and recycle it because now it had a large 236 component in there too, and 236 absorbs the neutron that goes to neptunium. And neptunium is the target you use to make plutonium-238. And the 238 that we built a facility to recover that out at the—in the 200 areas, and make it into fuel pieces for the space program. So you can say that the mission of the plan was focused on plutonium and tritium up to a point, and then it became focused still on plutonium and tritium, but also on the production of neptunium to be converted to plutonium-238 for the space program.

GERALD MERZ

I was actually stationed in the reactor building in R area and C Area. A lot of my time was in an office building named 706-C, which was an old Butler building that they had originally built for an office building. In addition to that, I spent some time in 703-A, which is the administrative area. And I spent about ten years in the Lab, Savannah River Lab, as opposed to SRP, Savannah River Plant—the distinction being the plant is the production facilities, the lab is the R&D facilities. So I split my time between the two, but in all cases, associated with reactors, with raw materials, with heavy water, with everything but separations and waste management.

The job that I retired from, was called superintendent of Reactor Technology, or Reactor and Raw Materials Technology. Under me were about, oh a hundred or so technical people—engineers, chemists, physicists, who did the technical support work, safety studies, efficiency, production studies, for the reactor areas, for the raw materials area and for a little while for the heavy water area, but that was being phased out by about the time I got into it. So a typical day for me towards the end of my career was, get the morning phone calls to see what was going on during the night, and if I showed up at work in the morning and hadn't gotten any calls during the night, it's a good day so no need to be in a hurry, and then discuss it with plant management and with Wilmington, Du Pont corporate management. And then typically read documents that any of these people have prepared, go out to the areas, wander around, talk to people, see what's going on, keep a finger on the pulse of the reactors basically.

Out of all the reactors, I'd have to say my favorite was R Area. That's where I spent my childhood. I went out to R Area when I was first hired in, that was one of my first assignments. And R is the oldest one. It's, of course, in the worst condition of all of them right now, but just because I was—that was the first one I ever saw, I guess I have a soft spot in my heart for it.

[Security changed over time.] Originally, DuPont provided the security. We had our own, in effect guards, police force, many security measures. One of them that we originally had is to get into a reactor building, you had to go through two fences, two gates, and everybody has a badge that they wear all the time, everywhere, which gets you through the first gate. To get through the second gate, you got to give that badge to the guard. He takes it over to another badge rack and finds another one with the same picture on it and swaps with you, which is kind of a simpleminded thing to do but very effective, because they have to have your badge picture on file, not just have you show up with something. Okay in the early eighties, at that time, this was designed to keep people out who shouldn't be in, and it was a guarding of information. We didn't want people who had no need to know, to get into a reactor area and see things that they have no need to know. And we guarded information.

In the 1980s, the emphasis on security changed and was more towards guarding the facilities. The information was starting to be declassified over the years anyway, so there wasn't that much emphasis on guarding information. But terrorism was starting to be noticed worldwide. At that time, DOE, in their shifting emphasis towards safeguarding facilities rather than information, asked Du Pont to buck up their security force to have things like SWAT teams, helicopters, stuff like that. The Du Pont reaction was: We're not in that business. We're a chemical company. Could you get somebody else to do it? Which they did—they got Wackenhut, who has been doing it every since. And they know the business.

But with the growth of the commercial industry, which as I say, was not allowed—was not even legal until '54, the commercial industry started sprouting up. They took a lot of their reactor safety information, their best practices, from Savannah River Plant, because that's all there was at the time. As the commercial industry grew, it got to be a mutual exchange of information and certainly the commercial industry then grew and grew and grew and outran Savannah River Plant, which was by that time getting stagnant or decreasing, as reactors were shut down and Cold War was easing down.

Certainly, for all of us, Three Mile Island and Chernobyl were kicks in the pants, and there were studies in the commercial industry, in our industry, on, What does all this mean to us? And both Three Mile Island and Chernobyl were different, very different types of reactors, particularly Chernobyl. But Three Mile Island was a very different type of reactor from the Savannah River Plant reactors. So certainly there were lessons to be learned as far as operating practices—how you do procedures, training, that kind of thing, from the hardware point of view, maybe to a lesser extent. One of the things that the commercial industry were building for themselves, and we didn't have and we wanted real bad, was a reactor simulator to use to train the operators on, similar to a flight simulator for pilots. And we and Department of Energy came to the conclusion that we better get on with that one, because that was one of the lessons of Three Mile Island. And we agreed, we got the money and we did it, built us a simulator [in C Area].

ROBERT ANDERSON

I got my bachelor's degree from Sam Houston State University, and I got my master's degree from Texas A&M. I got my bachelor's degree in chemistry and mathematics, and I got my master's degree in physical chemistry and mathematics and electrical engineering. I started working at Savannah River site in 1955 and worked there until 1991. I was superintendent of C Area at one time, and I worked in all five reactor areas at one time or another. I was superintendent of L Area when I retired.

Usually, I was in to work by 7:30 at least and I went over all the night logs and the logs prior to me coming in that morning, and then I got together a morning report and gave the morning report to my boss, which was the superintendent of the Reactor department. And after that, why I looked into the things that we had scheduled for the day, made sure that they were consistent with the safety of the plant, and then I did the other things that was necessary to run the area. And sometimes that consisted of a number of meetings, plant people. Sometimes it consisted with the area people. And also I coordinated the effort of the construction forces. The day was officially over at 4:15, but a lot of times it was much later. I got home after nine o'clock at night sometimes.

My favorite reactor would have to be L Area because it was taken out of service early on, and it was out of service for a number of years. I was the superintendent that helped put it back, re-did the reactor completely and put it back into service. And so I had really more understanding of L Area and what was in it than the others because I saw it all put together and refurbished, and had the L Area lake built.

In L Area, every system was reworked, all the instrumentation, all the hydraulic systems, all the electric systems. Every system in the building was reworked. The physical building itself probably would hold up for hundreds of years without deteriorating, but the equipment that went in the building had to be all reworked.

I could tell some good stories about different things, but I thought one of the biggest was at one time they kept wanting to irradiate special elements. So we had a fairly new component that was radiating and yet we were supposed to make a certain amount of plutonium. So people in Washington couldn't understand why when processed, it wasn't getting that amount of plutonium out of it. Of course they had asked us and we'd put in a bunch of special assemblies in the reactor to make other products. And of course— And so they came down to Savannah River and I guess they came down (unintelligible) y'all told us, you know. And turned out that when I put up on the board what all the things that we've made and the equivalent plutonium, we made exactly the amount of plutonium that they said. But when you got a bunch of assemblies in there with neptunium in them and other things that you were radiating, why it took away from the final product.

Training reactor operators was always an issue because you've got different levels of people. You've got people who do the Reactor building things, like run your purification, prepare the fuel to go into the reactor, take the fuel out of the reactor, put it into disassembly basins, disassemble the fuel and ship it to Separations. And then you got the people that are actually in the control room. Well, the people that were actually in the control room had to know more and be actually trained in the nuclear process and what equipment was for and safety and all the specifications and the technical standards that they had to operate with and so forth and so it'd take longer to train people to do that. And it'd depend on the background of the people that you've got, which is some people— Like anywhere you go where some people are just smarter than other people. So really, the training was an ongoing process. But let me state right here that the people that we had training and we run the reactors with, I didn't have any trouble sleeping at night.

The neutrino work was mostly done at P reactor and sometimes they came in on off-shifts and so forth when I wasn't there, so I don't really know how often they was there. And if they really needed some help with something, they'd come in on the dayshift when I was there and I'd make sure they got it. Sometimes they came in late on the dayshift and I'd get it before they left.

Changing the reactor out between cycles was one of the most important operations in the reactor building. For most cycles, we put stuff in the tank in about two or three work shifts, and change out the control rods if they had to be changed out, do all the things that had to be done and had to run a tank top check. Then once the reactor was charged, you had to lower the actuator and connect the actuator and make sure that it'd run. A lot of times we had—you had to run a special test after the actuator was put down to check all the control rods worked right—I mean all the safety rods worked right. As you drop them, and time the drop in of them. And of course keep the hydraulics, everything else usually buttoned up by the time you got there and if there was anything was buttoned up well then you had to get all the hydraulics on and you had to run all your start-up DPSOL's, which take a shift. And prepare to run the reactor. You always had four senior reactor people in the area. We had the area superintendent, system area superintendent and two area supervisors. One of us was always present to start the reactor up.

There was also as cafeteria. It was in 704 administrative building. And also there was a lot of people brought their own lunch and we had a lunchroom was in the reactor building. It had a stove and refrigerator, where people could store their lunch. A lot of people brought their own lunch. I think in the early days they did breakfast. I know they did in some areas. I got called in sometime and I know I ate in the cafeteria for breakfast and that's where I learned to eat grits. In Texas, we ate potatoes for breakfast.

HARVEY ALLEN

I worked at the site from 1959 to 1993. Twenty-eight years of that was in Reactor Technology department, three years in the 100 areas, which is reactor area's project department. And I got a reprieve for another three years, and a couple of other assignments. And I started off as a rookie engineer, working on reactor components, and I worked as a supervisor for ten or fifteen years in each of K area and C area, running the technical group of the area. Eventually I became chief supervisor of two different groups in Reactor Technology, one of them running the Engineering section and one of them running the Technical Assistance section, which is responsible for all the technical groups in the reactors. When I started work out there, five reactors were running. We closed up C area in 1964 and L area in 1967. And then L Area was restarted in the 1980's, I don't remember exactly when. I tried to forget everything I learned about it since they said you're not supposed to talk.

I worked in K area for, I don't know, eight or nine years as a technical group supervisor and C area for five or six years as technical group supervisor. Our main job there was to help the reactor department with the technical stuff, but we also were sort of an oversight—we looked for any errors they made affecting reactor safety and we'd write reactor incident reports, which told of the incident and evaluated how it affected the safety and that sort of thing. Of course, in starting to work in engineering and ending up as a chief supervisor, there's a wide range of responsibilities over twenty-eight years. And there wasn't such a thing as a typical day. Being an engineer, there was something new everyday.

Some time in the 1960s, we converted C reactor into a sort of experimental reactor with the "high flux charge." The core was normally 15 feet in diameter and we made it about seven feet, instead of the normal 15 feet, and we ran a charge and made microgram quantities of californium-252. That was kind of fun. But a few years later, we ran a similar deal in K area. Again, we had the 7 foot-diameter core, seven feet high, and we called it the "californium charge." We ran, I think it was ninety some charges trying to make californium. The object there was to keep the reactor running because you lost production every time it shut down. And for a normal charge, you'd shut the reactor down and discharge it and charge it. It would take about three, four or five days. On this californium charge, our record was eleven-and-a-half hours. We shut the reactor down, it was critical eleven-and-a-half hours later, and discharge the fuel and recharge the fuel, which is kind of a record. One of the guys in the Reactor department used to give us "stars" when we did well. We got five gold stars for that one. I think we averaged something like thirteen hours for the ninety-some charges. And if you SCRAM the reactor, the xenon quantity was so high, you'd have to wait three or four days to recover, so we just discharged and recharged and throw it away, but fortunately didn't have very many SCRAMS during that charge.

The reactor cycle for californium was quicker than the others because it was a real high flux charge and you burnt fuel up very quickly. You also burned out control rods. A lot of things we did in that charge to kind of combat the burning out of the control rods, which we use lithium and the lithium would absorb the neutrons in the tritium also. We would use cobalt control rods. And we made the highest specific activity of cobalt the world's ever seen in that charge. And unfortunately, I don't think anybody had any use for it, but we did make it. It also led to a problem later on, but it was kind of fun. The high-flux charge— If I can remember the number, we reached 2.1×10^{15} neutrons per centimeter second squared, I think that was the units we used. We actually had a plaque. We did this in C Area about in the late sixties. But I think the californium charge in K area ran in 1971. We ended it November 1971. The DOE gave us a plaque. We used to have it mounted right under a spotlight near the lunchroom in C Area. It kind of disappeared, although I think Walt Joseph said they found it and have it in their historical building somewhere.

Du Pont was noted for their safety program, and they were always interested in safety. Personnel said they even wanted you to be safe at home because for them it was a moneymaking thing. If you didn't have accidents, you saved on your liability insurance, and it was better not to have people stay home sick and things like that. They had a very, very rigorous safety program and, like I said, in Reactor Technology, we were sort of the safety officers for the reactors, as far as operating reactors go. We were kind of looking over the shoulders of the operations people and making sure they followed the technical standards and specifications and followed the operating procedures and things. If they didn't, we'd write them up on the incident report.

There was always a supervisor in the control room and there was always at least one operator. Usually there were two operators—one at the reactor end, reactor operator, and at the other end—[what did they call that guy?]. The hydraulics—the pumps and everything was operated from the one end of the reactor, and the reactor building control rods operate at the other end, there was a big old control room. But there was always at least two people there, because the guy at the one end—I guess it's called a graphic panel operator—he also answered the telephone in case somebody wasn't in the supervisor's office, which was adjacent to the control room, and it was surrounded like with glass, like a fishbowl, the operation room. And right behind that was the control room for the charging and discharging machines, at a slightly different level. Yeah, there's always somebody there, and if they weren't there, there was a reactor incident report written.

In the Reactor building there would have been four rotating shifts. So each shift had a senior supervisor, a shift supervisor and about twelve or thirteen, fourteen operators. So those—multiply that by four and that's the number of guys operating the reactor. In addition, they had the assembly-disassembly crews. They had a senior supervisor in charge of both, and they had a foreman for assembly and a foreman for disassembly and they had maybe ten or twelve operators on— well, I'm not sure they had them separate, because I think the assembly and disassembly operators worked on both sides. They worked assembling a charge getting it ready, and when they came out and cooled down, they'd do the disassembly and the shipping of the stuff to the 200 Area. Then, they also ran the distillation plant. They had a little distillation plant they kept the heavy water pure, from radiation and light water getting into the reactor.

And when you had to SCRAM— This is kind of a neat thing. They had a Polaroid camera set up, and they had a little bulb, indicating the delta-P for each one of the fuel assemblies, because you had to SCRAM from a high delta-P or a low delta-P. That first light, the one that caused it, would come on first and when the reactor SCRAM everybody'd come on. So the Polaroid, it'd take a picture of that panel and you could see the one that caused it. And when you walked in later on, you'd go, They're all on, which one was it? But that identified the culprit.

Training increasingly became an issue. People actually stayed in training all the time and especially after people got all excited about reactor safety in the 1980s. In the beginning, I think they could probably train an operator in a year and be happy with it. But then they got into the deal where they were in training all the time, they'd go back to the simulator and they had to go back for classes every year. So it was a constant retraining type thing.

By the 1980s, training was either in the reactor building or in the simulator, the training facility in 707-C. Before that, they were training in 706-C, I think. But when they got the 707 simulator out here, they had a real good training outfit, real modern compared to the early days when it was just sort of on-the-job training.

Fishing and hunting were always good on Savannah River Site. People would sneak on and fish in Par Pond. They'd get caught. I remember— Every once in a while you'd see some little four-wheel vehicle that the patrol guys or Wackenhut would catch. I don't think they did it so much when Wackenhut got there, but with DuPont patrol, you know, they'd just confiscate the vehicles. They'd take them to C Area and they'd sit there and their tires would go down and they'd eventually get rid of it somehow or another. But the guys— The fishing's so good, they'd go back several times even though they'd get caught. I don't know whether they got fined or what. They'd sneak in from the Barnwell side of the plant, R Area, and fish. The game was also good, since the site was a protected area. There is all kinds of game. Lots of deer, more deer than you want to shake a stick at. They have a lot of deer accidents. They'd have controlled deer hunts. And I remember in the early days they were taking out a thousand deer a year in their deer hunts. Turkeys that would run down the road. Bobcats, fox, Lord knows what—and hogs. There's wild hogs running around, boars I guess you'd call them. They'd shoot them once in a while on the deer hunts.

When they started monitoring in the 50 million gallon basin, to monitor the level, a guy would have to go down a ramp to get samples of water from the bottom. He turned around one day and there's a bobcat coming down. He said, Oops, what am I going to do now? Fortunately, it didn't attack him or anything.

In K Area one time, we tried cleaning a heat exchanger or overhauling a heat exchanger with phosphoric acid. They thought they cleaned out all the phosphoric acid but they didn't. And we ran the reactor. And one day the area superintendent of production walked in the reactor and for some reason he stepped on the hand and foot counter going in instead of going out. And his feet were contaminated; his shoes were contaminated. Well, find out it was phosphorus-35. So they looked around and they found all kinds of toads around, and he'd stepped in some toad manure, it was contaminated. Well, we were— At that time, for some reason, we were purging the disassembly basin out the 50 million gallon basin, and there was phosphorus in that dang gone stuff and the bugs were getting in the water and getting some phosphorus and then the toads were eating the bugs and contaminating the whole area and we didn't even know it. We got rid of that heat exchanger and that stopped the problem. There was—it got through the whole reactor, but the source was still in that one particular heat exchanger. Once we took it out and put the others in, it pretty well cleared up.

We didn't really have much contamination in the Reactor building. It was amazingly clean. I remember I went to the 200 area one time and we had to do all this dressing out, and they were serious because they had nasty stuff all over the place. We didn't. Tritium is probably the worse thing that we could get there. Unless you're chipping concrete when you might get some cobalt-60 or something, but tritium was usually the worst problem that we ever had. If you went up in the actuator tower early in the game, they found out if you had on a nylon necktie, for example, or nylon shoes, you'd get argon-85 or something like that. Apparently, nylon has a charge on it, had stuff that adhered to it. It decayed real quickly, but when you came down you thought, my gosh, I'm really contaminated. But it was just argon, no big deal.

WOODY DASPIT

I was born in south Louisiana. We always claimed that we were from Houma, Louisiana, but that was in a different parish. They have parishes, not counties there. We were just across the line into Lafourche Parish. We went to school there and so forth. Houma, Louisiana, is probably the place where I grew up until I was sixteen and left home and went to college.

At the ripe old age of sixteen, I arrived at LSU, Louisiana State University, and stayed there until I got drafted. I was drafted in the navy pool, and I was told to report to a place in New Orleans... And here comes a marine sergeant, says I need three volunteers for the Marine Corps. I ended up in the Marine Corps and went to the Pacific and into China for a period of time after the war. And came back and went to LSU and got a degree in physics. And we were a small group, probably about twenty people, majoring in physics. And I was not the smart guy. I did all right, but by the time I graduated, I was looking for a job, and I was the only one that had a job offer.

I went to work at the Naval Ordinance Test Station in California doing ordinance work, I guess, experimentation, but soon I went back to LSU and got another degree in physics. In '52 I went to work for Du Pont, starting out at the Argonne National Lab.

I arrived at Savannah River Site in April 1953, having served eight months at Argonne National Laboratory, preparatory to coming here because we had no facilities. And I worked in the Savannah River Laboratory at the Process Development Pile, PDP, for about two or three years, and then they transferred me to the plant into the Reactor Technology group, and that was in mid 1955, I think. And I stayed there the rest of my career, had almost every job there was there except the manager. I retired at the end of March 1986.

And I will say that one of the things that we were not able to do in the early days is monitor the radioactivity because we did not have instrumentation that was capable of detecting it. We were looking at parts—one part per thousand and parts per million and later on parts per billion, I guess, what they're looking at. And this is the thing where they point and say, Hey you didn't do your job. We couldn't do the job. We didn't know how to do it. Anyway, this was what I did there and finally, they transferred me to L Area. That was in late 1955.

With the Reactor Technology group at L, there was a supervisor and two supervisors—an engineering supervisor and a physics supervisor, and I was the physics supervisor there. We had two of each of those and we were watching the process. Our job was to make sure that they did the work properly, safely, followed the procedures, and of course we had oodles of procedures. The procedures for P and R were different than they were for L, K, and C.

An interesting story developed out of my work at the PDP. My supervisor was Jack Crandall. We were working 16-hour shifts to get the place going. We were doing things that we didn't know what the story was yet. Even so, I wanted to go to Washington to visit up there, take a few days off. One day, Crandall told me to go help the guys who are working on getting the instrumentation lined up. I went there and talked to the supervisor. He said, This is our list of things to do. What you're going to do is on the bottom of the list. What's at top of the list? I says on the top of the list you want to look at something called ground— I can't remember the terminology. Anyway, you connect it to a ground system. And you're talking in the nano-area for current, and if you had this motor over here and this ventilation system, and I was connected to the ground over here, this would have a slight thing there. And one of the construction foremen said, we've got ground loops. I said, What's that? He explained it to me. So I went there and I told him, They're going to do ground loops. Says okay. So the bottom of the list, had to go through about five people. So I turned around and said, Well I tell you, y'all go to lunch and I'll fix this out while I'm going. I went and took all the grounds out except one and brought it in as well, and said, Well, there it is and we fixed it just like that. And the reactors had—ions caused ground loops all over, and had to go back and do that, so it was interesting. Of course Jack Crandall said, Woody, when you want to go to Washington? That happened a bunch of times.

We also had training programs, especially in later years, for reactor operators up through the senior supervisor level. That was formal, graded and so forth. And I worked on that. Had people that would go around and give them written and oral exams. Sort of based on what the NRC was requiring from commercial reactor personnel. We gave talks to the service groups—electrical groups, electronic groups, maintenance groups, the power groups that were interested. They weren't interested in the reactor, they were interested in the powerhouse and the steam generation. But the other groups—health physics—would go to these lectures. I gave a lot of them. And some of the guys would come up and say, Woody why in the world didn't y'all tell us some of this in the past? We didn't understand that and now we understand what's going on. Well, you know, they didn't want people to understand too much in the early days.

LINDA PERRY

I work for Washington Group International, Westinghouse and I've been here twenty-six years. I was born July 22, 1955 in Augusta, Georgia and lived my life—childhood, in Aiken, South Carolina, until I married in 1975, at which time I moved to North Augusta, South Carolina. My hire date at Savannah River Site was February 21, 1981.

I came in at what you call on the ground floor. I worked first as a stenographer in Reactor Technology in C Area. And that was the brain building for all of the reactors, where all of the engineering and procedures were based. And I showed an interest in what I was reading and doing and typing at the time. I was a stenographer for about four months from February to about June/July and then took the Production test on a dare at lunch. In the production unit, you could go into Reactors or you could go into Separations. I chose to go into reactors because I just had an interest in that, being in Reactor Technology. I passed the test and after lunch I was in Reactors.

C-reactor is where I began my initial training, then from there I went to K-reactor. I also worked some in P-reactor, not as a permanent staff but as an augmented staff for the reactor control room crew and I then, after finishing my training and working some period in K Area, I then went to L Area in 1984 as part of the LSPT L Area start-up crew.

The L area reconstruction process had been going, I believe, since 1981, prior to me going over there in 1984. But the startup of L Area actually came maybe in late 1985 or early 1986. But I was there during the startup of the night that we—the afternoon that we started L Area up and we took it to the power level that we were allowed to take it to. We were limited by the L Area lake temperatures, so we couldn't take it to full power like we had been used to doing in the other reactor areas.

A typical day for a senior control room operator was to be in the control room by ten of eight, at which time we would take our shift turnover based on the various positions that we were going to relieve in the control room. That could either be the graphic panel operator or the data operator or the nuclear console operator. So depending on where we were in that rotation, we would get our turnover as to anything other than routine operation that was going on—if there were any procedures that were being run or any particular pieces of equipment that were out of order or had broken down that we were on any kind of limiting time, to where we only had a certain amount of time to get it fixed so we either had to reduce power or shut the reactor down.

So a typical day would be starting on dayshift, starting at about ten of eight and then going in, and if you were the data operator or the graphic panel operator, you would begin taking your hourly readings, which would be several clipboards of readings that you would take. You would learn the status of the plant, so to speak, by going around the panels and doing the various readings. So that really started your day as to where you began familiarizing yourself with the control room and the indications that you had in the control room and any abnormalities. During the day, you would again continue those data-taking rounds periodically. Some of them were every fifteen minutes, some of them were every hour, some of them were once a shift, could be every four hours, twice a shift or whatever. But you would be constantly taking data, monitoring the panels, responding to any alarms that went off in the control room, and just making sure that all aspects of reactor operation was covered.

You dressed for the comfort of the job and a lot of times for the position. If you were a building operator, the type of clothes typically worn up until about probably 1987 were blue jeans and knit shirts, T-shirts—very comfortable loose-fitting clothing. Of course, during that time and depending on what was going on at the reactor, you would change out into what we called SWP [Safety Worker Protection] clothing, would be the white coveralls, if you had to do inside work into the radiation zone. That type of work would only be done during reactor shutdown, usually. But there were some areas of the reactor that during operation you would have to dress out into SWP clothing, which consisted of the white coveralls, the white cotton gloves with the rubber gloves over them, and the white cotton booties with the rubber shoe covers over those. So you would have to dress out to periodically go in certain areas during reactor operation and take samples or do monitoring or things like that. But typically it was just street clothes as far as comfortable clothes that you could do physical work if you were out in the building. Now often if you were assigned to the control room job, you may wear blue jeans also or dress pants and maybe a nicer shirt, whatever.

Around 1987, we instituted what we called reactor operator uniforms, or reactor uniforms, which that was during the reactor restart period to where we were trying to adapt to commercial standards and improve our conduct of operations, which included the overall appearance of our reactor staff. During that time, we would have various colors, all of them within the white, blue and gray family of colors. For a reactor senior supervisor, it would usually be gray pants and a white shirt. For a control room supervisor, it would be gray pants or skirt and a gray shirt, which would be a dress shirt. For a reactor operator out in the building, it was usually gray pants and a blue shirt, a dress shirt. Again, we had coveralls, maintenance coveralls, we could dress into if it was particularly dirty work and of course the protective SWP clothing that we could dress into if we needed to go into a radiation zone. So we gravitated toward uniforms and of course on the dayshift most of the time with the senior control room supervisors who wore the gray pants and the white shirt, they would also wear a tie with that. So we polished ourselves up, so to speak.

From 1982 until 1987, I worked what they call the—I guess the southern swing shift, which was horrible. The southern swing— I believe that's what you call that shift schedule– is where you would have seven days on days, which would be 8 to 4, you get one day off during the week. Or six days 8 to 4, one day off during the week, then you get a day off on Friday, so to speak, but then you would go into work Friday night, which would be for Saturday morning, so really that was no day off. So then you'd work seven midnights and then you'd get what you called a long weekend, you'd get one of those a month. And you'd come off Friday morning and you would not go back to work until— And that was your only weekend off during the month. You wouldn't go back to work until Wednesday, four-to-twelve shift, and you would have to report at ten to four on that Wednesday, at which time you would work seven four-to-twelve shifts and then you'd be off two days before you started your dayshift over again. So really once a month you had a long weekend, the rest of the time you were working on the weekends.

It was part of the shift that everybody cooked and ate meals together. Not so much on dayshift, except for dayshift on the weekends, but always on the four-to-twelve shift and the midnight shift. And most shifts had a grocery rotation cycle to where everybody had a turn to bring in groceries for a particular night. And so usually the shift would talk about what they wanted to eat the night before or any special occasion. It wasn't uncommon to grill steaks outside the Reactor building. The patrol folks always were cooking something. Some of the best food was out at the powerhouse. I mean, everybody had their favorites– who could cook chicken the best, or who could make the best biscuits. Patrol was always good on deer stews, I can remember. Powerhouse folks were good on the salmon stew and catfish stew. Somebody was always frying fish.

And then you'd have different food preferences, sometimes from area to area. A lot of people from the Low Country down towards the Barnwell, Allendale, Hampton area, preferred to work in P Area because it was closer to their home. And you would have a different type of cooking from those people. I know I had possum out there one time and never had that before, had an alligator tail, which was delicious, never had that. Someone cooked rattlesnake, but I couldn't eat that.

That was a really big part of the camaraderie of the shifts and everybody knew each other and we all knew who could cook what they cooked. Back then everybody knew how many kids everybody had, who was married to who, what their hobbies were, their little idiosyncrasies. And it was a magical camaraderie and an esprit de corps that has never been seen since. It survived all those years until we shut these reactors down. And then it was gone. When Du Pont left, it was gone. Westinghouse came in and that's one of the first things they did was rip out all the kitchens.

Also during that period, we were opened up to the world. Prior to that, we had been in our own little world and had operated safely and with impeccable conduct. After Three Mile Island and Chernobyl, the nuclear commercial industry and the nuclear navy industry were looking for a place to hide out, infiltrate, or squat, and we were a prime target for it. And of course we sucked them all in. And as one group would get in, they would bring in their other group. And we became a holding pond for the sagging commercial industry.

I left Reactors after the K restart in 1992. At that time I was personnel manager for Reactors. My office was in the C Area, 706-C Building, Reactor Technology building, when I became personnel manager. And then I supported the K Area restart by making sure that the operator supervision was trained, qualified, certified, all the shifts were staffed, even did some training to the people—to the operations at that time and readying them for K restart training. And at that time, as soon as K Area started, I moved out. My last assignment after K restart was to excess the reactor people into the site. After that, my position was taken over by the human resource organization and I then went into human resource management supervisory skill training.

MARK COLLINS

I was born in 1956 in Augusta, Georgia. I put in an application several years before I was hired, and one day they just happened to call my number. I was a police officer before I came here. When I first came in, I was hired as part of the L-Area start up, and I was hired as a general operator in production. I worked in Reactors from 1981 to 1984 and then went from Reactors to Tritium. From 1984 until 1989, I was a maintenance mechanic in Tritium. And then from 1989 to 1997, I was in charge of the off-site leasing program when we moved off site. I was construction liaison for all the off-site buildings. Since 1997, I've been facility administrator in the SRTC area. Now I'm the facility administrator for F- and H-Area, taking care of all the administrative facilities in those two areas. I just transferred from Du Pont on into Westinghouse when they took over. All it was, was color of paycheck. I think the checks we had before were yellow, then they went to blue and green, if I remember.

My father-in-law had worked here, and he was still out here when I first come on. Back then in the eighties, you didn't know a whole lot about the site. It was not publicized like it is now, where every time you open the paper you've got an article on it. When I was first working here, everything was hush-hush. But you knew— You knew they made nuclear material for weapons, that's about it. You heard all kind of stories about what went on out here, but you were never really sure.

My first job was in L-Area, in what they refer to as the "center section." That's where the operation of the building itself was located. At the time, L-Area was down, it was dead, and we were just trying to get everything back into shape so we could open it up. I did a little bit of everything.

After L area, I went to K reactor, which was working on a 30-day cycle. You had to get the load ready to go into the reactor in thirty days. You had to load the slugs and the columns of slugs and the fuel and have it hanging, ready to go into the reactor. And it took you a full thirty days of loading. You'd get about thirty of them a day and it took like three hundred columns so you figure that and the fuel plus testing it, it took you right to the last minute. A lot of time we worked overtime to get it ready.

First off, the material would come to the reactor building in crates. It was slugs and there was an outer slug and an inner slug. I think the outer slug weighed twenty-six pounds, the inner slug fifteen, sixteen pounds.

The tube was a canister-looking thing about a foot long. And there was a inner target, which is just a pole which resembles a chain link fence pole. You'd put the pole down into a test capsule, and then you'd load the slugs on there. Each column took about eighteen slugs. You'd put the outer slug on there and you slide the inner slug on there—outer, inner– all the way until you get to the top then you'd take it and you'd put it in a metal thing and pressure test it and see if you have any ruptures in the seals. Then you'd hang it in the final storage room until time. Each assembly had a number. They were all numbered. It had to go in a certain way and come out a certain way, and so you couldn't just randomly just stick them in there; you had to put them in order.

From final storage, we'd take it over to the presentation point. And then the C&D crane would come over inside the containment room where the reactor is, pick up the load of slugs and take it over to the top of the rector to a certain position on the reactor and then lower it down into it. Another C&D machine would take a hot one out of the reactor and lower that straight into the water of the C&D canal and it would then go out into the disassembly basin.

On a routine basis, they'd drop one or two assemblies almost every shutdown. And it's usually a panic mode when that happens and we had a procedure you'd follow when it happened. The main thing you had to do is get it off the basin floor. You had four hours to get it up off the floor. And you'd put some rope down there, you'd catch it, you'd bring it up off the floor and you just leave it hanging until you got a chance to go in there and put it on the cutting press and cut it into sections and take the slugs off a piece at a time, which it was a nightmare doing that underwater.

There were major differences between the Du Pont era and the Westinghouse years. Du Pont's management was people-oriented. They were really concerned about your safety and I think they meant it, personally. I'm not so sure if Westinghouse feels that way. Du Pont was a good company. I hated to see them go.

Westinghouse had a different philosophy. When they first came in here it was hire, hire, hire, and—and then right after that, fire, fire, fire. They were known for that, bringing in a lot of people and then next thing you know, cutting them loose. And they did. We ramped up to 25,000 people out here and then right after that they had about ten thousand cut. They also hired for a lot of projects that never happened, like the New Production Reactor they thought they was going to get in the late eighties, early nineties. That didn't materialize and they had to lay off a lot of people as a result.

There were other differences between the Du Pont era and Westinghouse. The Du Pont Patrol was kind of like Andy of Mayberry. Later they went to Wackenhut, which is a lot stricter and a lot more of them. I think it got tougher, security-wise.

One of the problems with Du Pont: unless you were an engineer, they didn't put you in any kind of management position. I've got a master's in psychology. And they didn't even consider that. I mean it's like you don't exist. We don't need any psychologists out here. I beg to differ. You've got a bunch of nuts out here. When Westinghouse came in, they did honor that. If you had a degree, they'll look at you, try to put you in a good a position. That's one thing I didn't like about DuPont: they didn't honor any degree but an engineering degree, period.

FRANK PAGANE

I was born in 1925 in Brooklyn, New York. I graduated from Polytechnic Institute. This was my first job, you might say, after having been in the service and college.

I first heard about Savannah River Site during the interview with a representative from the plant and also from some literature from Strom Thurman and people of that nature who were pretty vocal about it in the press. James Burns was also very instrumental in getting the project at Aiken. But other than that, the only exposure I had had to radioactivity was after the war was over, I volunteered for the Bikini Atoll Test, but my captain wouldn't let me go. In a way I'm sad but I'm lucky.

At Savannah River Site, I was assigned to the project in August of 1952. My first assignment, though, was at New York Ship Building, which is where the reactors were constructed. It was rather an interesting project. One of the reactors was mocked up with pumps and other stuff and went through the shakedown of the equipment, including the control rod apparatus. We didn't have the heavy water pumps that were going to actually be used there, but we had some water pumps which simulated the flow. There was some auxiliary equipment like the—what they call the foil press and shear, which was to take the empty fuel containers, the fuel foils, and drop them into the disassembly basin, get the slugs out and then run it through a device which flattened it and then cut it up. So that's why they called it the foil press and shear. That was a headache. It had to operate under water. A lot of the hydraulic work was established at that time, the data on the hydraulics of the reactors themselves. I was in the maintenance department at that time, so I was in the peripheries, but it was still interesting.

I started working at Savannah River Plant after we moved down in March of 1953. Later, I was in the Power department, so I was involved in the construction of the water treatment facilities, the distribution of power facilities, the emergency power backup systems in the 100 areas and back in the reactor areas, and somewhat, to some degree, with the Transmission department. Four of the five 100 areas had turbo-generators for generating electricity, 100-C did not. So I was involved with the turbo-generators and to some degree the boilers.

Construction work was organized pretty well. I would have to say that Du Pont had a very good engineering department at the time and of course, they were the main contractor for a great many subcontractors, Gibbs and Hills and people like that, that would do certain aspects of the project, but I think the Du Pont construction company did an excellent job.

After the initial facility was in, you try to smooth the process out and make changes for the next area. And that was the good thing about it, we learned from the problems that occurred in the 100-R area, and we tried to incorporate modifications. In 100-R, plans were made to treat all of the river cooling water going to the reactors. Now you're looking at 65,000 gallons a minute. We were going to treat every bit of that, clarify it, get all the Savannah River mud out of it, treat it with massive loads of chlorine and so forth. Then we found that the river silt actually helped keep the exchanges cleaner. So from then on in, we eliminated all of the clarification basins in the other reactor areas.

Another major change: we increased the power load, and that was a pretty significant venture, because we had to recalibrate orifice plates for flow sensitivity in the two headers that entered the Reactor. We had a consultant from MIT that worked with us, advised us. If you can believe it, we drained the three basins so that we could calibrate the flow going through the orifice. That was a pretty significant. And I happened to be one of those guys that worked on that project, we shot-gunned that job.

Relations between management and labor were generally good. I think Du Pont went overboard to some degree in trying to establish communications. As shift supervisor, you would have these meetings with your people to find out if they had any gripes and sometimes when you ask people do you have any gripes, then they generate them. But generally speaking, I think that we had a good grievance procedure. We successfully beat down three attempts to organize the plant. So apparently the people were satisfied.

Of course, we managers had to push safety. The worst thing that could happen to you as a supervisor was to have a lost-time injury occur on your shift. I think that a good many of the wage roll people thought that we overreacted to this, that there was too much emphasis on safety. Whether that's realistic or not, I don't know. But we had a pretty good safety record there. The company might have gone overboard to some degree. But wage roll had to go along with the flow.

I think Du Pont's inherent belief in safety drove the processes to be the safest possible. I think we had the best available technology to safeguard the health of the workers. I consider it a valuable experience. It's nice being able to go around and say that you were involved in one of the biggest construction projects in the world, when you think of it. A lot of us that were there, brag about that. We have a lot of pride in it, and I think we did a good job.

PETER GRAY

I was born in 1929 in Port Chester, New York. When the plant was first announced on Thanksgiving weekend of 1950, I was still attending university. By the time I graduated, in June of 1952, I had a job with the Du Pont company to work at Savannah River already in hand. At the site, I have been employed by Du Pont, then by Westinghouse and others in a period from 1952 through 1997.

In the early days, it was not clear that the job would last. Everybody at Savannah River could have considered it temporary home because Du Pont had a five-year contract with the government. We didn't know whether the contract would be renewed. We didn't know what the outcome of the Korean War would be. We didn't know what the problems with the communist world would be—Russia and the iron curtain and that sort of thing. It might well be temporary, but we sort of liked the work. I found it very fascinating. I hoped it would continue.

The local mores took some getting used to. Segregation was the law of the land, and segregated facilities were built into Savannah River, which I think was just an acknowledgement by Du Pont of the social situation in the South in those days. I remember one day in the cafeteria, the permanent operations cafeteria, going through the line, getting my tray of food, finding every table in the front was taken up. So I went in the back and sat down. And I was very firmly told this was not where people of my race sat. We were supposed to sit in the front. I said, Well what's wrong with sitting here? Here's a table and a chair and some nice people for me to talk with. I'm going to sit here and eat. No, you will sit in the front and eat.

At Savannah River, especially in the early days, we worked many extra hours. I remember the longest day I worked at Savannah River was twenty-five hours. I can't even remember driving home. I didn't hit anybody, but I can't remember seeing the road. I did have, during my very first assignment at Savannah River, I had a boss tell me to keep track of extra time I worked beyond the scheduled eight hours. So I kept this list. After a very short while, I had something like 175 days. Now I don't know what happened to it. I didn't keep track of the two hours here, three hours there, five hours elsewhere. And I figured, 175 days, the company owes me seven months time off. So when I went to my next assignment, I told my new boss about it and he said, Don't write that down. Just keep working. I don't know how many extra hours we worked. We just had a job to get done. Turned out, we were all fired up to get it done and we did it.

I was on shift while the very first fuel assemblies were being put into R Reactor reactor. And I was part of Reactor Tech, which was independent from the Reactor Department. Reactor Department had the responsibility to run the reactors and operate them. Reactor Tech had the responsibility and the free hand to oversee everything that was being done and to blow the whistle whenever they saw anything that they thought was not right. We were not allowed to operate any other equipment, but we could blow the whistle. So in essence, perhaps one of our functions was quality control. And I remember, we were given standards by which to judge each of these fuel assemblies as they were passing by the presentation point on their way into the reactor room to be put in the reactor. And at the end of each shift, we would turn our list in of the fuel assemblies that we thought were not qualified to be in the reactor.

The Reactor Department, because they owned the building and ran it said, This goes in. And our boss, at eight o'clock every morning, would check over the list from the four-to-twelve shift and the twelve-to-eight shift. And he would say, What fuel assemblies went in that shouldn't be there? And he would insist that the Reactor Department haul them out, and the day people would inspect them again. And many of the ones that we rejected remained rejected afterwards. So I think in one respect Reactor Tech could be called a quality control outfit. Later, a consulting firm was asked to come in and do an assessment of the startup and the early operation of the Savannah River reactors. It was a very thorough report, and it was very laudatory of DuPont and the startup of the reactors. It made specific mention of the fact that the Reactor Tech Group, as an independent organization under A. A. Johnson, was in large measure responsible for the success of the reactors, just because we were independently overseeing the Reactor Department.

The Reactor Tech people could only observe and take notes, and so we would go around with notebooks or clipboards. We were called "squirrels" by the hourly paid operators. One guy asked why. Well, all you guys are doing is going around gathering nuts. You're writing down comments. And I think they had a point. They didn't see that we were doing anything productive.

WALT JOSEPH

I was born in 1928 in Oak Park, Illinois. I'm a longtime employee of the site. I came here in 1954 after I got out of the army and graduate school, and was here until 1993, almost forty years. I found out about Savannah River Site while in graduate school at Penn State and there was a notice posted on the bulletin board that they were hiring. And at the time I was taking mechanical engineering with a minor in nuclear. And I went to my nuclear prof, who had been in the Manhattan District during the war, and asked him about what it would be like down here. He asked if I still had my clearance from the army? And I said, No. And he said, In that case, I can only tell you it's near Aiken South Carolina. Anyway, Paula and I came down at Christmas. Paula was wearing her fur coat because it was cold up in Pennsylvania.

When we got down here, the town was a mess. There had been a big gas explosion in downtown Aiken. And I went out to the site and I told her to look around town and see what it was like. At the site, they put me in one room in Building 703 and people came in and talked to me and went out, and none of them told me what positions they had or what organizations they represented or what they were interested in me for. It was all very hush-hush. Despite that, they made an offer and I took it, and as soon as I finished my thesis, we came down.

The work was an opportunity to be in on something new. It was a startup, a new facility. There were a lot of unknowns, and we were pioneering everyday, so it was very exciting. And there was also the feeling that you were working for the national interest, making a contribution to the country.

In the early days, traffic was fearsome. We all carpooled, and that was almost a requirement. I mean, they made it very plain to all the new employees you were expected to carpool, and—because they had to cut down on the traffic as best they could and it was awful. It was bumper to bumper, generally moving at pretty high speeds. There were frequent fender benders. When we first came down, there was essentially open range in this area and periodically a pig would walk out into traffic, and it would wind up totaling half a dozen cars.

One of the social problems was having so many strangers in a new community. Du Pont organized the Operations Recreation Association, the ORA, which sponsored very frequent dances and get-togethers. They worked hard to keep morale up, and that was the only way they could do it. You couldn't even tell your spouse anything about what you did, and that made for some tensions at home when the wives just saw husbands go off and didn't know what they did.

One of things that happened to us when my son Joe was very little, we used to take him up to my parents in Greensboro, North Carolina, for a week every summer. And when they had him, they always liked to show him off, so they'd have people in to talk to Joe and all that. He was probably a couple years old. We came up to get him that weekend and my mother was really upset. She said, You need to talk to your son about what you do. And I said, Why is that? And she said, Well they had this party and someone asked Joe, What does your father do? And he thought about it for a while and he said, I guess he's a barber. And my mother was pretty annoyed by that. But we figured out that what it was. When I needed a haircut, I'd have the carpool drop me off at a barbershop, which was on the way home. In those days, Paula and Joe would come out and pick me up at the barbershop. So the only place he had seen me other than at home was at the barbershop.

That was the same place, by the way, where I heard for the first time why they had located the Savannah River Plant where they did. The barber confided to me that it's on the site of the world's largest tritium mine!

Much later, in 1979, the plant manager called me in and said, Walt, we're going to promote you to be superintendent of Traffic and Transportation Department. And I told him, you could have looked long and hard before you found a job I know less about than that one. But it turned out to be a really interesting assignment. In that job I was inside boilers and on top of coal silos and out in the swamp breaking down Beaver dams. The railroad guys taught me to run the switch engines at night when there was nobody around, and it was a great job.

And from there I went to the L-Startup Project. I can remember that one vividly. I had been sent to a training class in Wilmington. They called me out of class to say that I had a phone call and it was my boss, Mack McGuire, a guy I could have a little fun with. He said, Walt, he said, I've got a piece of paper here that says they're forming something called the L-Startup Project Team and you're the superintendent. He said, Should I sign it? I figured, Well, this is my chance to have a little fun. I said, Mack, what would you say if I told you I didn't want that job? There was a long pause and he came back, Walt, can you find another job while you're up there in Wilmington? I said, Just kidding. I'm ready to go. That was the beginning of an interesting three-year assignment.

By the early 1980s, L reactor had been on stand-by for over a decade. If something was placed on stand-by, that meant that you couldn't steal parts from it for the operating reactors, unlike R, which was cannibalized. But there was no maintenance, and no attempt made to upgrade the reactor as improvements were put into the other areas. And so in eleven years of continuous improvement in the operating areas, when we came into L, first a lot of the equipment was rusted up and disabled totally. And second, we had eleven years worth of modifications to put into the area. And some of that was pretty straightforward. We had to put in things like the M2 containment console, which is the big console which is a—it's hardwired logic, which took specific actions in the event of a major-loss-of-coolant accident. You have a major leak and the M2 console kicks in. The operator doesn't have to do anything, except watch the lights.

Getting L reactor ready for restart was harder than you might think. L had to be made standardized with the other operating reactors. The C&D machines were a particular problem. They're very sensitive machines, and have to be extremely accurate in positioning. And all kinds of modifications had been made to these while L was in standby. Unfortunately, the modifications made had been made in probably a dozen individual projects. One project would do this and let's change the cooling water system. Another project would change the grippers, another project would do—and so on. And unfortunately, there were no as-built drawings of the machines in the operating areas, which meant that we couldn't just upgrade what we needed and go directly to the end point. We had to install each individual project just as it was in the operating area in chronological order, because what we put in on Project A might be removed on Project G.

Another big job was the heat exchangers. The heat exchangers were railroad car-sized stainless steel thing, very, very tight tolerances. And they were all sitting there in L because they had not been cannibalized. But what had been happening was that as a heat exchanger developed leaks or problems in one area, they'd take it over and just swap it out. So L had its twelve heat exchangers, all right, but they weren't good ones.

The decision was made that we had to buy new heat exchangers. And of course we wanted them built in this country, if we could. We could not find a vendor in the U.S. who would build them. We wound up buying the heat exchanger tubing in the U.S. and shipping it to Japan, where two vendors collaborated on the production. One of them built the shell and the other one built the head and assembled them. And then they shipped them back to us. And they worked great. But it grieved me that we were no longer capable of building that kind of equipment in this country. We couldn't find anybody who could physically do it. The people who had been able to do that in the fifties were no longer able to do it, which is an interesting commentary on the state of American manufacturing.

JAMES BOSWELL

I'm seventy years old and was born in 1929. When I was in school, one of my classmates at the University of Louisville, Edward Green, came to work at the Savannah River Plant, and he was a year ahead of me. He came back to Louisville on a vacation and he told me how great Savannah River was and it just sounded like a great place to work. So I interviewed with the Du Pont Company and decided to accept the work. Even though I'd gotten several offers that paid more than Savannah River, this just looked more interesting.

I came to work at the Savannah River Site in June of 1953. We lived in North Augusta when I first came here, but then we saw that most of our friends were living in Aiken so we decided to move there. At SRS, I spent the first ten years in the Reactor Technology Section of the Works Technical Department, and the last twenty-six years in the Technical Division in various positions.

I didn't know that much about what was made at Savannah River Plant when I first got here. In fact, for about a month, I was in the 400 area where they made heavy water and my boss there said, You just stick to your job, don't even ask what the people working next to you are doing. I mean, it was just that compartmentalized at that time. And that was for security reasons. Of course I had later bosses that said, Find out everything you can about everything around you everywhere that's going on because you're going to be more useful that way.

In the 400 area was the heavy water production area. And I counted drops of water that leaked from pump seals. And it was a smelly place down there because of the H_2S they used in the process. It was hot and there were gnats, and if I'd had enough money to quit and go someplace else, I would have done it at that time. But that soon changed because I was only there for about a month then went into the Reactor Technology, where I was in an air-conditioned room with no H_2S smell.

When I was in Reactor Technology, A-Squared Johnson was the superintendent. And if you forgot your badge, you had to go home and get it. I mean, he wouldn't let anybody come in that didn't have a badge. I think he'd fire you if you came in without a badge, or tried to get in. He just said, You go home and get it. And that was typical, and if you got a security infraction, you had to write an essay on how that wouldn't happen again. he told one guy, You want to make light of this, you will work someplace else. Even so, I saw some pretty funny essays.

The most rewarding research that I did was looking at all the different kinds of fuel and target assemblies that could be built. I was supported on anything we wanted to do, any new assembly that we wanted to develop. And obviously that was very rewarding, since it was the fuel and target assemblies that allowed us to go to the higher powers and to make the variety of radioisotopes that we made.

The mixed lattice arrangement was one of the main inventions there. The fuel and target were in different positions and my boss likened that to like an oven. The fuel assemblies were the heating elements in the oven and the targets were the different pies you wanted to make. I mean you make a pumpkin pie or an apple pie or whatever you wanted to put in. You tailored the target material to whatever you wanted to make, and I think that was the most significant thing. And that was the one thing that caused the Savannah River reactors to continue operating, I believe, and the Hanford reactors shut down because the Hanford reactors couldn't make other isotopes very well. There just wasn't the versatility in the reactor design to do that.

I think a lot of people probably wondered whether it was the right thing to do to make materials for atomic weapons, and that crossed my mind, but the longer I worked, I began to believe that the very fact that we had these atomic weapons has kept peace in the world rather than promoting war because people are afraid now to start a war.

ENDNOTES

CHAPTER II

1. Lenore Fine and Jesse A. Remington, *United States Army in World War II: The Technical Services. The Corps of Engineers: Construction in the United States* (Washington, DC: Center of Military History, 1989), 659.
2. Henry D. Smyth, *Atomic Energy for Military Purposes: the Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government.* (Princeton, NJ: Princeton University Press, 1945).
3. Fine and Remington, *United States Army in World War II: The Technical Services,* 663.
4. Rodney P. Carlisle and Joan M. Zenzen, *Supplying the Nuclear Arsenal: American Production Reactors, 1942-1992* (Baltimore, MD: John Hopkins University Press, 1996), 11.
5. Fine and Remington, *United States Army in World War II: The Technical Services*, 650-651.
6. F. G. Gosling, *The Manhattan Project: Making the Atomic Bomb* (US Department of Energy, Washington, DC: Government Printing, 1994), 13-14.
7. Gosling, *The Manhattan Project*, 15-16; Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1995), 71.
8. Gosling, *The Manhattan Project,* 15-16.
9. Jon Jefferson, *Swords to Plowshares: A Short History of Oak Ridge National Laboratory*, edited by Sybill Wyatt and Cindy Robinson (Oak Ridge National Laboratory, Office of Public Affairs, US Department of Energy, Oak Ridge, TN: Government Printing Office, 1993), 3; Gosling, *The Manhattan Project*, 16.
10. Fine and Remington, *United States Army in World War II: The Technical Services*, 667; Gosling, *The Manhattan Project*, 23-25.
11. Oak Ridge National Laboratory, *Power and Flux: Neutron Science R&D at Oak Ridge National Laboratory* (Oak Ridge, TN: Office of Planning and Management, US Department of Energy, 1995).
12. Fine and Remington, *United States Army in World War II: The Technical Services*, 667; Gosling, *The Manhattan Project, 667*.
13. Dale F. Babcock, *Du Pont and Nuclear Energy An Address at Savannah River Laboratory*, E. I. Du Pont de Nemours and Company, Aiken, South Carolina, June 22, 1982," Manuscript, (Wilmington, DE: Hagley Museum, Series II, Box 7, Folder 2, 1982), 2.
14. *Time the Weekly Magazine*, "The Wizards of Wilmington," Volume LVII, No. 16, April 16,1951, 95.
15. Smyth, *Atomic Energy for Military Purposes*, 110-111.
16. Carlisle and Zenzen, *Supplying the Nuclear Arsenal,* 37, 44.
17. Rhodes, *The Making of the Atomic Bomb*, 216.
18. Fine and Remington, *United States Army in World War II: The Technical Services*, 667; Gosling, *The Manhattan Project*, 687, 692.
19. Gosling, *The Manhattan Project*, 41-42.
20. Rhodes, *The Making of the Atomic Bomb*, 233-238.
21. Carlisle and Zenzen, *Supplying the Nuclear Arsenal, 56;* Rhodes, *The Making of the Atomic Bomb*, 283.
22. Richard G. Hewlett and Francis Duncan, *Atomic Shield, 1947/1952: A History of the United States Atomic Energy Commission Volume II 1947-1952* (Berkeley: University of California Press, 1990).
23. Carlisle and Zenzen, *Supplying the Nuclear Arsenal*, 66; Rhodes, *The Making of the Atomic Bomb*, 317-321.
24. Rhodes, *The Making of the Atomic Bomb*, 323.
25. Office of Environmental Management, U.S. Department of Energy, *Nuclear Age Timeline: Poster Supplement and Resource Guide,* 1994,12; Rhodes, *The Making of the Atomic Bomb*, 210-211, 241.
26. Carlisle and Zenzen, *Supplying the Nuclear Arsenal,* 70.
27. Office of Environmental Management, U.S. Department of Energy, *Nuclear Age Timeline: Poster Supplement and Resource Guide,* 1994,14-16.
28. Ibid.,12-14.
29. David Albright, Frans Berkhout, and William Walker, *World Inventory of Plutonium and Highly Enriched Uranium*, (New York: Oxford University Press, 1993) 31-33; T.B. Cochran, *Nuclear Weapons Databook,* (Cambridge, Massachusetts: Ballinger Publishing Company, 1984),6.

30. Carlisle and Zenzen, *Supplying the Nuclear Arsenal, 96.*

31. Engineering Department, E.I. Du Pont de Nemours and Company, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company 1957b),16-17.

32. *Ibid.*, 16, 18, 204.

33. Hewlett and Duncan, *Atomic Shield*, 428.

34. *Ibid.*, 430.

35. W. P. Bebbington, *History of Du Pont at the Savannah River Plant,* (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1990), 2.

36. Engineering Department, E .I. Du Pont de Nemours and Company, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company 1957b),17-18.

37. R. M. Evans, Letter to Walter J. Williams, Director of Production, Atomic Energy Commission, Washington, D.C., from R. M. Evans, Assistant General Manager, E. I. Du Pont de Nemours and Company, Wilmington, Delaware, August 28, 1950.

38. Atomic Energy Commission and E. I. Du Pont de Nemours and Company, (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1950).

39. Crawford H. Greenewalt, Letter to Stockholders of E. I. Du Pont de Nemours and Company, October 18, 1950, (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1950).

40. Carlisle and Zenzen, *Supplying the Nuclear Arsenal,* 19.

41. H. C. Benhardt, *DPSTM-100, 100-Area Technical Manual Unclassified Version,* (Aiken, SC: Savannah River Laboratory, 1988), 101.

42. E. I. Du Pont de Nemours & Co., *Occupational Safety and Health: A Du Pont Company View,* (Wilmington, DE: Savannah River Plant Engineering and Design History, Volume II, 100-R, P, L, K, and C Areas, 1957), 26.

43. Hewlett and Duncan, *Atomic Shield,* 531.

44. C. H. Topping, *Plant 124-Site Survey* (Wilmington, DE: E.I. Du Pont de Nemours & Co., 1950), 1-3.

45. Engineering Department, E.I. Du Pont de Nemours, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1957b), 32.

46. *Ibid.*,16.

47. Topping, *Plant 124-Site Survey*.

48. Newspaper of the Savannah River Project, Feb 29, 1952:5.

49. Engineering Department, E.I. Du Pont de Nemours, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1957b),42.

50. Richard Rhodes, *The Making of the Atomic Bomb,* 618-619.

51. Thomas Fetters, *Logging Railroads of South Carolina,* (Illinois: Heimburger House Publishing Company, 1990), 210.

52. Engineering Department, E. I. Du Pont de Nemours, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1957a), Vol. I, 23-24.

53. *Ibid.*, 23-39.

54. *Ibid.*, 35.

55. Engineering Department, E. I. Du Pont de Nemours, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours and Company 1957a),Vol. II, 408.

56. American Machine and Foundry Company, *Savannah River Plant Engineering and Design History, Volume I* (New York: American Machine and Foundry, 1954), 8.

57. The Lummus Company, *Savannah River Plant Engineering and Design History (*New York: The Lummus Company, 1954).

58. Engineering Deparment, E. I. Du Pont de Nemours and Company, *SRP Engineering and Design History, Volume II*, *55*.

59. *Architectural Forum,* "Voorhees Walker Foley & Smith Have Become Architects to Industry," November, 1954, 140.

60. Carlisle and Zenzen, *Supplying the Nuclear Arsenal*, 87-88.

61. New York Shipbuilding Corporation, *History Project 8980 - NYX* (Camden, NJ: New York Shipbuilding, 1954).

62. Carlisle and Zenzen, *Supplying the Nuclear Arsenal, 77*.

63. *Ibid.*, 77.

64. *Ibid.*

65. J. Brotherton and M. W. Lower, *Savannah River Plant External Affairs Fact Book,* (Aiken, SC: E. I. Du Pont de Nemours and Company, Savannah River Plant 1988),1.

66. Bebbington, *History of Du Pont at the Savannah River Plant,*11, 22.

67. *Ibid.*, 46,73.

68. *Ibid.*, 46.

69. *Ibid.*,47, 71.

70. *Ibid.*, 70-71, 226; USDOE Office of Environmental Management, 158.

71. Bebbington , *History of Du Pont at the Savannah River Plant,* 49-51.

72. *Ibid.*, 66-67.

73. *Ibid.*, 68-69.

74. *Ibid.*, 81-82, 87.

75. *Ibid.*, 52-53.

76. *Ibid.*, 52.

77. *Ibid.*, 71.

78. *Ibid.*, 71-72.

79. *Ibid.*, 72-73, 112-113; USDOE Office of Environmental Management, 177.

80. Engineering Department, E. I. Du Pont de Nemours and Company, *Savannah River Plant Engineering and Design History, Volume I, Administration*, (Wilmington, DE: E. I. Du Pont de Nemours, 1957b), 253; Engineering Department, E. I. Du Pont de Nemours and Company, *Savannah River Plant Construction History, Volumes I—IV*, (Wilmington, DE: E. I. Du Pont de Nemours, 1957d),339, 346.

81. Bebbington, *History of Du Pont at the Savannah River Plant*, 112, 130; Engineering Department, E. I. Du Pont de Nemours and Company 1957d, 338-339, 350.

82. Bebbington, *History of Du Pont at the Savannah River Plant,*130-132; J. E. Haywood and T.H. Killian, "Overview of Savannah River Plant Waste Management Operations" in Waste Management'87: Waste Isolation in the U.S. Technical Programs and Public Education, Volume 2, (Tucson, AZ: Conference Proceedings of the Symposium on Waste Management, 1987), 51.

83. Bebbington, *History of Du Pont at the Savannah River Plant,* 146; Engineering Department, E. I. Du Pont de Nemours and Company 1957e, 442; W. L. Marter "Ground Waste Disposal Practices at the Savannah River Plant" in Disposal of Radioactive Wastes into the Ground, Proceedings of the Disposal of Radioactive Wastes into the Ground (Vienna, Austria: International Atomic Energy Agency Conference, 1967), 101; National Research Council, Radioactive Waste Management at the Savannah River Plant: A Technical Review (Washington, DC: National Academy Press, 1981), 16.

84. Bebbington, *History of Du Pont at the Savannah River Plant,* (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1990), 190.

85. Bebbington, *History of Du Pont at the Savannah River Plant,* (Wilmington, DE: E. I. Du Pont de Nemours and Company, 1990), 193-194.

86. David E. Lilienthal, *The Journals of David Lilienthal, Volume II, The Atomic Energy Years, 1945-1950* (New York: Harper and Row, 1964), 7.

87. Atomic Energy Commission, *A.E.C. Telephone Directory*, (Washington, DC: U.S. Atomic Energy Commission, 1947). On file, History Division, U.S. Department of Energy, Germantown, MD, Job 0017, Box 3301, Folder 3.

88. *New York Times*, "We Must Grasp the Facts about the Atom: Mr. Lilienthal Says Development of Atomic Energy Depends on our Knowledge of the Issues at Stake," May 4, 1947. On file, Biographical Files, History Division, U.S. Department of Energy, Germantown, MD; *New York Times*, "Atomic Energy is your Business: Lilienthal of the Atomic Energy Commission Urges Everyone to Become Familiar with this Miraculous Power" Magazine Section, January 11, 1948. On file, Biographical Files, History Division, U.S. Department of Energy, Germantown, MD; David Lilienthal, "Your Future in the Atomic Age," Transcript of Radio Broadcast, Prudential Family Hour, Columbia Broadcasting System, January 18, 1948. On file, Biographical Files, History Division, U.S. Department of Energy, Germantown, MD.

89. *Florida Times-Union*, "Lilienthal Expects Three Big Benefits from Atom Energy, January 19, 1948. On file, Biographical Files, History Division, U.S. Department of Energy, Germantown, MD.

90. Arthur Kemp, "The Role of Government in Developing Peaceful Uses of Atomic Energy," No. 461 in Series: *National Economic Problems* (Washington, DC: American Enterprise Association, Inc., 1956). On file at Hagley Museum and Library.

91. Office of Environmental Management, U.S. Department of Energy, *Nuclear Age Timeline: Poster Supplement and Resource Guide,* 1994, 16-17.

92. Atomic Energy Commission, *Seventeenth Semiannual Report of the Atomic Energy Commission, January 1955* (Washington, DC: Government Printing Office, 1955), vii.

93. Jon Jefferson, Swords to Plowshares: A Short History of Oak Ridge National Laboratory(Oak Ridge, TN: US Department of Energy, Oak Ridge National Laboratory, 1993), 8.

94. Office of Environmental Management, U.S. Department of Energy, *Nuclear Age Timeline: Poster Supplement and Resource Guide,* 1994, 15-17.

95. J. L. Crandall, *Status of the United States Effort in D_2O Reactor Physics* (Aiken, SC: Savannah River Laboratory, AEC Research and Development Report, September 1962), 8-9.; W. H. Arnold and W. D. Leggett, W. J. McShane, N. J. Liparulo, J. D. McAdoo, L. E. Strawbridge, G. Toto, H. K. Fauske and D. W. Call, *Westinghouse Independent Safety Review of Savannah River Production Reactors*, (Aiken, SC: Westinghouse Savannah River Company, 1989), xvii.

96. J. L. Crandall, *Status of the United States Effort in D_2O Reactor Physics*, 8.

97. W. H. Arnold and W. D. Leggett, W. J. McShane, N. J. Liparulo, J. D. McAdoo, L. E. Strawbridge, G. Toto, H. K. Fauske and D. W. Call, *Westinghouse Independent Safety Review of Savannah River Production Reactors*, xvii.

98. J. L. Crandall, *Status of the United States Effort in D_2O Reactor Physics,7.*; Carlisle and Zenzen, *Supplying the Nuclear Arsenal*, 90-91.

99. W. H. Arnold and W. D. Leggett, W. J. McShane, N. J. Liparulo, J. D. McAdoo, L. E. Strawbridge, G. Toto, H. K. Fauske and D. W. Call, *Westinghouse Independent Safety Review of Savannah River Production Reactors*, xvii.

100. David Lilienthal, "Change, Hope, and the Bomb," *Stafford Little Lectures*, *Lecture II Princeton University Lecture Delivered February 13, 1963*, 11.

101. C. P. Ross, "Cobalt-60 for Power Sources" in *Isotopes and Radiation Technology* 5(3) (Oak Ridge, TN: Isotopes Information Center, Oak Ridge National Laboratory, 1968), 185-194.; D. Thomas Rankin, P. Kent Smith, Phillip E. McBeath, James R. Keski and William R. McDonell, "Production of Co-60 Ceramic Fuel Forms" in *Ceramic Bulletin* 54 (11), published by the American Ceramic Society, 982-985.

102. W. P Overbeck and C. H. Ice and G. Dessauer, *Production of Transplutonium Elements at Savannah River*, Presentation, American Nuclear Society Meeting, Washington, DC, November, 1965, (SRS Document - DP-1000), 6,10.

103. J. L. Crandall, *Californium-252 Neutron Sources*, Presentation, American Nuclear Society's Topical Meeting on Applications of Californium-252,Austin, TX, September 1972, (SRS Document - DP-MS-72-45), 15.

104. William R. McDonell, A. R. Boulogne, J. P. Faraci, S. F. Peterson, B. L. Dahlen, W. C. Mosley, D. J. Mahoney and V. Whatley, *Preparation of Industrial Cf-252 Neutron Sources at Savannah River Laboratory*, Presentation, Neutron Sources and Applications, American Nuclear Society's Topical Meeting, Augusta, GA, April 1971 (Conference 710-402, Volume II), 72-85; V. W. Walker, *Equipment and Operations for Preparing Cf-252 Neutron Sources for Interstitial Cancer Radiotherapy Research,* Presentation, American Nuclear Society.

105. Bebbington, *History of Du Pont at the Savannah River Plant,* 225-226.

106. Carlisle and Zenzen, *Supplying the Nuclear Arsenal,* 181-182.

107. *Savannah River Plant News* (December 2, 1982).

108. *SRP News*, Various articles. On file, Savannah River Site Archives, January 21, 1982.

109. Bebbington, *History of Du Pont at the Savannah River Plant*, 228.

110. *Ibid.*, 138-143.

111. *Ibid.*, 228.

112. James Boswell, "Historical Perspective of U-Al Fueled Reactors at Savannah River", unpublished manuscript, 1990, 58.

113. League of Women Voters Education Fund, *The Nuclear Waste Primer,* (New York: Lyons & Burford , 1993), 39.

114. David Muhlbaier, Sam Mirshak, Vascoe Whatley, and Elwyn Wingo, "Experimental Thermal-Fluids Program in Support of Reactor Operations," in *Savannah River Site 50th Anniversary, Proceedings of the Symposium, May 17, 2000*, WSRC-MS-2000-00061 (Washington, DC Government Printing Office, 2000), 87.

115. Emergency Cooling System, 11/15/1983 (videotape on file, 83-049, video Services Master Library, Westinghouse Savannah River Company).

116. League of Women Voters Education Fund, *The Nuclear Waste Primer,* (New York: Lyons & Burford, 1993), 64-65.

117. *Ibid.*

118. Hearings Before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, October 22, 1987 and May 11, (Washington, DC: U.S. Government Printing Office, 1988), 2.

119. Westinghouse Savannah River Company 1997a:1.2; 1997b:1.2; U.S. Department of Energy, Basis for Interim Operation (BIO) for the K-Reactor Facility. Westinghouse Savannah River Company, (Aiken, South Carolina, Engineering and Construction Division 1994a).

120. Lewis, Karen, Katherine Roxlau, Lori Rhodes, Paul Boyer and Joseph Murphey, *A Systematic Study of Air Combat Command Cold War Material Culture. Volume II-20; A Baseline Inventory of Cold War Material Culture at Moody Air Force Base,* (Albuquerque, NM: Mariah Associates, Inc., 1996), 50.

CHAPTER III

1. Richard G. Hewlett and Francis Duncan, *Atomic Shield, 1947/1952: Volume II, A History of the United States Atomic Energy Commission* (University Park: Pennsylvania State University Press 1969), 429; Norm Baumann, oral interview with Mark Swanson, October 19, 1999; Peter Gray, oral interview with Mark Swanson, October 13, 1999; *Fact Book, Savannah River Plant, Office of Public Education – Public Information* (Savannah River Operations Office, US Atomic Energy Commission, Aiken, South Carolina, 1960), 12.

2. Reed, Mary Beth, Mark T. Swanson, Steven Gaither, J. W. Joseph, and William R. Henry, *Savannah River Site at Fifty*, U.S. Government Printing Office, 2002, 173.

3. Tom Gorrell, Interview with Mark Swanson, January 30, 2006.

4. E. I. Du Pont de Nemours and Company, *Savannah River Plant History, All Areas, August 1950 through June 1953*, 5-6.

5. Jack M. Holl, *Argonne National Laboratory, 1946-96*, with assistance of Richard G. Hewlett and Ruth R. Harris; foreword by Alan Schriesheim (Chicago: University of Illinois Press, 1997), 51.

6. *Ibid.*, 149; Charles W. J. Wende, "Operation of PDP" (Memorandum to L. Squires, E. I. Du Pont de Nemours and Company, Explosives Department, Wilmington, Delaware, December 9, 1952), 9.

7. B. H. Mackey, "Reactor Safeguards – PDP" (Letter to Curtis A. Nelson, Manager, U.S. Atomic Energy Commission, Savannah River Operations Office, Augusta, Georgia, February 26, 1953), 2; Wende, "Operation of PDP," 10.

8. Wende, "Operation of PDP," 2.

9. E. H. Lockwood, *Reactor Physics Primer* (General Electric, Hanford Atomic Products Operation, Richland, Washington, November 15, 1957), 76-7.

10. Wende, "Operation of PDP," 2.

11. Mackey, "Reactor Safeguards – PDP," 1-3.

12. Du Pont, *SRP Engineering and Design*, v. II, 433.

13. *Ibid.*, 25-28.

14. *Ibid.*, 412.

15. *Ibid.*, 26.

16. *Ibid.*, 26.

17. *Ibid.*, 42-43.

18. *Ibid.*, 43-44.

19. *Ibid.*, 130-131.

20. *Ibid.*, 44.

21. *Ibid.*, 45.

22. *Ibid.*, 45-46.

23 *bid.*, 24-25, 46.

24. *Ibid.*, 195-199.

25. I*bid.*, 27-28.

26. *Ibid.*, 27-8; *Instrument Start-Up Manual, Building R Reactor* (February 1953, on file, SRS Archival Records), 1001.

27. Du Pont, *SRP Engineering and Design History*, v. II, 27-28.

28. *Ibid.*, 117.

29. *Ibid.*, 129.

30. *Ibid.*, 109-111.

31. Voorhees Walker Foley and Smith, *Savannah River Plant Engineering and Design History, Volume I, Text and Exhibits* (Voorhees Walker Foley and Smith, Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-6-1/2, December 1, 1953; DPEZ-379, on file, SRS Archival Records), 7-8.

32. *Ibid.*, 134-136.

CHAPTER IV

1. Du Pont, SRP Engineering and Design, Vol. 2, 18.

2. *Ibid.*, 11.

3. Du Pont, SRP Construction History, Vol. 3, 42.

4. *Ibid.*, 17.

5. Du Pont, SRP Engineering and Design, Vol. 2, 48-9.

6. Mary Beth Reed, Mark T. Swanson, Steven Gaither, J. W. Joseph, and William R. Henry, Savannah River Site at Fifty (Washington, D.C.: U.S. Government Printing Office, 2002), 175.

7. Gibbs and Hill, Inc., Savannah River Plant Engineering and Design History, Volume Number 1: Organization, Policies and Procedures (Gibbs and Hill, Inc., Engineers, New York; Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-5 ½; Issued 1954), 1.

8. Voorhees Walker Foley and Smith, Savannah River Plant Engineering and Design History, Volume I, Text and Exhibits (Voorhees Walker Foley and Smith, Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-6-1/2, December 1, 1953; DPEZ-379, on file, SRS Archival Records), 3; Du Pont, SRP Engineering and Design, Vol. 2, 19.

9. E. I. du Pont de Nemours and Company, Savannah River Plant Engineering and Design History, Volume I, Administration. (Engineering Department, E. I. du Pont de Nemours and Company (Inc.), Wilmington, Delaware. Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1. Du Pont Project 8980, January 1957. DPE-970, on file, Savannah River Site Archival Records), 241-242.

10. Carole Rifkind, A Field Guide to Contemporary American Architecture (New York: Dutton, 1998), 6.

11. James F. Munce, Industrial Architecture. (New York: F. W. Dodge Corporation, 1960).

12. *Ibid.*, 44.

13. "Voorhees, Walker, Foley & Smith Have Become Architects to Industry," in Architectural Forum (November 1954), 143.

14. E. I. du Pont de Nemours and Company, Savannah River Plant Construction History, Volume II of IV, Administration (Engineering Department, E. I. du Pont de Nemours and Company (Inc.), Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1; Du Pont Project 8980, January 1957; DPES-1403, on file, Savannah River Site Archival Records), 521.

15. Du Pont, SRP Engineering and Design History, Vol. I, 260.

16. Mary Beth Reed, Steve Gaither, Mark Swanson, and William R. Henry, Savannah River Cold War Context and Resource Study (Prepared for DOE by New South Associates, May 10, 2004), 119-129.

17. Caleb Hornbostel, Construction Materials Types, Uses and Applications (New York: John Wiley & Sons, 1978), 78.

18. Du Pont, SRP Construction History, Vol. 3, 17.

19. *Ibid.*, 105-106.

20. Design Division, Project 8980 – SRP Description of Facilities, 129-30.

21. Du Pont, SRP Engineering and Design History, Vol. 2, 453-5).

22. Design Division, Project 8980 – SRP Description of Facilities, 145-8; H. C. Benhardt, 100-Area Technical Manual, Unclassified Version. DPSTM-100 (extracted from 1953 classified version in 1988, Savannah River Laboratory (Aiken, South Carolina, Savanah River Site Archival Records), 104.

23. Design Division, Project 8980 – SRP Description of Facilities, 149-50, 156-59; Benhardt, 100-Area Technical Manual, 105.

24. Design Division, Project 8980 – SRP Description of Facilities, 151, 163; Du Pont, SRP Engineering and Design History, Vol. 2, 23; Du Pont, SRP Construction History, Vol. 3, 122; Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 2, 234; Design Division, Project 8980 – SRP Description of Facilities, 150.
25. Design Division, Project 8980 – SRP Description of Facilities, 179-84.
26. Design Division, Project 8980 – SRP Description of Facilities, 185-7; Du Pont, SRP Engineering and Design History, Vol. 2, 455-56.
27. Design Division, Project 8980 – SRP Description of Facilities, 188-91; Du Pont, SRP Engineering and Design History, Vol. 2, 457-59.
28. Design Division, Project 8980 – SRP Description of Facilities, 192-93; Du Pont, SRP Engineering and Design History, Vol. 2, 459-61.
29. Design Division, Project 8980 – SRP Description of Facilities, 218-19; Gibbs and Hill, Inc., Savannah River Plant Engineering and Design History, Volume Number 5: Water Treatment (Gibbs and Hill, Inc., Engineers, New York; Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission, U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-5 ½; Issued 1954), 41-2, Exhibit IV.
30. Design Division, Project 8980 – SRP Description of Facilities, 218-19; E and D, Volume 6:243-254
31. Design Division, Project 8980 – SRP Description of Facilities, 240-254; Du Pont, SRP Engineering and Design History, Vol. 2, 479; Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 5, 53, 73 [Exhibit VIII].
32. Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 5, 49, 75.
33. Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 2, 215; Design Division, Project 8980 – SRP Description of Facilities, 255-74.
34. Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 3, 9, 91.
35. Design Division, Project 8980 – SRP Description of Facilities, 275; Benhardt, 100-Area Technical Manual, 107.
36. Design Division, Project 8980 – SRP Description of Facilities, 281-82; Du Pont, SRP Engineering and Design History, Vol. 2, 479-80; Benhardt, 100-Area Technical Manual, 106.
37. Design Division, Project 8980 – SRP Description of Facilities, 288-95; Gibbs and Hill, Inc., SRP Engineering and Design History, Volume 2, 231; Voorhees Walker Foley and Smith, SRP Engineering and Design History, Vol. 1, 131-2; Benhardt, 100-Area Technical Manual, 106.
38. Design Division, Project 8980 – SRP Description of Facilities, 316-22; Du Pont, SRP Engineering and Design History, Vol. 2, 461-66; Voorhees Walker Foley and Smith, SRP Engineering and Design History, Vol. 1, 3.
39. Design Division, Project 8980 – SRP Description of Facilities, 323; Du Pont, SRP Engineering and Design History, Vol. 2, 466-69.
40. Design Division, Project 8980 – SRP Description of Facilities, 326; Du Pont, SRP Engineering and Design History, Vol. 2, 470-75; Voorhees Walker Foley and Smith, SRP Engineering and Design History, Vol. 1, 3.
41. Design Division, Project 8980 – SRP Description of Facilities, 334; Du Pont, SRP Engineering and Design History, Vol. 2, 475; Voorhees Walker Foley and Smith, SRP Engineering and Design History, Vol. 1, 3.

CHAPTER V

1. Christensen, "Savannah River Plant Stories."
2. Design Division, *SRP Description of Facilities*, 4.
3. Du Pont, SRP Construction History, Vol. III, 106.
4. *Ibid.*, 63.
5. *Instrument Start-Up Manual, Building R Reactor,* v.
6. Du Pont, *SRP Engineering and Design History, Vol. 2*, 407.
7. *Ibid.*, 47-48.
8. *Ibid.*
9. Du Pont, *SRP Engineering and Design, Vol. 2*, 48-50.
10. Du Pont, *SRP Engineering and Design, Vol. 2*, 342,

11. Du Pont, *SRP Engineering and Design, Vol. 2*, 50-51.
12. Design Division, *SRP Description of Facilities*, 5-23.
13. Du Pont, *SRP Engineering and Design, Vol. 2*, 50, 341.
14. *Ibid.*, 344.
15. *Ibid.*, 407.
16. American Machine and Foundry Company, *Savannah River Plant Engineering and Design History, American Machine and Foundry Company, Volume I of IV* (Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Wilmington, Delaware, Prime Contractor for United States Atomic Energy Commission; U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-8-1/2, February 28, 1954, DPEZ-215).
17. *Ibid.*, 342, 346.
18. Du Pont, *SRP Engineering and Design, Vol. 2*, 341.
19. *Ibid.*
20. *Instrument Start-Up Manual, Building R Reactor*, 3021.
21. Du Pont, SRP Engineering and Design, Vol. 2, 120.
22. *Ibid.*,121-22.
23. *Ibid.*, 50.
24. Ibid., 125-26.
25. *Ibid.*, 346.
26. *Instrument Start-Up Manual, Building R Reactor*, 3011-3020.
27. Du Pont, *SRP Engineering and Design, Vol. 2*, 344.
28. *Ibid.*, 121-125.
29. *Ibid.*, 50, 342.
30. *Ibid.*, 126-127, 346.

CHAPTER VI

1. Du Pont, SRP Engineering and Design History, Vol. 2, 51.
2. Du Pont, SRP Engineering and Design History, Vol. 2, 82-3.
3. *Ibid.*
4. Design Division, SRP Description of Facilities, 47-8.
5. Du Pont, SRP Engineering and Design History, Vol. 2, 82-84.
6. Design Division, SRP Description of Facilities, 43-44.
7. Du Pont, SRP Engineering and Design History, Vol. 2, 65.
8. Larry Heinrich, oral interview with Mark Swanson, April 17, 2007.
9. Du Pont, SRP Engineering and Design History, Vol. 2, 357; Benhardt, 100-Area Technical Manual, 108-09.
10. Benhardt, 100-Area Technical Manual, 109.
11. Du Pont, SRP Engineering and Design History, Vol. 2, 357.
12. *Ibid.*, 234.
13. American Machine and Foundry Company, Savannah River Plant Engineering and Design History, American Machine and Foundry Company, Volume I of IV (Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, (Inc.), Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission; U.S. Contract No. AT(07-2)-1, Du Pont Project 8980; Subcontract No. AXC-8-1/2; February 28, 1954, DPEZ – 215), 6.
14. American Machine and Foundry, SRP Engineering and Design History, Vol. 1, 25-28, 181, Item No. 1.093, p.1; American

Machine and Foundry, SRP Engineering and Design History, Vol. 2, 577; American Machine and Foundry, SRP Engineering and Design History, Vol. 3, 594.

15. Du Pont, SRP Engineering and Design History, Vol. 2, 218-9.

16. Design Division, SRP Description of Facilities, 52; Du Pont, SRP Engineering and Design History, Vol. 2, 222-223, 215.

17. Du Pont, SRP Engineering and Design History, Vol. 2, 222-223, 215; American Machine and Foundry, SRP Engineering and Design History, Vol. 2, Item No. 1.093, p.1.

18. Du Pont, SRP Engineering and Design History, Vol. 2, 215.

19. *Ibid.*, 159,211, 217.

20. Design Division, SRP Description of Facilities, 52; Du Pont, SRP Engineering and Design History, Vol. 2, 211; Larry Heinrich interview, April 17, 2007.

21. Du Pont, SRP Engineering and Design History, Vol. 2, 413-14.

22 Design Division, SRP Description of Facilities, 52; Du Pont, SRP Engineering and Design History, Vol. 2, 356.

23. Du Pont, SRP Engineering and Design History, Vol. 2, 234-238; Design Division, SRP Description of Facilities, 51.

24. Du Pont, SRP Engineering and Design History, Vol. 2, 243-4; Du Pont, SRP Construction History, Vol. 3, 107; Design Division, SRP Description of Facilities, 53.

25. Design Division, SRP Description of Facilities, 54; Du Pont, SRP Engineering and Design History, Vol. 2, 359.

26. Du Pont, SRP Engineering and Design History, Vol. 2, 354-355.

27. Du Pont, SRP Engineering and Design History, Vol. 2, 133, 137; Control Computer Sequence Map, Reactor Department, Center Section, Control Computer DPSOP Ref. 330-46, DPSOL 105-2210-PLK, September 9, 1981.

28. Du Pont, SRP Engineering and Design History, Vol. 2, 129.

29. *Ibid.*, 129-131.

30. *Ibid.*, 133-134.

31. *Ibid.*, 132-133, 485.

32. New York Shipbuilding Corporation, Savannah River Plant Fabrication and Testing History, Prototype and Production Units (New York Shipbuilding Corporation, Camden, New Jersey; Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company (Inc.), Wilmington, Delaware; Prime Contractor for United States Atomic Energy Commission; U.S. Contract No. AT(07-2)-1; Du Pont Project No. 8980; Subcontract No. AXC-167-1/2; September 1954; DPE-837.

33. Ibid., 11-21, 23; History, Project 8980 – NYX, Du Pont Construction Division, New York Shipbuilding Corporation, Camden, New Jersey (AXC 167-1/2, Du Pont Contract No. CT-4143; on file, SRS Archival Records), 10-11.

34. History, Project 8980 - NYX , introduction, 9-10, 17.

35. New York Shipbuilding, SRP Fabrication and Testing History, 83-84; Du Pont, SRP Engineering and Design History, Vol. 2, 483, 495.

36. New York Shipbuilding, SRP Fabrication and Testing History, 46-50, 57-58, 69-72, 233-235.

37. R. W. Metter, Assembly and Erection of Reactor, NYX Test No. 1.6.1 (Prepared by R. W. Metter, NYX Technical Section; prepared for E. I. du Pont de Nemours and Company, Explosives Department; Atomic Energy Division, Wilmington, Delaware; February 1953; DPXN – 215; on file, SRS Archival Records), 7.

38. Du Pont, SRP Engineering and Design History, Vol. 2, 122-3, 501.

39. Metter, Assembly and Erection of Reactor, 5.

40. New York Shipbuilding, SRP Fabrication and Testing History, 180.

41. *Ibid.*, 29, 179-229.

42. Du Pont, SRP Engineering and Design History, Vol. 2, 528-9.

43. New York Shipbuilding, SRP Fabrication and Testing History, 235-7.

44. Du Pont, SRP Engineering and Design History, Vol. 2, 357.

45. *Ibid.*, 137.

46. *Ibid.*, 32.

47. *Ibid.*, 149-50.

48. *Ibid.*, 412; Walt Joseph, telephone conversation on March 23, 2007.

49. Du Pont, SRP Engineering and Design History, Vol. 2, 354-5.

50. Instrument Start-Up Manual.

51. Du Pont, SRP Engineering and Design History, Vol. 2, 50.

52. *Ibid.*, 160.

53. Ibid., 153, 155; C. E. Bailey, W. H. Baker, D. H. Knoebel, G. F. Merz, J. A. Smith, and R. S. Wingard, Nuclear Systems Design (Aiken, South Carolina: Savannah River Laboratory, E. I. du Pont de Nemours and Company; DP-MS-70-50; 1970), Figure I-9.

54. Du Pont, SRP Engineering and Design History, Vol. 2, 159.

55. *Ibid.*, 180-1.

56. *Ibid.*, 162, 350.

57. *Ibid.*, 162, 348.

58. *Ibid.*, 159, 162-163.

59. *Ibid.*, 159, 163-164.

60. *Ibid.*, 159-160.

61. *Ibid.*, 166-167.

62. *Ibid.*, 164-165.

63. *Ibid.*, 347-348.

64. *Ibid.*, 350.

65. Walt Joseph, telephone conversation on March 23, 2007.

66. Du Pont, SRP Construction History, Vol. 3, 107-109.

67. Du Pont, SRP Engineering and Design History, Vol. 2, 160.

68. *Ibid.*, 348-350; Design Division, SRP Description of Facilities, 60.

69. Du Pont, SRP Engineering and Design History, Vol. 2, 347-348.

70. Du Pont, SRP Engineering and Design History, Vol. 2, 349.

71. *Ibid.*

72. *Ibid.*, 167.

73. *Ibid.*

74. *Ibid.*, 167-168.

75. *Ibid.*, 169-170.

76. *Ibid.*, 171, 174.

77. *Ibid.*, 173-177.

78. *Ibid.*, 33, 161.

79. *Ibid.*, 32.

80. Design Division, SRP Description of Facilities, 58-59.

81. Du Pont, SRP Engineering and Design History, Vol. 2, 161.

82. *Ibid.*, 179.

83. Design Division, SRP Description of Facilities, 63.

84. Du Pont, SRP Engineering and Design History, Vol. 2, 179-180; Walt Joseph, telephone conversation on March 23, 2007.

85. Instrument Start-Up Manual, 1001.

86. Du Pont, SRP Engineering and Design History, Vol. 2, 182-3.

87. *Ibid.*, 185-187.

88. *Ibid.*, 186.

89. *Ibid.*, 180-182.

90. *Ibid.*, 187.

91. *Ibid.*, 183.

92. Design Division, SRP Description of Facilities, 63; Du Pont, SRP Engineering and Design History, Vol. 2, 352; Benhardt, 100-Area Technical Manual, 109.

93. Du Pont, SRP Engineering and Design History, Vol. 2, 97-98; 348.

94. *Ibid.*, 348; Design Division, SRP Description of Facilities, 63.

95. Du Pont, SRP Engineering and Design History, Vol. 2, 84.

96. Du Pont, SRP Engineering and Design History, Vol. 2, 116-117.

97. *Ibid.*, 412-413; 193.

98. *Ibid.*, 192.

99. *Ibid.*, 190-191.

100. *Ibid.*

101. *Ibid.*, 200-202.

102. *Ibid.*, 24, 202-205.

103. *Ibid.*, 364-366; Design Division, SRP Description of Facilities, 64.

104. Du Pont, SRP Engineering and Design History, Vol. 2, 361-363.

105. Jerry Merz, oral interview with Mark Swanson, September 11, 2007.

106. Woody Daspit, oral interview with Mark Swanson, September 13, 2006; Christensen, "SRP Stories."

107. Christensen, "SRP Stories."

108. Larry Heinrich, oral interview with Mark Swanson, April 17, 2007.

109. DPW-3336 Pile Control, dated 9/27/51; Instrument Start-Up Manual.

110. Instrument Start-Up Manual, iii.

111. Christensen, "SRP Stories."

112. Du Pont, SRP Engineering and Design History, Vol. 2, 275.

113. *Ibid.*, 276; Instrument Start-Up Manual, v.

114. Instrument Start-Up Manual, 1001.

115. Du Pont, SRP Engineering and Design History, Vol. 2, 278.

116. *Ibid.*, 278-280.

117. Instrument Start-Up Manual, 1001; Du Pont, SRP Engineering and Design History, Vol. 2, 393-5.

118. Blume and Associates, *Seismic Analysis of Buildings 105-C and R Reactor and Associated Systems and Equipment of the Savannah River Plant, Volume 1* (San Francisco: John A. Blume and Associates, Engineers, January 31, 1969; In "Work Request 850891 – Savannah River Plant Earthquake Study – 100 Areas: Reactor Building Analysis and Modifications, Final Report," E. I. du Pont de Nemours and Company, Engineering Department, Wilmington, Delaware; DPE-2400; on file, SRS Archival Records), 5.

119. Reactor Certification Training Manual, Reactor Operator and Supervisor Study Guide (Principles of Reactor Operation; Revised March 1982; on file, SRS Archival Records), 8-12.

120. Du Pont, SRP Engineering and Design History, Vol. 2, 275-276.

121. Instrument Start-Up Manual, 1001.

122. Reactor Certification Training Manual, 1; Instrument Start-Up Manual, 1081.

123. Du Pont, SRP Engineering and Design History, Vol. 2, 97; Christensen, SRP Stories."

124. Du Pont, SRP Engineering and Design History, Vol. 2, 211; Benhardt, 100-Area Technical Manual, 109.

125. Design Division, SRP Description of Facilities, 56-58; Du Pont, SRP Engineering and Design History, Vol. 2, 23.

126. Du Pont, SRP Engineering and Design History, Vol. 2, 358.

CHAPTER VII

1. Du Pont, *SRP Engineering and Design History, Vol. 2*, 417.
2. *Ibid.*
3. *Ibid.*, 52-53.
4. *Ibid.*, 53-54.
5. *Ibid.*, 373.
6. *Ibid.*, 373.
7. *Ibid.*, 368.
8. *Ibid.*, 368-369.
9. *Ibid.*, 368.
10. *Ibid.*, 249, 375.
11. *Ibid.*, 371.
12. *Ibid.*, 258-259.
13. *Ibid.*, 250-253.
14. *Ibid.*, 254-255, 370-371.
15. *Ibid.*, 370-371.
15. *Ibid.*, 371.

CHAPTER VIII

1. Du Pont, *SRP Engineering and Design History, Vol. 2*, 23, 55; Blaw-Knox, *Savannah River Plant Engineering and Design History, Blaw-Knox Company – Chemical Plants Division, Volume I, Sections I – XVI, Text and Exhibits* (Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic energy Commission; U.S. Contract No. AT(07-2)-1; Du Pont Project 8980; Subcontract No. AXC-7-1/2; June 30, 1954), 36; Blaw-Knox, *Savannah River Plant Engineering and Design History, Blaw-Knox Company – Chemical Plants Division, Volume II, Text, Buildings, and Equipment* (Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime Contractor for United States Atomic energy Commission; U.S. Contract No. AT(07-2)-1; Du Pont Project 8980; Subcontract No. AXC-7-1/2; June 30, 1954), 431.
2. Design Division, *SRP Description of Facilities*, 143.
3. Du Pont, *SRP Engineering and Design History, Vol. 2*, 19, 48-49, 55; Blaw-Knox, *SRP Engineering and Design, Vol. 1*, 35, 62.
4. Du Pont, *SRP Engineering and Design History, Vol. 2*, 56.
5. *Ibid.*
6. Design Division, *SRP Description of Facilities*, 122; Du Pont, *SRP Engineering and Design History, Vol. 2*, 263-266, 381-382; Blaw-Knox, *SRP Engineering and Design, Vol. 1*, 36.
7. Blaw-Knox, *SRP Engineering and Design, Vol. 1*, 155.
8. Design Division, *SRP Description of Facilities*, 129-130.
9. Blaw-Knox, *SRP Engineering and Design, Vol. 2*, 431-433.
10. *Ibid.*, 433-435.
11. Du Pont, *SRP Engineering and Design History, Vol. 2*, 382-383.
12. Blaw-Knox, *SRP Engineering and Design, Vol. 1*, 37-38; Blaw-Knox, *SRP Engineering and Design, Vol. 2*, 271-272, 436, 473-507.
13. Blaw-Knox, *SRP Engineering and Design, Vol. 2*, 437-438.
14. Du Pont, *SRP Engineering and Design History, Vol. 2*, 382-383.

15. Blaw-Knox, *SRP Engineering and Design, Vol. 2,* 273-275.

CHAPTER IX

1. Du Pont, *SRP Engineering and Design, Vol. 2,* 358.
2. *Ibid.*, 60, 343-385.
3. *Ibid.*, 46, 54.
4. *Ibid.*, 51.
5. Voorhees Walker Foley and Smith, *SRP Engineering and Design History, Vol. 1*, 130; Du Pont, *SRP Engineering and Design, Vol. 2,* 67-73.
6. Du Pont, *SRP Engineering and Design, Vol. 2,* 34, 171-173.
7. *Ibid.*, 46-47.
8. *Ibid.*, 32-33.
9. Voorhees Walker Foley and Smith, *SRP Engineering and Design History, Vol. 1*, 130.
10. Du Pont, *SRP Engineering and Design, Vol. 2,* 46-47.
11. *Ibid.*, 51.
12. *Ibid.*, 97.
13. *Ibid.*, 88.
14. *Ibid.*, 54.
15. Blaw-Knox, *SRP Engineering and Design, Vol. 2,* 445-447; Du Pont, *SRP Engineering and Design, Vol. 2, 57*.
16. Du Pont, *SRP Engineering and Design, Vol. 2, 57*; Blaw-Knox, *SRP Engineering and Design, Vol. 2*, 450.
17. Blaw-Knox, *SRP Engineering and Design, Vol. 2,* 448-449.
18. Harvey Allen, oral interview with Mark Swanson, September 11, 2006.
19. Du Pont, *SRP Engineering and Design, Vol. 2,* 34-36, 147.
20. *Ibid.*, 34-36.
21. *Ibid.*
22. *Ibid.*, 151.
23. *Ibid.*, 205.
24. *Ibid.*, 54-55.
25. *Ibid.*, 58-59.
26. Gibbs and Hill, Inc., *Savannah River Plant Engineering and Design History, Volume No. 3: Power Facilities* (Gibbs and Hill, Inc., Engineers, New York; Subcontractor for Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware; Prime contractor for United States Atomic energy Commission; U.S. Contract No. AT(07-2)-1; Du Pont 8980; Subcontract No. AXC-5-1/2; Issued 1954), first figure.
27. Du Pont, *SRP Engineering and Design, Vol. 2,* 475.

CHAPTER X

1. Mary Beth Reed, Mark T. Swanson, Steven Gaither, J. W. Joseph, and William R. Henry, *Savannah River Site at Fifty* (Washington, D.C.: U.S. Government Printing Office, 2002), 328.
2. *Ibid.*, 347.
3. *Ibid.*, 425.

4. *Ibid.*, 501-502.
5. *Ibid.*, 509.
6. *Ibid.*, 518.
7. Ben Rusche, "Johnson Was Dedicated to Safety," *Aiken Standard* (Aiken, South Carolina), July 5, 2007.
8. Christensen, "SRP Stories."
9. *Ibid.*
10. *Ibid.*; Rusche, *Johnson*; James Boswell, telephone conversation, July 16, 2007.
11. James Boswell, telephone conversation, July 5, 2007.
12. Du Pont, *SRP Engineering and Design History, Vol. 2*, 410.
13. William P. Bebbington, *History of Du Pont at the Savannah River Plant* (Wilmington, Delaware: E. I. du Pont de Nemours and Company, 1990), 97.
14. Woody Daspit, oral interview with Mark Swanson, September 13, 2006.
15. Andy Cwalina, oral interview with Mark Swanson, September 12, 2006.
16. Jerry Merz, oral interview with Mark Swanson, September 11, 2006.
17. Bebbington, *History of Du Pont at SRP*, 51.
18. Reed et al., *SRS at Fifty*, 341.
19. E. I. du Pont de Nemours and Company, *Savannah River Plant History, Reactor Areas, July 1954 through December 1972* (Aiken, South Carolina: E. I. du Pont de Nemours and Company, Savannah River Plant, April 1973; DPSP-55-454-1, deleted version), 57-62; Bebbington, *History of Du Pont at SRP*, 67-69; Reed et al., *SRS at Fifty*, 341.
20. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 66-74, 87-90.
21. Reed et al., *SRS at Fifty*, 342-343.
22. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 112-117.
23. Bebbington, *History of Du Pont at SRP*, 69; Reed et al., *SRS at Fifty*, 266.
24. Reed et al., *SRS at Fifty*, 435.
25. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 2, 4.
26. *Ibid.*, 16-17.
27. *Ibid.*, 48-50.
28. James Boswell, telephone conversation, July 16, 2007.
29. Christensen, "SRP Stories."
30. Reed et al., *SRS at Fifty*, 337-338.
31. Jerry Merz, oral interview with Mark Swanson, September 11, 2006; Reed et al., *SRS at Fifty*, 439.
32. M. C. Wilkins and Earl W. Ready, *Reactor Charge and Discharge Machines Bibliography* (Memorandum from M. C. Wilkins and Earl W. Ready, to E. C. Bertsche, Reactor Technology Department, August 14, 1967; on file SRS Archival Records), 1.
33. Andy Cwalina, oral interview with Mark Swanson, September 12, 2006.
34. Bebbington, *History of Du Pont at SRP*, 97-99; Reed et al., *SRS at Fifty*, 349-57.
35. Reed et al., *SRS at Fifty*, 348.
36. Andy Cwalina, oral interview with Mark Swanson, September 12, 2006.
37. Reed et al., *SRS at Fifty*, 355, 428.
38. *Ibid.*, 359.
39. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 244-251.
40. E. I. du Pont de Nemours and Company, *Savannah River Plant History, Reactor Areas, January 1973 through December 1975* (Aiken, South Carolina: E. I. du Pont de Nemours and Company, Savannah River Plant; 1976; DPSP-74-454-1), 16-27; E. I. du Pont de Nemours and Company, *Savannah River Plant History, Reactor Areas, January 1976 through December 1987* (Aiken, South Carolina: E. I. du Pont de Nemours and Company, Savannah River Plant; October 1988; DPSP-77-454-1), 2-17.
41. Reed et al., *SRS at Fifty*, 428-33.

42. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 163-4; Bebbington, *History of Du Pont at SRP*, 100.
43. Bailey et al., *Nuclear Systems*, I-1.
44. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 176; Bailey et al., *Nuclear Systems*, I-3.
45. Bebbington, *History of Du Pont at SRP*, 97.
46. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 163-4; Christensen, "SRP Stories."
47. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 161, 190.
48. Christensen, "SRP Stories."
49. Reed et al., *SRS at Fifty*, 438; Bebbington, *History of Du Pont at SRP*, 101.
50. Larry Heinrich, oral interview with Mark Swanson, April 17, 2007.
51. Bebbington, *History of Du Pont at SRP*, 92-93; Reed et al., *SRS at Fifty*, 342, 447.
52. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 128-142, 217-223.
53. Bebbington, *History of Du Pont at SRP*, 77; Reed et al., *SRS at Fifty*, 344.
54. Larry Heinrich, oral interview with Mark Swanson, April 17, 2007.
55. Christensen, "SRP Stories."
56. *Ibid.*
57. *Ibid.*
58. Bebbington, *History of Du Pont at SRP*, 81-82.
59. Du Pont, *SRP History, Reactor Areas, 1954-1972*, 128-142.
60. Du Pont, *SRP History, Reactor Areas, 1973 through 1975*, 2-13; Reed et al., *SRS at Fifty*, 449
61. George W. Housner, *Seismic Criteria Report for the Savannah River Plant* (Prepared by George W. Housner, California Institute of Technology, Pasadena, California, for E. I. du Pont de Nemours and Company, Wilmington, Delaware, December 1967), 2.
62. E. I. du Pont de Nemours and Company, *Work Request 850891 – Savannah River Plant Earthquake Study – 100 Areas: Earthquake Criteria for the Savannah River Plant, March 1968* (Wilmington, Delaware: E. I. du Pont de Nemours and Company, Engineering Department; work done under Contract AT(07-2)-1 with Atomic Energy Commission; 1968; DPE-2383; on file, SRS Archival Records) 4-5; Blume and Associates, *Seismic Analysis of Buildings 105-C and R Reactor and Associated Systems and Equipment of the SRP, Volume 1, John A. Blume and Associates, Engineers, San Francisco, January 31, 1969* (In *Work Request 850891 – Savannah River Plant Earthquake Study – 100 Areas: Reactor Building Analysis and Modifications, Final Report*, E. I. du Pont de Nemours and Company, Engineering Department, Wilmington, Delaware, DPE-2400, on file, SRS Archival Records).
63. Bebbington, *History of Du Pont at SRP*, 83-84.
64. Reed et al., *SRS at Fifty*, 489.
65. Du Pont, *SRP History, Reactor Areas, 1976 through 1987*, 117, 145, 172, 204.
66. Harvey Allen, oral interview with Mark Swanson, September 11, 2006; Andy Cwalina, oral interview with Mark Swanson, September 11, 2006; Bebbington, *History of Du Pont at SRP*, 84; Reed et al., *SRS at Fifty*, 489.
67. Bebbington, *History of Du Pont at SRP*, 225; Reed et al., *SRS at Fifty*, 498.
68. Reed et al., *SRS at Fifty*, 474-485.
69. Bebbington, *History of Du Pont at SRP*, 227.
70. *Ibid.*, 228.
71. *Ibid.*, 226-228.
72. *Ibid.*, 228-229.
73. Reed et al., *SRS at Fifty*, 513.

CHAPTER XI

1. Reed et al., *SRS at Fifty*, 513.
2. *Ibid.*, 518.
3. *Ibid.*, 516-518

4. *Ibid.*, 519-520.
5. *Ibid.*, 522-523.
6. *Ibid.*, 487, 520.
7. *Ibid.*, 491-492, 529.
8. *Ibid.*, 528.
9. *Ibid.*, 524.
10. *Ibid.*, 527.

GLOSSARY

A

Alpha Particle
A positively-charged particle from the nucleus of an atom, emitted during radioactive decay.

Atom
A particle of matter which cannot be broken up by chemical means. Atoms have a nucleus consisting of positively-charged protons and uncharged neutrons of the same mass. The positive charges on the protons are balanced by a number of negatively-charged electrons in motion around the nucleus.

Atomic Bomb
An explosive device whose energy comes from the fission of heavy elements such as uranium or plutonium.

B

Becquerel (Bq)
A unit of radiation equal to one disintegration per second.

Beta Particle
A particle emitted from an atom during radioactive decay.

Biological Shield
A mass of absorbing material (e.g., thick concrete walls) placed around a reactor or radioactive material to reduce the radiation (especially neutrons and gamma rays respectively) to a level safe for humans.

Breed
To form fissile nuclei, usually as a result of neutron capture, possibly followed by radioactive decay.

C

Chain Reaction
A reaction that stimulates its own repetition, in particular where the neutrons originating from nuclear fission cause an ongoing series of fission reactions.

Containment Building
A containment building houses the reactor, pressurizer, reactor coolant pumps, steam generator and other equipment or piping containing reactor coolant. The containment building is an airtight structure made of steel-reinforced concrete. The base slab is approximately 9 feet thick; the vertical walls are 3 3/4 feet thick; and the dome is 3 feet thick.

Control Rods
Devices to absorb neutrons so that the chain reaction in a reactor core may be slowed or stopped.

Coolant
This is a fluid, usually water, circulated through the core of a nuclear power reactor to remove and transfer heat energy.

Core
The central part of a nuclear reactor containing the fuel elements and any moderator.

Critical Mass
The smallest mass of fissile material that will support a self-sustaining chain reaction under specified conditions.

Curie (Ci)
A unit of radiation measurement, equal to 3.7×10^{10} disintegrations per second.

D

Decay
Decrease in activity of a radioactive substance due to the disintegration of an atomic nucleus resulting in the release of alpha or beta particles or gamma radiation.

Decommissioning
Removal of a facility (e.g., reactor) from service, also the subsequent actions of safe storage, dismantling and and making the site available for unrestricted use.

Depleted Uranium
Uranium having less than the natural 0.7% U-235. As a by-product of enrichment in the fuel cycle it generally has 0.25-0.30% U-235, the rest being U-238. Can be blended with highly-enriched uranium (e.g., from weapons) to make reactor fuel.

Deuterium
"Heavy Hydrogen", an isotope having one proton and one neutron in the nucleus. It occurs in nature as 1 atom to 6,500 atoms of normal hydrogen, (Hydrogen atoms contain one proton and no neutrons).

Dose Equivalent
The absolute measurement of exposure to a dose of ionising radiation depends upon the type of particle and the body tissue with which it interacts - hence the conversion to dose equivalent, which has units of rem. Rads are converted to rems by multiplying by a factor that depends upon the type of ionising radiation and it's biological effect. For example, with gamma radiation the factor is 1 and a rad is equal to a rem.

E

Element
A chemical substance that cannot be divided into simple substances by chemical means; atomic species with same number of protons.

Enriched Uranium
Uranium in which the proportion of U-235 (to U-238) has been increased above the natural 0.7%. Reactor-grade uranium is usually enriched to about 3.5% U-235, weapons-grade uranium is more than 90% U-235.

Enrichment
Physical process of increasing the proportion of U-235 to U-238.

F

Fast Breeder Reactor (FBR)
A fast neutron reactor (qv) configured to produce more fissile material than it consumes, using fertile material such as depleted uranium.

Fast Neutron Reactor (FNR)
A reactor with little or no moderator and hence utilising fast neutrons and able to utilize fertile material such as depleted uranium.

Fertile (of an isotope)
Capable of becoming fissile, by capturing one or more neutrons, possibly followed by radioactive decay. U-238 is an example.

Fissile (of an isotope)
Capable of capturing a neutron and undergoing nuclear fission, e.g., U-235, Pu-239.

Fission
The splitting of a heavy nucleus into two, accompanied by the release of a relatively large amount of heat and generally one or more neutrons. It may be spontaneous but usually is due to a nucleus absorbing a neutron.

Fission Products
Daughter nuclei resulting either from the fission of heavy elements such as uranium, or the radioactive decay of those primary daughters. Usually highly radioactive.

Fuel Assemblies
These are a group of fuel rods.

Fuel Fabrication
Making reactor fuel elements.

G

Gamma Rays
High energy electro-magnetic radiation.

Graphite
A form of carbon used in a very pure form as a reactor moderator.

H

Half-Life
The period required for half of the atoms of a particular radioactive isotope to decay and become an isotope of another element.

Heavy Water
Water containing an elevated concentration of molecules with deuterium (“heavy hydrogen”) atoms.

Heavy Water Reactor (HWR)
A reactor which uses heavy water as its moderator.

High-Level Wastes
Extremely radioactive fission products and transuranic elements (usually other than plutonium) separated as a result of reprocessing spent nuclear fuel.

Highly (or High)-Enriched Uranium (HEU)
Uranium enriched to at least 20% U-235. Uranium in weapons is about 90% U-235.

I

Isotope
An atomic form of an element having a particular number of neutrons. Different isotopes of an element have the same number of protons but different numbers of neutrons and hence different atomic masses, e.g., U-235, U-238.

J

Joule
A unit of energy.

K

KeV
One thousand electron-volts. An electronvolt (symbol: eV) is the amount of energy gained by a single unbound electron when it falls through an electrostatic potential difference of one volt. This is a very small amount of energy.

Kilowatt
A Kilowatt is a unit of electric energy equal to 1,000 watts.

Kilowatt-Hour
This is a unit of energy consumption that equals 1,000 watts used for one hour. For example, ten 100-watt light bulbs burned for one hour use one kilowatt-hour of electricity.

L

Lattice
Structural configuration in a reactor organizing positioning of fuel rods, control rods, and safety rods.

Light Water
Ordinary water (H20) as distinct from heavy water.

Light Water Reactor (LWR)
A common nuclear reactor cooled and usually moderated by ordinary water.

Low-Enriched Uranium (LEU)
Uranium enriched to less than 20% U-235. Uranium in power reactors is about 3.5% U-235.

M

Megawatt (MW)
A unit of power, = 10^6 Watts. MWe refers to electric output from a generator, MWt to thermal output from a reactor or heat source (e.g., the gross heat output of a reactor itself, typically three times the MWe figure).

Metal Fuels
Natural uranium metal as used in a gas-cooled reactor.

Micro
One millionth of a unit (e.g., microsievert is one millionth of a Sv).

Millirem
This is a measurement of the biological effects of different types of radiation equaling 1/1000th of a REM.

Mixed Oxide Fuel (MOX)
Reactor fuel which consists of both uranium and plutonium oxides, usually with about 5% Pu.

Moderator
A material such as light or heavy water or graphite used in a reactor to slow down fast neutrons so as to expedite further fission.

N

Natural Uranium
Uranium with an isotopic composition as found in nature, containing 99.3% U-238, 0.7% U-235 and a trace of U-234.

Neutron
An uncharged elementary particle found in the nucleus of every atom except hydrogen. Solitary mobile neutrons travelling at various speeds originate from fission reactions. Slow neutrons can in turn readily cause fission in atoms of some isotopes, e.g., U-235, and fast neutrons can readily cause fission in atoms of others, e.g., Pu-239. Sometimes atomic nuclei simply capture neutrons.

Nuclear Reactor
A device in which a nuclear fission chain reaction occurs under controlled conditions so that the heat yield can be harnessed or the neutron beams utilized. All commercial reactors are thermal reactors, using a moderator to slow down the neutrons.

O

Oxide Fuels
Enriched or natural uranium in the form of the oxide U02, used in many types of reactor.

P

Plutonium
A transuranic element, formed in a nuclear reactor by neutron capture. It has several isotopes, some of which are fissile and some of which undergo spontaneous fission, releasing neutrons. Weapons-grade plutonium is produced with >90% Pu-239, reactor-grade plutonium contains about 30% non-fissile isotopes.

Pressurized Water Reactor (PWR)
The most common type of light water reactor (LWR).

R

Radiation
The emission and propagation of energy by means of electromagnetic waves or sub-atomic particles.

Radioactivity
The spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation.

Radionuclide
A radioactive isotope of an element.

Radiotoxicity
The adverse health effect of a radionuclide due to its radioactivity.

Rads
A unit to measure the absorption of radiation by the body. A rad is equivalent to 100 ergs of energy from ionising radiation absorbed per gram of soft tissue.

Reactor Vessel
It is the steel pressure vessel that holds the fuel elements in a reactor.

rem (Roentgen Equivalent Man)
REM is the common unit for measuring human radiation doses, usually in millirems (1,000 millirems = 1 rem).

Reprocessing
Chemical treatment of spent reactor fuel to separate uranium and plutonium from the small quantitiy of fission products (and from each other), leaving a much reduced quantity of high-level waste.

S

Shielding
Material, such as lead or concrete, that is used around a nuclear reactor to prevent the escape of radiation and to protect workers and equipment.

Spent Fuel
This is used nuclear fuel awaiting disposal.

Stable
Incapable of spontaneous radioactive decay.

T

Thermal Reactor
A reactor in which the fission chain reaction is sustained primarily by slow neutrons (as distinct from Fast Neutron Reactor).

Transuranic Element
A very heavy element formed artificially by neutron capture and subsequent beta decay(s). Has a higher atomic number than uranium (92). All are radioactive. Neptunium, plutonium and americium are the best-known.

U

Uranium
A mildly radioactive element with two isotopes which are fissile (U-235 and U-233) and two which are fertile (U-238 and U-234). Uranium is the basic raw material of nuclear energy.

Uranium Oxide Concentrate (U308)
The mixture of uranium oxides produced after milling uranium ore from a mine. Sometimes loosely called yellowcake. It is khaki in colour and is usually represented by the empirical formula U308. Uranium is exported from Australia in this form.

V

Vitrification
The incorporation of high-level wastes into borosilicate glass.

W

Waste
High-level waste (HLW) is highly radioactive material arising from nuclear fission. It is recovered from reprocessing spent fuel, though some countries regard spent fuel itself as HLW and plan to dispose of it in that form. It requires very careful handling, storage and disposal.

Waste
Low-level waste is mildly radioactive material usually disposed of by incineration and burial.

Y

Yellowcake
Ammonium diuranate, the penultimate uranium compound in U308 production, but the form in which mine product was sold until about 1970.

Sources Used:
www.gnep.energy.gov/gnepGlossaryOfTerms.html;
http://www.sea-us.org.au/glossary.html

SUGGESTED READING

Albright, David, Frans Berkhout, and William Walker
1993 *World Inventory of Plutonium and Highly Enriched Uranium, 1992*. Oxford University Press, New York.

Bebbington, W.P.
1990 *History of DuPont at the Savannah River Plant.* Published by E. I. Du Pont de Nemours and Company, Wilmington, DE.

Bilderback, D.R.
1995 Documenting South Carolina's Military Bases and Cold War Legacy. In *Preserving the Recent Past*, edited by Deborah Slaton and Rebecca Shiffer, Heritage Preservation Education Foundation, Washington, DC.

Browder, Tonya Algerine, Richard David Brooks, and David C. Crass
1993 *Memories of Home: Dunbarton and Meyers Mill Remembered.* Archaeological Research Heritage Series 1. Occasional Papers of the Savannah River Archaeological Research Program, Community History Project. South Carolina Institute of Archaeology and Anthropology University of South Carolina.

Browder, Tonya Algerine and Richard David Brooks
1996 *Memories of Home: Reminiscences of Ellenton.* Savannah River Archaeological Research Heritage Series 2. Occasional Papers of the Savannah River Archaeological Research Program, Community History Project. South Carolina Institute of Archaeology and Anthropology University of South Carolina.

Buley, Rex D., and Don J. Green
1995 "Tritium Processing and Containment at the Savannah River Site," *in Fusion Technology*, 28 (October):1307-1311, American Nuclear Society, Inc., La Grange Park, Illinois. On file, Georgia Institute of Technology.

Cabak, Melanie A. and Mary M. Inkrot
1997 *Old Farm, New Farm An Archaeology of Rural Modernization in the Aiken Plateau, 1875-1950*. Savannah River Archaeological Research Papers No. 9. Occasional Papers of the Savannah River Archaeological Research Program, South Carolina Institute of Archaeology and Anthropology, University of South Carolina.

Carlisle, Rodney P., and Joan M. Zenzen
1996 *Supplying the Nuclear Arsenal American Production Reactors, 1942-1992.* The John Hopkins University Press, Baltimore and London.

Center for Air Force History
1994 *Coming in from the Cold: Military Heritage in the Cold War*. Report on the Department of Defense Legacy Cold War Project, Washington, DC.

Chapin, F. Stuart and Theodore W. Wirths, Alfred M. Denton and John C. Gould
1954 *In the Shadow of a Defense Plant: A Study of Urbanization in Rural South Carolina*. Institute for Research in Social Science, University of North Carolina, Chapel Hill, NC.

Cochran, T. B.
1984 *Nuclear Weapons Databook*. Ballinger Publishing Company, Cambridge, Massachusetts.

Crandall, J. L.
1962 Status of the United States Effort in D2O Reactor Physics. AEC Research and Development Report, Savannah River Laboratory, Aiken, South Carolina, September 1962. DP-787.

1972 Californium-252 Neutron Sources. Paper for presentation, American Nuclear Society National Topical Meeting on Applications of Californium-252, Austin, Texas, September 11, 1972. DP-MS-72-45.

Dahl, Per F.

1999 *Heavy Water and the Wartime Race for Nuclear Energy*. Institute of Physics Publishing, Bristol and Philadelphia.

E.I. Du Pont de Nemours & Company

1952 *DuPont The Autobiography of An American Enterprise*. Charles Scribner, New York.

1954 *This is Du Pont, The Story of Safety*. Wilmington, Delaware. On file, Hagley Museum and Library, Wilmington, Delaware.

1977 *Occupational Safety and Health: A Du Pont Company View.* Wilmington, Delaware. Document Number SRS-98-0139.

Engineering Department, E.I. Du Pont de Nemours & Co.

1957a *Savannah River Plant Construction History, Volumes I–IV.* Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980. DPE-1403, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1957b *Savannah River Plant Engineering and Design History, Volume I, Administration*. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980. DPE-972, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1957c *Savannah River Plant Engineering and Design History, Volume II, #100 Areas*. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980. DPE-972, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1957d *Savannah River Plant Engineering and Design History, Volume III, #200-F and H Areas.* Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980. DPE-972, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1957e *Savannah River Plant Engineering and Design History, Volume IV, #300/700 Areas.* Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980. DPE-972, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1957f *Savannah River Plant Engineering and Design History, Volume V, #400 Area*. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, DuPont Project 8980. DPE-972, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

1960 *History of the "S" projects, 1953-1960.* Prime Contractor for United States Atomic Energy Commission. On deposit at the Hagley Museum and Library, Wilmington, Delaware

Fehner, Terrence R., and Jack M. Holl

1994 *Department of Energy, 1977-1994: A Summary History*. History Division, Department of Energy.

Fine, Lenore, and Jesse A. Remington

1989 "Atomic Mission" (Chapter XX) in *United States Army in World War II: The Technical Services. The Corps of Engineers: Construction in the United States*. Center of Military History, United States Army, Washington, D.C. (First Printed 1972).

Gibbs & Hill. Inc.

1954 *Savannah River Plant Engineering and Design History, Volume IV, Water Supply.* Subcontractor for Engineering Department, E. I. Du Pont de Nemours & Co. Inv. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980 Subcontract No. AXC-5 1/2. DPEZ-380, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

Gibbs & Hill. Inc

1954 *Savannah River Plant Engineering and Design History, Volumes I through V.* Subcontractor for Engineering Department, E.I. Du Pont de Nemours & Co. Inv. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8980 Subcontract No. AXC-5 1/2. DPEZ-380, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

Girdler Corporation
1952 *Dana Plant Construction History.* Subcontractor for Engineering Department, E. I. Du Pont de Nemours & Co. Inv. Prime Contractor for United States Atomic Energy Commission. U.S. Contract No. AT(07-2)-1, Du Pont Project 8987 Subcontract No. ADC 1 1/2. DPEG-17, on deposit at the Hagley Museum and Library, Wilmington, Delaware.

Gosling, F. G.
1994 The Manhattan Project: Making the Atomic Bomb. U.S. Department of Energy, History Division. September 1994. On file, American Museum of Science and Energy.

Groves, Leslie R.
1962 *Now It Can Be Told: The Story of the Manhattan Project*. Harper and Brothers, New York.

Hearings Before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives
1988 Hearings Before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, One Hundredth Congress, October 22, 1987, and May 11, 1988, Serial No. 100-138, Safety at DOE Nuclear Weapons Facilities. U.S. Government Printing Office, Washington, D.C.

Heavy Water Components Test Reactor
c.1962 Brochure, Savannah River Laboratory, Aiken, South Carolina. On file, Savannah River Site History Project.

Hennelly, E. J.
1969 Production of Cf-252 at Savannah River: Past Accomplishments and Future Plans. Savannah River Laboratory, Aiken, South Carolina. Paper for presentation, 157th National Meeting, American Chemical Society, Minneapolis, Minnesota, April 13-18, 1969. DP-MS-68-108.

Hewlett, Richard G., and Oscar E. Anderson, Jr.
1990 *The New World: A History of the United States Atomic Energy Commission, Volume I, 1939-46*. University of California Press, Berkeley.

Hewlett, Richard G., and Francis Duncan
1990 *Atomic Shield A History of the United States Atomic Energy Commission, 1947-1952.* Volume II. University of California Press, Berkeley.

Holl, Jack M and Richard G. Hewlett and Ruth R. Harris
1997 *Argonne National Laboratory, 1946-96.* University of Illinois Press, Urbana and Chicago.

Hood, R. R.
1965 Heavy Water Moderated Power Reactors, Progress Report, November-December 1964. AEC Research and Development Report, Savannah River Laboratory, Aiken, South Carolina, January 1965. DP-945.

HWCTR: A High-Flux Reactor for Testing Fuel Elements and Components
1964 Brochure, E. I. Du Pont de Nemours and Company, Savannah River Plant, Aiken, South Carolina. On file, SRS-89-0139 (Pamphlet History, 1952-1982, vol. 1).

Jefferson, Jon
1993 Swords to Plowshares: A Short History of Oak Ridge National Laboratory. Edited by Sybil Wyatt and Cindy Robinson. Booklet published by Oak Ridge National Laboratory, Office of Public Affairs, U.S. Department of Energy. On file, American Museum of Science and Energy.

Johnson, Leland, and Daniel Schaffer

1992 *Oak Ridge National Laboratory Review*. Volume 25, Nos. 3 and 4. Martin Marietta Energy Systems, Department of Energy.

Jones, Vincent C.

198 *United States Army in World War II. Special Studies Manhattan: the Army and the Atomic Bomb.* Center of Military History, United States Army, Washington, D.C.

Kemp, Arthur

1956 The Role of Government in Developing Peaceful Uses of Atomic Energy. No. 461 in Series *National Economic Problems.* Published and distributed by the American Enterprise Association, Inc., Washington, D.C. On file, Hagley Museum and Library.

Kiger, Eugene O.

1966 Operational Summary of the Heavy Water Components Test Reactor, October 1961-December 1964. Savannah River Laboratory, Aiken, South Carolina, April 1966. DP-991.

Lewis, Karen, Katherine Roxlau, Lori Rhodes, Paul Boyer and Joseph Murphey

1995 *A Systematic Study of Air Combat Command Cold War Material Culture. Volume II-20; A Baseline Inventory of Cold War Material Culture at Moody Air Force Base*. Mariah Associates, Inc. Albuquerque, NM.

Lilienthal, David E.

1964 *The Journals of David E. Lilienthal, Volume II, The Atomic Energy Years, 1945-1950.* Harper and Row, New York. On file, History Division, U.S. Department of Energy.

McDonell, William R., A. R. Boulogne, J. P. Faraci, S. F. Peterson, B. L. Dahlen, W. C. Mosley, D. J. Mahoney, and V. Whatley

1971 "Preparation of Industrial Cf-252 Neutron Sources at Savannah River Laboratory," *Neutron Sources and Applications.* American Nuclear Society Topical Meeting, April 19-21, 1971, Augusta, Georgia. Conf-710-402, Volume II, pp. I.72-85. On file, On file, Savannah River Site History Project.

Mitchell, Kris C.

2003 *Rhetoric to Reality: A Cold War Context Statement for the Pantex Plant, 1951-1991*. Prepared by BWXT Pantex, LLC., for U.s. Department of Energy, National Nuclear Security Administration, Pantex Site Office.

National Research Council

1981 *Radioactive Waste Management at the Savannah River Plant: A Technical Review.* National Academy Press, Washington, D. C.

New York Shipbuilding Corporation

1949 *Fifty Years New York Shipbuilding Corporation, Camden, NJ.* Published by New York Shipbuilding Corporation

Oak Ridge National Laboratory Review

1992 *ORNL The First Fifty Years.* US. Department of Energy/Martin Marietta Energy Systems. Volume 25, Nos. 3 and 4.

Okrent, David

1981 *Nuclear Reactor Safety, On the History of the Regulatory Process.* The University of Wisconsin Press, Madison, WI.

Overbeck, W. P.
1978 Production of Radioisotopes at the Savannah River Plant. Text of a presentation, dated December 31, 1978. SRL-78-003.

Overbeck, W. P., C. H. Ice, and G. Dessauer
1965 Production of Transplutonium Elements at Savannah River. Paper prepared for presentation, Winter Meeting of American Nuclear Society, November 15-18, 1965, Washington, D.C. Savannah River Laboratory, Aiken, South Carolina. DP-1000.

Reed, Mary Beth, Mark T. Swanson, Steven Gaither, J. W. Joseph, and William R. Henry
2002 *Savannah River Site at Fifty*. U.S. Government Printing Office, Washington, D.C.

Rhodes, Richard
1986 *The Making of the Atomic Bomb.* Simon & Schuster, New York.

Ridgely, G. C.
1985 SRP Reactor Incidents of Greatest Significance. Memorandum to G. F. Merz, August 14, 1985. On file, RTR-2316 Savannah River Site Archives.

Ross, C. P.
1968 "Cobalt-60 for Power Sources," *Isotopes and Radiation Technology* 5(3):185-194. Isotopes Information Center, Oak Ridge National Laboratory. On file, Savannah River Site History Project.

Savannah River Plant (SRP)
ca. 1954 *Savannah River Plant History, All Areas, August 1950 through June 1953*. Document Number DPSP-53-368.

ca. 1955 *Savannah River Plant History, All Areas, July 1953 through June 1954* (Deleted Version). On file, Document Number DPSP-54-448, Savannah River Site Archives.

ca. 1973 *Savannah River Plant History, Separations Areas, July 1954 through December 1972* (Deleted Version). Document Number DPSP-55-454-2.

Smyth, Henry D.
1945 *Atomic Energy for Military Purposes The Official Report on the Development of the Atomic Bomb under the Auspices of the United States Government.* Princeton University Press, Princeton, New Jersey.

Thayer, Harry
1996 *Management of the Hanford Engineer Works in World War II, How the Corps, DuPont and the Metallurgical Laboratory Fast Tracked the Original Plutonium Works.* American Society of Civil Engineers, New York.

The USC Legacy Project, Department of History, University of South Carolina
1995 *The Cold War in South Carolina, 1945-1991 An Inventory of Department of Defense Cold War Era Cultural and Historical Resources in the State of South Carolina.* Prepared for the Legacy Resource Management Program, United States Department of Defense, Demonstration Project No. DODC-6. Administered by the U.S. Army Environmental Center Legacy Program, Aberdeen Proving Ground, MD.

United States Department of Energy
1994 Nuclear Age Timeline: Poster Supplement and Resource Guide. Poster and Booklet prepared by U.S. Department of Energy, Office of Environmental Management, October 1994. On file, New South Associates.

1996 *Plutonium: The First 50 Years, United States Plutonium Production, Acquisition, and Utilization from 1944 through 1994.* February. Document Number DOE/DP-0137. U. S. Department of Energy, Washington, D. C.

United States Department of Energy, Office of Environmental Management
1997 *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes To Their Environmental Consequences.* Office of Strategic Planning and Analysis, DOE, Washington, DC.

Voorhees, Walker, Foley and Smith
1957 Construction History, Savannah River Plant. Subcontractor for Engineering Department, E. I. Du Pont de Nemours & Co. Inv. Prime Contractor for United States Atomic Energy Commission, Project 8980. Volumes I and II. On deposit at the Hagley Museum and Library, Wilmington, Delaware.

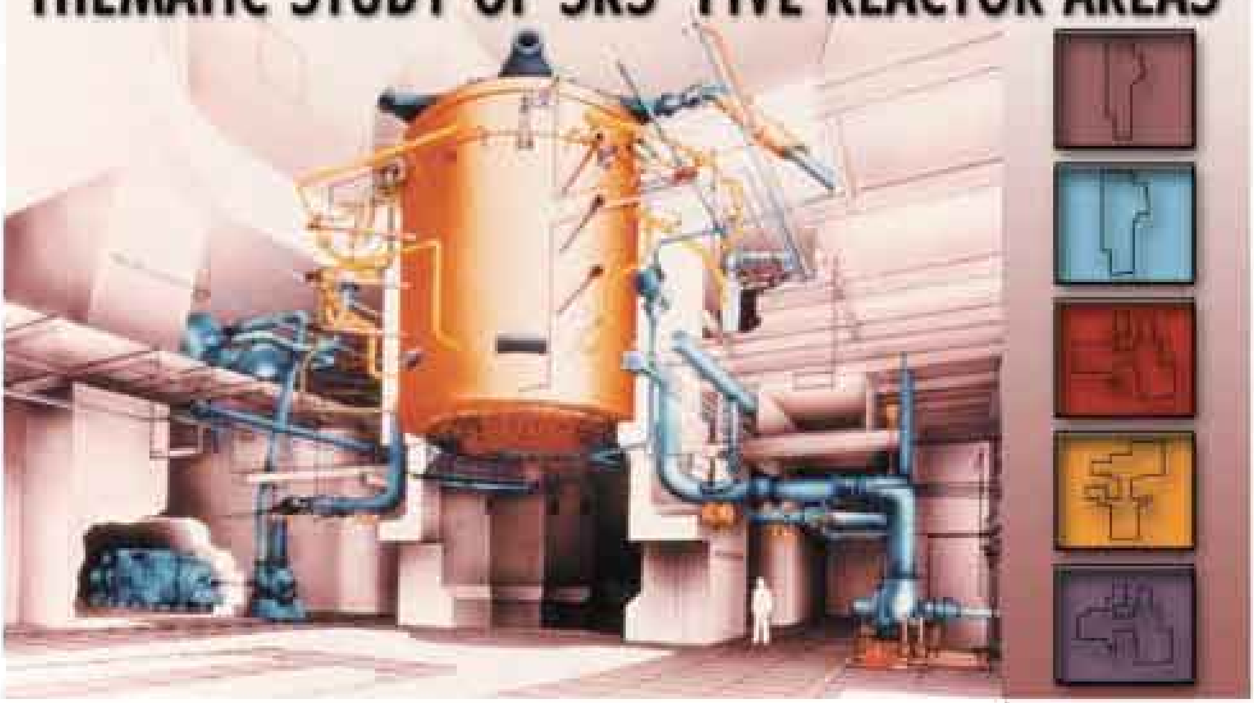
Walker, V. W.
1975 *Equipment and Operations for Preparing Cf-252 Neutron Sources for Interstitial Cancer Radiotherapy Research*. Paper proposed for Remote Systems Technology Conference, American Nuclear Society, San Francisco, California, November 16-21, 1975. Prepared by V. W. Walker, Savannah River Laboratory, E. I. Du Pont de Nemours and Company, Aiken, South Carolina. DP-MS-75-9.

Volume 3

Appendix B

REACTOR ON

THEMATIC STUDY OF SRS' FIVE REACTOR AREAS



NEW SOUTH ASSOCIATES

PROVIDING PERSPECTIVES ON THE PAST

APPENDIX B: ORAL HISTORY TRANSCRIPTIONS

Oral History Interview – Harvey Allen

Harvey Allen worked at Savannah River Site from 1959 to 1993. He worked in the 100 areas, and most of that time– 28 years– he worked in Reactor Technology. He started off working on reactor components, and later worked as a supervisor for some 20 years in K area and C area. Eventually he became a chief supervisor for two different groups in Reactor Technology: the Engineering section and the Technical Assistance section.

Interviewee: Harvey F. Allen, Jr.
Interviewer: Mark Swanson
Date of Interview: September 11, 2006

MS: This is an interview with Mr. Harvey Allen, who used to work with the reactors at Savannah River Site, and this is a study of the reactors in general and your participation in the reactor program at Savannah River Site. And if you would, just for the record, state your name and previous affiliation with Savannah River Site.

HA: Harvey F. Allen, Jr., I worked at the site 1959 to 1993. Twenty-eight years of that was in Reactor Technology department, three years in the 100 areas, which is reactor area's project department. And I got a reprieve for another three years, and a couple of other assignments. And I started off as a rookie engineer, working on reactor components, and I worked as a supervisor for ten or fifteen years in each of K Area and C Area, running the technical group of the area. Eventually I became chief supervisor of two different groups in Reactor Technology, one of them running the Engineering section and one of them running the Technical Assistance section, which is responsible for all the technical groups in the reactors. When I started work out there, five reactors were running. We closed up C area in 1964 and L area in 1967. And then L Area was restarted in 1980-something, I don't remember exactly when. I try and forget everything I learned about it but they said you're not supposed to talk so— (laughter)

MS: Yeah, if you wait long enough, then they want you to talk. We talked about some of the specific reactors. On a typical workday, were there some reactors you worked with more frequently than others or—

HA: Well, I worked in K Area for, I don't know, eight or nine years as a technical group supervisor and C Area for five or six years as technical group supervisor. Our main job there was to help the reactor department with the technical stuff, but we also were sort of an oversight—we looked for any errors they made effecting reactor safety and we'd write reactor incident reports, which told of the incident and evaluated how it affected the safety and that sort of thing. Of course, starting to work in engineering and ending up as a chief supervisor, there's a wide range of responsibilities over twenty-eight years. And there wasn't such a thing as a typical day. In engineering, that's anything—being an engineer, there's something new everyday, hopefully anyway.

MS: Did you have any dealings with the experimental reactors in 777?

HA: No, but actually in C Area— some time in the 1960s, we converted— it [C reactor] was sort of an experimental reactor and we called it the high flux charge. The core was normally 15 feet in diameter and we made it about a 7 feet 4 or seven feet high instead of the normal 15 feet, and we ran a charge and made microgram quantities of californium-252. That was kind of fun. But a few years later, we ran a similar deal in K Area. Again, we had the 7 foot-diameter core and seven feet high, and we called it the "californium charge." We ran, I think it was ninety some charges trying to make californium. The object there was to keep the reactor running because you lost production every time it shut down. And for a normal charge, you'd shut the reactor down and discharge it and charge it. It would take about three, four or five days. On this californium charge, our record was eleven-and-a-half hours. We shut the reactor down, it was critical eleven-and-a-half hours later, and discharge the fuel and recharge the fuel, which is kind of a record. One of the guys in the Reactor department used to give us stars when we did good. We got five gold stars for that one. I think we averaged something like thirteen hours for the ninety-some charges. And if you SCRAM the reactor, the xenon was so high—the xenon quantity was so high, you couldn't—you'd have to wait three or four days to recover, so we just discharged and recharged and throw it away, but fortunately didn't have very many SCRAMS during that charge.

MS: You talk about some of the operating cycles and everything. What was the range of operating cycles?

HA: What do you mean by range?

MS: Like talking about how many days—

HA: Some of the natural reactor charges where they're just radiating natural uranium, they'd run about— you'd start off about a month-and-a-half to two months. Then we ran some where we were producing tritium, they'd last six months or longer, best I can remember. Hopefully, you didn't have any shutdowns in between. The fuel cycle was about six months.

MS: That's a long time. So they would just be cooking for six months?

HA: Right.

MS: And then for the californium stuff, it was much, much shorter, right?

MS: It was quicker because it was a real high flux charge and you burnt fuel up very quickly. You also burned out control rods. A lot of things we did in that charge to kind of combat the burning out of the control rods, which we use lithium and the lithium would absorb the neutrons in the tritium also. We would use cobalt control rods. And we made the highest specific activity of cobalt the world's ever seen in that charge. And unfortunately, I don't think anybody had any use for it, but we did make it. It also led to a problem later on, but it was kind of fun. The high-flux charge— If I can remember the number, we reached 2.1×10^{15} neutrons per centimeter second squared, I think that was the units we used. We actually had a plaque. We did this in C Area about—

MS: Wasn't that in like 1967 or something?

HA: Something like that, in the late sixties. But I think the californium charge in K Area ran in 1971. We ended it November, 1971. The DOE gave us a plaque. We used to have it mounted right under a spotlight near the lunchroom in C Area. It kind of disappeared, although I think Walt Joseph said they found it and have it in their—they're trying to make a historical building somewhere. He said they found it and they have it in there.

MS: Okay. I know they've got a lot of material that they thought was lost and Walt Joseph has a lot of stuff from the L-Reactor restart program.

HA: Yeah, they made some really good records when they did the L restart. One of the things they kind of made a mistake in is—they weren't thinking of history at the time, was they made a simulator—they simulated the control room. And it would have been nice if they kept that, but I understand they tore it down.

MS: Where was that?

HA: It was in C Area, 707-C.

MS: 707-C?

HA: Um-hm. And that was a dirty shame when we heard that was gone. But that would have been a perfect historical thing. You could simulate running a reactor, assuming you still had people that remembered how to do it.

MS: Right, um-hm, yeah. I think Mr. Merz made some mention of that, he was talking about the simulator. And they didn't have that at the beginning; they came up with that. When did they install that?

HA: I'm not—I think it was probably in the eighties sometime. Because we were in 704-C—707-C, we moved there in about 1984 or '85, and the simulator was installed some time after that. But when they started the reactor, they were designed for something like 500 megawatts. And in C Reactor and when I was there, we got that thing up to 2900, and my memory says 45 megawatts, when we had a real cold winter and a real good charge. Typically you could run them up to 2600 in the winter– 2600 megawatts, that's pretty good.

MS: Right. Did that make a difference in running the reactors as to how cold the river water was?

HA: Oh yeah. We pumped water from the river right through the reactor heat exchangers and right back to the river, somewhat warmer than when it started. But in the wintertime, you could do better than you could in the summertime. Like when that L Restart by then, environmentalists got involved and they said, you can't discharge water straight to the river so they built a pond for L Area. And they said, well, the pond water can get to 90 degrees, which it would in the summertime by itself. When the reactor reached 90 degrees, you had to shut it down. So it'd happen sometime in June, you couldn't start it back up again until late September, early October. We did that for three or four years.

MS: And out of curiosity, I know that's the result of—the state of South Carolina had some say in that, but in the early days they [Du Pont] pretty much could do what they wanted to do.

HA: That's right.

MS: So how did that change? Is that too long a story to go into? (laughter)

HA: The environmentalists of course, got involved— I remember when I first came to the site. I had been working in the Coast Guard. I had been in the Coast Guard and then I came here. And we had a budget problem all the time. We had to go through the budget cycle. The AEC didn't have a budget. They somehow or another— The president got a $4 billion or $8 billion slush fund and the AEC used that, and they did everything they wanted to. But I remember the guy from the Project department came out and said, well, he says, I've got good news and bad news. The bad news is that we're going to have to go through the government to get budget cycles too, it's a four-year cycle. You plan four years in advance and you get your budget enacted. The good news is, that means you're probably going to last forever, which is kind of what I thought too (laugh), going to be like all the other government agencies, you'll never get to shut the place down, and that's about what happened.

MS: What were some of the products that were made in the reactors at Savannah River?

HA: We made plutonium-239, tritium. We made some polonium, I think it's like 208, something like that. We made cobalt-60, we made the californium, we made americium, and we made plutonium-238, which is the isotope used for the energy sources for the satellites we shot up. They made some kind of battery out of them—some are still circling around the earth, I guess.

I can't think of anything else right now. Those are the main things. We mentioned some americium. There were some byproducts, when you take the plutonium out and you get some other isotopes. We made some scandium just for the heck of it. In the late—mid-sixties, I'd say we were kind of worried about keeping the reactors going so we'd go around and try to market things. We'd say, well, you know anybody who wants cobalt-60? We could make some—we made more than the world could use. Scandium was another one. It's something like cobalt-60 that you could have used as a heat source.

MS: I heard that when they were actually running the reactors and stuff that they would take the stuff in by truck, the fuel and everything, but the final product always went out by rail.

HA: Yeah, and that's because we shipped the fuel and targets to the 200 area for Separation in a cask, a 70-ton cask that had about eight inches of lead and stainless steel and stuff like that. And of course you didn't ship it until it cooled down. It'd sit in the disassembly basin and the radiation would decay down until the heat source was not so bad it couldn't be handled in the cask. It's kind of hard to find trucks that handle a 70-ton cask, but it could have been done. Rail was easy, but— the neat thing is, you take the rail in the canyons, sort of the 200 Separations area, you could remotely remove the lead, the motor, and remotely remove the fuel assemblies out of the cask, and you wouldn't have to— I guess you'd have to have a train to back it in there, but you wouldn't have to have a truck go inside the canyon. With the train, you just back the car in there and go inside the canyon.

MS: Right, yeah, that kind of makes sense. How many people would you say worked in each of the reactor areas?

HA: It was on the order of 350 to 400, depending on the area. Like C Area was sort of a 100 area administrative area and they had a couple of administrative buildings. They had an extra 50 to 100 people there than they did in many of the other reactor buildings. That's best I can remember. The population of the plant varied considerably. I remember when I first went to work for the Du Pont Company, I worked at Dana, the heavy water plant before I went into the Coast Guard. And we used to get the safety reports and they had a number of operations people. I remember seeing they had 8,000 people working at the Savannah River Site, in Operations. In the mid-seventies, we were down to less than 4,100, but by then we weren't running but three reactors, but we were running everything else. But that was before the DOE wanted things like, what do you call it, "quality assurance" and they had a lot of these other programs that didn't add anything but paperwork, that's my humble opinion. I couldn't see that "quality assurance" did anything but make paperwork. It made somebody happy.

MS: Well, that's one of those things I guess they were—they got more concerned about safety and that sort of thing.

HA: Well, Du Pont has been noted for their safety program, and they were always interested in safety. Personnel said they even wanted you to be safe at home because for them it was a moneymaking thing. If you didn't have accidents, you saved on your liability insurance, and the people that stayed home sick and things like that. They had a very, very rigorous safety program and, like I said, in Reactor Technology, we were sort of the safety officers for the reactors, as far as operating reactors go. We were kind of looking over the shoulders of the operations people and making sure they followed the technical standards and specifications and followed the operating procedures and things. If they didn't, we'd write them up on the incident report.

MS: I've heard that in Reactor Tech, for example, they normally didn't actually manipulate controls—

HA: No, Reactor Technology guys were not allowed to do anything except watch.

MS: But they did have access to the logs and things like that?

HA: Oh yeah, access to logs and people, no problem.

MS: Were they— Was somebody from Reactor Control, were they always at the reactor?

HA: Yes, there was always a supervisor in the control room and there was always at least one operator. Usually there were two operators—one at the reactor end, reactor operator, and at the other end—what did they called that guy. The hydraulics—the pumps and everything was operated from the one end of the reactor, and the reactor building control rods operate at the other end, there was a big old control room. But there was always at least two people there, because the guy at the one end—I guess it's called a graphic panel operator—he also answered the telephone in case somebody wasn't in the supervisor's office, which was adjacent to the control room, and it was surrounded like with glass, like a fishbowl, the operation room. And right behind that was the control room for the charging and discharging machines, at a slightly different level. Yeah, there's always somebody there, and if they weren't there, there was a reactor incident report written.

MS: Okay. Yeah I heard about those. Talking about there being about 300 to 400 people in each reactor area, how many would have actually been working in 105?

HA: Okay. There were four rotating shifts. So each shift had a senior supervisor, a shift supervisor and about twelve or thirteen, fourteen operators. So those—multiply that by four and that's the number of guys operating the reactor. In addition, they had the assembly-disassembly crews. They had a senior supervisor in charge of both, and they had a foreman for assembly and a foreman for disassembly and they had maybe ten or twelve operators on— well, I'm not sure they had them separate, because I think the assembly and disassembly operators worked on both sides. They worked assembling a charge getting it ready, and when they came out and cooled down, they'd do the disassembly and the shipping of the stuff to the 200 Area. Then, they also ran the distillation plant. They had a little distillation plant they kept the heavy water pure, from radiation and light water getting into the reactor.

MS: We're talking about—this is in the reactor area?

HA: In the reactor area.

MS: Where was that?

HA: It was kind of outside on one side of the reactor building, opposite the control room usually, at least in L, K and C, it was. In R and P, I'm not so sure because their arrangements were different.

MS: How big a thing was that?

HA: It wasn't very big. I can't remember the capacity or anything, but they didn't run but a small, one or two gallons a minute, something like that, a very small stream. But it was very effective. It kept the water purity up.

MS: How did security change at the reactors over time?

HA: It changed quite a bit. In the beginning, Du Pont ran the security force and you'd have a patrolman at the entrance at 105 building checking badges as you came in. And they had another, it's called exclusionary. It was another fence around the reactor building proper, and you had to go through another guard to get there. Eventually, they got worried about people—terrorists—somebody actually trying to come in and take over the building, and they gave the guys M1 rifles and Du Pont said, you know, we're really not in the business of shooting people. So they got out of the security business and they hired Wackenhut to do that, and they had what they call these SWAT teams, like, and these guys came around looking like SWAT teams and carrying all kinds of weapons. The [Du Pont] security guys only carried a 38-caliber pistol or something like that. These guys were carrying their Glocks and they're carrying M1s or M15s, whatever the heck they use nowadays. And they had rapid response guys in trucks wandering around the plant. Had a couple helicopters, that came around and they could get from place to place real quickly. And they practiced actually storming in the reactor building. And of course we didn't like that with guys with guns coming in the control room.

Then they'd set up inside the building, they set up— They could actually isolate each part of the building and you had a keyed door to go through with a guard outside it so they had, I don't remember, four, five or six

Wackenhut guards inside the building itself. They made it very inconvenient to go to one side of the building to the other because you had to pass through two or three of these locked doors. It was a pain. And then they had the little key-operated things and you had to remember the password. And they changed the dang-gone number every month, so that was a real pain in the rear end. It's okay if you're in that building. Like I had a job when I went from building to building to building, I had to know all three of them. And they didn't always use the same number for all the dang-gone doors so that was kind of a pain in the rear end, but I guess it did make them safer from the terrorists. That was quite a change, yeah.

MS: How did like reactor safety change or perceptions of reactor safety change?

HA: That changed a lot too. The one thing, I guess that changed it the most was when the Chernobyl accident happened. You talked to Gerry Merz—he was our superintendent at the time, and he said his life became hell after that. And we had to go through and show through a lot of studies that our reactor—our reactors didn't run anything like Chernobyl, and we didn't take any type of the chances that those dudes did in shutting that reactor down. And I guess before Chernobyl the Three Mile Island thing happened. We did the same thing—we did a bunch of studies to show why that couldn't happen at our plant, our reactors. And when they had the Discovery—when the shuttle, which one was it that exploded on the way up? Challenger?

MS: Yeah, I think it's Challenger.

HA: Challenger. They did a bunch of studies on that to see how those errors they made leading to that disaster would have affected us, if it would have.

MS: I wouldn't think that would have any impact on—

HA: I wouldn't either but, you know, people making errors and making assumptions, administration or management is applicable to anybody, when you get right down to it.

MS: I guess that's true. Were you involved in any of the searches they were doing for that neutrino research?

HA: No. The neutrino was in R area—not R. Maybe it started in R, but it was—P Area

MS: I think P area—yeah P was when it–.

HA: There was a great big tank of kerosene, and I walked by it. That was the best I did. In the californium—not in the californium. In the high flux charge, to get support for this from national laboratories, we went around and asked them was there anything we can do? And so this guy says—We installed a rabbit and we put in little capsules about—they were about three-eighths inch in diameter, maybe three inches long and they put some kind of rare thing in there and shoot it in the reactor and pull it out and then they would count it real fast. And this one guy from the University of California at Berkley, I guess it was, was doing something. He was looking for einsteinium or something like that. And they come out and one of the things that had— we actually installed two rabbits. One of them we used a fish tape, put it in, take it out. It takes a couple minutes. The other one we shot in with helium and shot it back out, and it was real fast. And unfortunately, the helium actually got irradiated and when it came up there was a burst of activity. The counters would see that, so that didn't do any good, so we put in a little tape to stop it and then opened it up and then go the rest of the way and all that helium—or that helium activity was real short-lived. It'd be gone and then he could count for whatever he's looking for, I'm thinking einsteinium, but I'm not sure. He thought he saw some, but we're not really positive about that. That rabbit was so successful in C Area that when we went to K Area for the californium charge, we put in another rabbit and we irradiated lots and lots of stuff, experimental stuff.

I remember one guy put in gold. I don't know remember what he was looking for, but he put in little gold capsules and he'd irradiate them and use them for research at the Savannah River Lab. And we did a lot of stuff. Some guys wanted some stuff and they wanted to get it from here to Chicago, the University of what is that—the one where they started the reactors and did the test? I've forgotten now, but anyway—Argonne. Is it Argonne in Chicago?

MS: Yeah.

HA: Argonne National Lab. Anyway, these guys came down, we did a test run. They had this cask. It was about a foot cubed. It weighed about 500 pounds. And we were going to irradiate this thing and take it out of the water, drop it in a cask, put the cask in a pickup truck and take over to the airport, put it in a little charter airplane and fly it up to Argonne. I said, Well this is okay, except, how we going to move this cask? We got it over to the airport and two great big old husky guys just picked that thing up and put it in an airplane. So that's kind of funny, interesting. A big old strong batch. We did a lot of that stuff. I can't remember all the little tiny things that we did. But I remember one time we lost the world supply of one isotope because we dropped the thing down in the [disassembly basin]— you know, the disassembly basins were 30 feet deep, thirty feet of water and there was always a lot of sludge at the bottom. We dropped this thing, and you could see it at first because of the Cherenkov radiation, but that didn't last very long and then we couldn't find it. They didn't find it until years later, they drained the basin and then said, Oh, here's that thing you lost, Harvey (laughter) 1969 or '70, '71, whenever it was.

MS: Were there any reactors that were more commonly used for some materials than others? We talked about neutrinos and all that, but—

HA: Well, C and K were typically used for the tritium charges, the ones that ran six months. And L Area was used for it once. Typically R and P only ran natural uranium charges, and the rest depleted charges. I don't think they ever ran the tritium charges, mainly because they only usually ran one or two or three of those at a time. They'd get enough tritium and they didn't need the tritium. The others were just making plutonium or plutonium-238, or both.

MS: Is there any particular reason why they wouldn't run tritium in like R and P?

HA: I'm not real sure. C was our most efficient reactor. It had a bigger tank so it had what we called a—not a blanket, but a reflector on the outside. It had about a foot of heavy water on the outside so the charge ran flatter. A typical charge—it looked like a co-sine charge as far as the power, it ran a lot flatter. The individual tubes would be about 10 percent less, but the whole reactor run at a higher power level. I don't know really why we run it— Like I said, we did L, K and C for the enriched charge— I mean the tritium charges. I don't think we ever ran them in R and P. I'm not even sure they had them. Well I guess they did. I was going to say we probably didn't even have those kind of charges before R shut down, but I think that they did.

MS: Were you ever involved in that HWCTR program?

HA: No. I know some names of the guys that were, I can tell you— A neighbor of mine was.

MS: It's sort of like a peripheral thing, I think, for us.

HA: Yeah, they were building this reactor to test heavy water components and that didn't last, so they decided we're not having any heavy water production, I mean power reactor, so they got it started and ran a very short time and everybody went back to the reactors or laboratory, wherever they came from.

MS: Yeah, apparently I think the light water—power reactors—were too well entrenched by then and they just decided not to go with it. What about— I kind of forgot what I was going to say. Hopefully, it'll come back later.

HA: You look too young to be losing your senses.

MS: Oh no. They can— You're never too young to lose it. Let's see— It's all that aluminum. (laugh) We talked about the transplutonium program, in considerable detail I guess. Was there any particular reactor that was favored for transplutonium work over another one?

HA: Transplutonium, what are you talking about?

MS: The whole range of stuff they did. It may be too— Transplutonium may be too broad a question, but that would be like everything like from americium, working on up to californium.

HA: It usually ran in K and C. I'm not sure why, other than the flux was lower. The power was lower. But we ran the— That tritium charge— Had tritium assemblies in all reactors, making the plutonium-238.

MS: Oh yeah, talking about the reactor cycles in some of the transplutonium work, I heard those were very short.

HA: Well for the californium they were. We had something called the universal sleeve housing, was the outer tube, and you put the fuel assemblies and the target assemblies inside and we got those sort of semi-permanently in the reactors. For the californium we actually put—I think it was plutonium-242 was co-extruded with the tube itself and those targets stayed in the reactor several years, even after the californium was—the charge was over. Left those in there, that kind of maintained the californium when they needed some, you'd take them out and then they'd process them. And some of the other things—we'd put in plutonium-242 in targets, leave them in the reactor a long time as sort of a blanket. And I think we did those mostly in K and C. C would have probably been— I can't remember for sure. The flux level in those blankets would have been higher in C area than it would have been in K, but I think we did them in both reactors over the years, best I can remember.

MS: How long did it take to prepare for a cycle?

HA: Depending on the cycle. Like when we were doing the californium, you had three or four days, but you only had about a hundred tubes to get ready. The others it'd take about two or three weeks. And part of the problem— Well, we had to flow test each and every assembly with sort of a quality assurance—not a quality assurance but a quality control check. We'd run a flow test on each and every assembly for both the fuel and the targets. So you had about five hundred some assemblies to test and it'd take two or three minutes apiece, it took three weeks. The thing that would hold the assembly guys up was Reactor Tech guys telling them what to put in. They also had to assemble the control rods and they had to assemble them the way they were going to present it to the charging machine. Each one had to be identified with the certain particular hole that it was going to go in. If they were flow zoned, then the flow zoning had to be right. And in the case of the fuel, it would be nice if you could make every fuel assembly exactly the same, but it didn't come out. So they'd tell you what the fuel was and they would spiral that in. And I guess the lowest—or the highest—must have been the lowest 235 started on the outside and they came in the inside where the large amount of flow was. And they flow zoned it to match what you thought the power level was going to be in the assembly when it was running. The idea was—try to make— If you was perfect, you'd have had everybody run the same power level, but it didn't work that way. Plus it's kind of cosine shaped. But you'd try to force the power up by cutting down the flow on the outside ones and make them higher on the inside so that everybody run as high a power as he possibly could, an efficiency type thing.

MS: When did computers first come in?

HA: Who?

MS: Computers first come into use with the reactors?

HA: I would say we put the first operating computer in K area in—mid-sixties, best I can tell you, by mid-1960s. Put an experimental job in K and it worked so well, they put them in all the reactors. But the budgeting thing took several years. Then they went to computer flow monitoring, which was really a big help. And they went into at least a second cycle of computers to run the reactors. They were very successful.

MS: What about reactor leaks? Were there any reactors that had particular problems with that sort of thing?

HA: Yeah. R Area developed a leak in a nozzle up close to the reactor and we had to chip concrete and go in there and fix it. The L Area had one that got fixed. C Area, the reactor tank actually got cracked. They had something that's called a "knuckle." They would join the bottom of the reactor— The bottom of the reactor actually had a bunch of holes in it. What'd they call those things? The flow monitor. The flow and temperature monitor came up here. You had four thermocouples inside and it measures the delta-P for the flow and the temperatures and use that as a safety circuit. Then to join that to the sides of the reactor, they had something called a knuckle, and it started off at one thickness, I can't remember if it was ¾, then went down to another thickness there. And they cold-rolled it and annealed it—or heat-treated it or something. Anyway, everything they did to it, they set it up for stress corrosion cracking.

And I can't remember the dates but the thing cracked and we went in the reactor and actually welded a patch on it. And that worked for a number of years, and some time—I can't remember exactly when—the thing started leaking again. And they tried to repair it again, they found out they couldn't. There was— I think it was argon generated in the thing. Whenever they tried to weld, the argon released and made it crack worse so it—After that repair attempt, which they hired Westinghouse to do and spent $30 million or $40 million trying to fix it, never was successful. So that was the end of C-reactor, they never, ever started it again.

I can't remember if anybody else had a leak or not, but we had— Sometimes you'd have leaks in the pipes down in the control room, you'd find it. We always— The neat thing about the heavy water was it had a little bit of tritium in it, and you could detect the tritium very, very easily, you go through your— And any time you'd go in the radiation zone, the health protection folks would go in there and scan for tritium and you could locate the leaks that way. Never had any real bad leaks from cracked pipes.

One time in C Area— In fact, it was during the high flux charge, we actually blew the plug out of the reactor. You had to take a plug out in order to put a fuel and target assembly down into the reactor and there were about 3½-, 4-inch holes and this upper plug had a latch on it. And it blew out and we had to shut the—reactor shutdown real quickly. But the Lab came up with something called the "hold down" and it was put on the bottom of the— Actually it came down to latch at the control rods, and so those plugs couldn't go out anymore. We put those in all the reactors. It was the evolution type thing where you started off with 500 megawatt reactors and went up to 3000 megawatt reactors and on the way you've made all kinds of improvements, added safety devices here and there.

We actually put little detector devices on the reactors. We had a little plug and it was connected to electrical circuit and had a little insulator between that and the top of the reactor. If any water got there, it conducted and tell you where the leak was. Anytime you had a tank top leak, you had to shut the reactor down. You don't want to have water leaking, losing any coolant so that was one thing that was added.

There were other safety devices added too. We had the flow monitor that you worried about. The theory was you lost the flow to an assembly, you'd go from water to steam real fast and you wouldn't be looking for a low delta-P, you'd be looking for a high delta-P. So you had a high delta-P switch and a low delta-P switch for a low flow or a high delta-P for—if you get steam. And you'd monitor all the temperatures all the time looking for when it got too hot. If a fuel— The natural uranium, when it got wet, if you had a leak in the aluminum casing, it'd swell up. Uranium oxide, it had a lower density than uranium, so it'd swell up and you'd cut off the flow so the temperatures would go up and the flow would go down and you could see it coming. Sometimes they'd start swelling before they actually started reacting with the water. And so you'd find out your flow and temperature monitor that way.

And when you had to SCRAM— This is kind of a neat thing. They had a Polaroid camera set up, and they had a little bulb, indicating the delta-P for each one of the fuel assemblies, because you had to SCRAM from a high delta-P or a low delta-P. That first light, the one that caused it, would come on first and when the reactor SCRAM everybody'd come on. So the Polaroid, it'd take a picture of that panel and you could see the one that caused it. And when you walked in later on, you'd go, They're all on, which one was it? But that identifies the culprit.

MS: Was that always in place?

HA: Yeah, I think far as I know, yeah. I think it started from the very beginning. So they started—the first reactor went critical in '53 and I didn't get here until '59, so the first six years of history I don't know anything about it except hearsay.

MS: Right. Yeah, that's a good idea. That's the first I'd ever heard of like a Polaroid set up for that.

HA: Well with computer, that would tell you. They could catch it. They were pretty fast.

MS: Right. But at '59, they wouldn't have had any computers in there.

HA: No. Actually '53, '54 is when this stuff got started. C-reactor, I think went critical in '55. They started building these things in the fifties. In '53 the first was critical.

MS: Right, yeah it was like in December of '53, I think, yeah.

HA: You couldn't build a reactor that fast nowadays. But they had national priority. We'd get all the stainless steel in the country you wanted and anything you wanted Truman would get for you.

MS: Right. Yeah, talking about that stainless steel, I heard that— This is something that Mr. Merz was talking about. He said that 304 stainless steel turned out to be not terribly good. That was the industry standard, but it was not—it just corroded too much. What'd did they eventually use?

HA: Well we didn't change it.

MS: Oh yeah okay.

HA: We didn't change it. It's still there.

MS: They're still there, yeah. What do they prefer to use now?

HA: I don't know. It's a lot thicker, though, I know that.

MS: Yeah he said that they used something else, but he didn't specify it and I don't think I followed it up.

HA: Power reactor, they got a lot higher pressure, and we had a very low pressure reactor. We had 5 pound blanket gas on the bulk of the water. If the water's being pumped through there, it was a lot higher pressure, maybe 100 pounds, something like that. But the reactor itself, we only had 5 pounds of blanket gas pressure, so that's a low pressure outfit, low temperature.

MS: Right, yeah. Talking about that simulator, how long did it take to train reactor personnel?

HA: I have no idea. They actually stayed in training all the time and especially after people got all excited about reactor safety. In the beginning, I think they could probably train an operator in a year and be happy with it. But then they got into the deal where they were in training all the time, they'd go back to the simulator and they had to go back for classes every year. So it was a constant retraining type thing.

MS: Yeah. Where were they trained at?

HA: Well, either in the reactor building or in the simulator. And then they had this training facility in 707-C. Before that, they were training in 706-C, I think, where the training outfit was, but—best I can remember. But when they got the 707 simulator out here, they had a real good training outfit, real modern compared to the early days when it was just sort of on-the-job training.

MS: Right, yeah. How many new people did they take in to be trained to operate the reactors?

HA: I don't really know because they hired a bunch of people in the fifties, and you had this big hump moving through, and like in the sixties, early '59, '60, you'd hire maybe five or six people for the whole plant all year. And so it wasn't until people started retiring, some time maybe in the seventies or early eighties, but the personnel started changing fast enough that you had to hire a bunch of people. So, I don't really know what the numbers are, but we had a very, very stable workforce. You lost less than 1% a year. There weren't too many jobs and that was probably the best-paying job you'd get around here.

MS: Right. So there really wasn't too much personnel change until the seventies, probably.

HA: Seventies or eighties.

MS: Not just talking about the reactors, but talking about the entire plant, what was the maximum number of people that were ever employed there, aside from the construction era.

HA: Okay for operations now, like I say, we started off in the fifties at eight thousand and got down to less than 4,100 in the mid-seventies. I used to keep track of that. I used to write down in my notebook, down to 41-something. Then it started back up, they started adding programs. And when Du Pont left in 1989 they were probably up to eight or ten thousand. Westinghouse— DOE— When Du Pont left, Westinghouse told the new contractor they wanted everything down here. Du Pont had operations— They had the laboratory here, but it had an engineering force—Du Pont engineering force in Wilmington. And they hired some other—contracted other engineering design outfits in other places.
DOE said they wanted everything done here. So Westinghouse came down and they hired over— They had at one time over 26,000 people. And shortly after they got 26,000 people, the Cold War ended and then the population started going down. They kept saying, Oh look how the population go down, but there's still more people out there now than there were in the mid-seventies when we were running things. There's still something like ten thousand people, something like that. I can remember some time in the eighties I found out they had ten thousand people at Hanford and they weren't running anything. I said, Gee whiz are we going to do that? And they spent $70 billion trying to restart the E-reactor. And I said, Well— At that time, K was shut down. I said, Well we're probably going to do the same. So we spent $2 billion starting K. We started up and ran it maybe two weeks and then shut it down and nothing's running since.

MS: Right. They got that cooling tower.

HA: Yeah, never been used. We did a study in Reactor Tech on that cooling tower. We figured, Now how are we going to run the reactor with that thing? We didn't know how to do it. We weren't sure it worked.

MS: It's one of those things you were required to build, is that it?

HA: Yeah. The state of South Carolina required us to build it. If they'd been smart instead of trying to restart K, if they'd restarted L area, they already had a coolant pond. But somebody made a management decision—which one you going to restart? They said, Let's do K. But L area would have been a better choice. It had all new stuff. It was just completely overhauled and started up and only run two or three years, had a cooling pond. It could have started a lot faster, and wouldn't have had to build a cooling tower for $90 million that's never been used a day, going to be torn down.

MS: Why didn't they do that?

HA: They said it was just a DOE management decision. They said they were going to start up K and that's what they stuck with. Later on, we talked to some DOE guys said, You know, it would have been smarter to start up L. Yeah, maybe so, however—too late now, bubba.

MS: I guess it—who knows.

HA: It was kind of interesting on that, how the State of South Carolina and the environmental people got involved. They decided you had to do an environmental impact assessment or environmental assessment or something like that. And the DOE—maybe I shouldn't say this. The DOE guys were kind of arrogant and they just kind of sloughed off the State of South Carolina. And the State of South Carolina says, No, the assessment is not doing any good, we want an impact statement. That shut them down for another year. Then from then on, the state had their back up and they made them toe the line. If they'd been cooperative, I think maybe they wouldn't have required the dang gone cooling tower and all this other stuff. It's just like this plutonium thing. The governor says, I'm going to lay down in the road and you're not going to bring your old trucks in here, put plutonium in it. It's that same sort of thing. But the DOE guys in charge at the time were kind of arrogant and it ticked off the state guys, is what I've heard.

MS: Talking about the individual reactor areas and so on, were there any areas near the reactors that were used as like burial grounds for stuff?

HA: Yeah. The official burial ground was in the 200 area where they buried radioactive stuff, but each reactor had their own little burial ground. They buried junk. They had a trash pit. They'd bury stuff. But they wouldn't bury any radioactive stuff there.

MS: Okay so—

MS: Yeah, I think we were talking about some of the little burial grounds.

HA: In fact, I think R Area had something buried that was radioactive. I can't remember exactly what it is, but it's got asphalt over it and they monitor it and make sure the stuff's not coming out. One of the neatest talks I ever heard was whatever this thing was, where they lost some radioactivity, the health protection guy went out there and he made radiograms of a plant and a mouse and a frog where they got in there and got radioactive and laid them on a film and they took a radiogram and he was explaining how this stuff was moving out. I don't remember now what they did to stop it, but it was kind of a cool talk.

MS: Yeah I heard they had like some gigantic alligator in Par Pond was it, or L Lake, I can't remember.

HA: Probably Par Pond. They had big alligators and big fish. Actually I told you they pumped the water from the river, they had something called the 186 Basin, it was 25 million gallons of water and it was divided in three sections and there's two 42-inch pipes on each side and that water's pumped into half the reactor from one side and half the other. We found out after a number of years that those ponds were—those basins were filling up with silt. So we said, Well we got to clean them once in a while. So we shut the reactor down and drained the pond down. You'd find big fish in those suckers. I remember seeing fish two or three feet long. They had suckers and several different kinds of fish and they'd pump all that— And then you had to worry about mercury in that stuff, so they had a guy come out there with like a pontoon dredge and suck the stuff out, and then you'd drain everything all the way down, wash it out the rest of the way.
Like I say, at Par Pond in 1964 and people would go out there and put up night lines and fish and catch big fish out there. One of the jobs I had was going out there and doing sumping. We were closing off—blanking off all the water lines to the building and we were pumping the basin out. And the guy had a bunch of fish go through his pump and it was a dead fish.

Actually it was laying around there and there was a bunch of vultures and stuff come down (laugh) there help themselves to a fish dinner.

MS: Are you saying somebody was catching fish?

HA: Yeah. They'd put out night lines catching fish and eating them. People would sneak on and fish in Par Pond. They'd get caught. I remember— Every once in a while you'd see some little four-wheel vehicle (unintelligible) the patrol guys or Wackenhut. I don't think they did it so much when Wackenhut got there, but with Du Pont patrol guy, you know, they'd just confiscate the stuff then you'd see these vehicles. They'd take them to C Area and they'd sit there and their tires would go down and they'd eventually get rid of it somehow or another. But the guys— The fishing's so good, they'd go back several times even though they'd get caught. I don't know whether they got fined or what. They sneak in from the Barnwell side of the plant, R Area, fish. The game— It was sort of like a protected area. There's all kinds of game on the thing. There was lots of deer, more deer than you want to shake a stick at. They have a lot of deer accidents. They'd have controlled deer hunts. And I remember in the early days they were taking out a thousand deer a year in their deer hunts, and I don't know what they're taking out now. Turkeys run down the road—

MS: Yeah, I've seen turkeys.

HA: You mention the 50 million gallon basin, that was sort of an emergency thing. In K Area one time, we tried cleaning the heat exchanger or overhauling the heat exchanger with phosphoric acid. They thought they cleaned out all the phosphoric acid but they didn't. And we run the reactor. And one day the area superintendent of production walked in the reactor and for some reason he stepped on the hand and foot counter going in instead of going out. And his feet were contaminated; his shoes were contaminated. Well, find out it was phosphorus-35, I guess it was. So they looked around and they found all kinds of toads around, and he'd stepped in some toad manure, it was contaminated. Well, we were— At that time, for some reason, we were purging the disassembly basin out the 50 million gallon basin, and there was phosphorus in that dang gone stuff and the bugs were getting in the water and getting some phosphorus and then the toads were eating the bugs and contaminating the whole area and we didn't even know it. We got rid of that heat exchanger and that stopped the problem. There was—it got through the whole reactor, but the source was still in that one particular heat exchanger. Once we took it out and put the others in, it pretty well cleared up.

But when they started monitoring that in the 50 million gallon basin, to monitor the level, the guy would have to go down—just had a ramp so he could drive down to the bottom. He'd go down there and get samples of water. He turned around one day and there's a bobcat coming down. He said, Oops, what am I going to do now? Fortunately, it didn't attack him or anything. Bobcats, fox, Lord knows what—and hogs. There's wild hogs running around, boars I guess you'd call them. So they'd shoot them once in a while on the deer hunts.

MS: Talking about the reactors, I think you mentioned that universal sleeve housing that they had in the reactors. When did that come in?

HA: Probably some time in the late sixties, early seventies; I can't remember for sure. I know it was there by the seventies. Before that, they put in a fuel assembly, the whole thing went in and came out. And that saved a lot of aluminum. It was actually cheaper to put in that universal sleeve housing. And that formed the outer fuel channel of the assemblies then just put the fuel in, take it out, and you'd have to have an inner housing to throw away every time, but the rest of them you'd have to dispose of that aluminum, and they'd go to the 200 area and get buried and it was just wasted aluminum. So that was a big savings.

MS: I think we were talking about R-reactor earlier, and I heard they had some kind of clarification pond built at R-reactor that they did not duplicate at the other reactors because by then they'd figured out that wasn't a problem.

HA: They thought they had to get rid of the silt in the river water, and so they built this clarification thing, and they ran some experiments down at TNX. That was a technical area down by the river. They found out that the stuff was actually scouring the heat exchangers, the silt in the reactor, so they didn't have to use that thing, so they never built it anywhere else and didn't use it—never, ever used it in R Area either.

MS: So they never used it in R Area?

HA: Never used it in R Area either.

MS: What'd they use that tank for?

HA: Well it's a great big concrete—

MS: Concrete pond.

HA: It's just sitting there, never used it for anything. Well but it saved money once they found out they didn't need to build it in P or L or C or K.

MS: And they didn't build it in P right?

HA: No.

MS: Aside from that particular clarification pond or whatever, did they have any other things at R that they didn't have in the other reactors? I know R is supposed to be bigger than the other reactors, maybe R and P are—

HA: R and P are almost identical. And their assembly area, I think, is bigger. I can't think of what the differences are. I used to have a list of the difference between K and C. C is kind of different from the rest of them totally because of the reflector. They learned a lot of stuff when they built C. There are probably other differences but I don't remember what— Like C has a different number of safety rods, one-inch holes and things and also a different number of fuel holes. Everybody else had six hundred, I think they only had 588. And that's because they had twelve additional control rod positions. I can't think of anything else. Oh, I know, they had a laboratory in R Area. I'm not sure they had one in P or not, but they had a lab where they'd analyze the water, and I don't know if they analyzed anything else or not. They did some chemical analyses there.

MS: That's sort of related to that clarification again?

HA: Yes.

MS: We've been talking about the different reactors in the assembly area, disassembly area. If you wouldn't mind, would you kind of go through the entire process of what went on at a reactor? I mean, the stuff comes in, goes into the tank and then comes out.

HA: Okay, the reactor assemblies would come— Well the aluminum part would come from ALCOA, and they'd go through a quality control check. I think they went through Central Shops, and what they needed they'd send to the reactor building. But they'd run it through the degreaser. And the fuel assemblies would come—and target assemblies would come from the 300 area, the Raw Materials department. They'd degrease them. And eventually we put in an autoclave. When they got the assembly assembled we had a corrosion problem. We put them in an autoclave, put them all together, they'd stack them up, on the assembly, hang them on a hanger, run them through the flow station, make out their fuel card, then they'd hang them in the area of the big building called "final storage" on racks that would lead up to the charging point. Then when the reactor shut down, they open up the reactor, the discharge machine would go to a hole and take out an assembly and take it over to disassembly and put it down in there, and the charging machine would come in and put the new one in. And the machine also—I guess the charge machine would hold the upper plug. You'd put it back in and go to the next one, keep doing that. At disassembly, they'd be put on hangers and hang in vertical storage until they cooled down enough. Then the slug assemblies were put on a tipping table and they'd tip them over, pull the inner housing out. They'd pick them up and put them in buckets and put them in storage until they were cool enough. Then they'd put the buckets in a 70-ton cask and ship them to 200 area then they'd take them out and dump the buckets in the dissolver and process them. The fuel assemblies went to a different thing. They had to have a long furnace to melt them until they were about 15 feet long. So they would melt the assembly down and separate the fission product from the uranium, put the dissolved nasty stuff in those big old 50 million gallon tanks. They're still there trying to work out the—

MS: Oh yeah the waste tanks they've got.

HA: High-level waste.

MS: H and F.

HA: Yeah. That's essentially what they did. And when they got through charging it, they closed the reactor up, (unintelligible) bring the actuator tower, loaded the actuator, latch up all the control rods and start the reactor up. We had to start up the hydraulics, make sure there weren't any leaks.

MS: I'm understanding this right when you're saying that rather than taking— At the end of a cycle they'd take all the stuff out and they put the new stuff in, did they do it like one rod at a time—

HA: One at a time, yeah—one fuel assembly at a time. And the control rods, they had seven control rods in a cluster. You could take out all seven or any one that you want, and usually we'd only take out one or two or three, and keep a record on how much radiation it had. And you'd take them out based on how much burnout they had. Two of them you never, ever change. Two of the control rods are cadmium, we never, ever change those. We only changed the other five.

MS: Okay but they took one out, they would put another one back in, in that same spot at that time?

HA: At that time, right.

MS: So they didn't take everything out and then put everything in?

HA: No. Well, we may have done that once or twice when we were doing some kind of overhaul work like cleaning the reactor tank.

MS: But not usually?

HA: No. Normal thing is a discharge and a charge, discharge and a charge. We call it charge and discharge, but it actually was discharge and charge.

MS: Oh okay, right. How long would that take if you're doing it regular—

HA: If you're doing a 500 assembly charge, it'd take two or three days. They shut down, it lasts about a week.

MS: And then when it goes to disassembly, what kind of a cask or thing would it go into?

HA: When it went to disassembly, it just went into a big—sort of a big basin. The vertical section where they were just held vertically on their inner housing, the (unintelligible) thing or the outer housing if it was fuels assembly. It'd just hang in vertical storage until it's time to move them over somewhere. The fuel assemblies were actually bundled, about five per bundle and then they were put in horizontal storage. They'd take them and they cut the aluminum out, just put the fuel part in this thing and (unintelligible) it so they could move it and hang it. And they had to pick that up and put it in the 70-ton cask. They'd ship five bundles at a time. Because, you know, a fuel assembly weighed a hundred pounds. They're shipping 500 pounds of fuel, a 70-ton cask. The uranium, the natural uranium, that weighed three or four hundred pounds per assembly, as I remember. They were about a foot long and 37 inches in diameter. Depleted uranium, they were pretty dang on heavy. So they weighed several hundred pounds. But they'd put them in a bucket, could hold thirty or forty of the things. And all this was done under water.

MS: And then from there it would go to— The cask was sent to the—

HA: Separations department—

MS: Right, to go to the railroad and then into the Separations.

HA: I think they'd stay in disassembly three, four, five, six months and let that cool down, the fuel maybe longer than that.

MS: And just out of curiosity, in a given year, how much stuff are we talking about? Are we talking about like—

HA: Well, I say, depends on the charge. If you're running a natural uranium charge it lasts about two months, so you're talking about six charges in a year. So you're talking about, let's see, three and three—three fuel assemblies and three target assemblies in each cluster. And you had twenty—120— Three times nineteen that's sixty— Then there was a bunch more outside that. Say five hundred assemblies, half of them fuel and half of them targets times six, you're talking about three thousand assemblies in a year maybe. They run the californium and the tritium charges, you only do one charge of 500, 588 actually that was the number, 600. But there were 600 positions and the outer 84 were usually blankets, lithium blanket that made tritium. So you had to subtract 84 from 600 so you had what 588. No, that ain't right. Six hundred minus 84, yeah 512, 516 I guess it was, 516.

MS: Just out of curiosity, when you were working in the reactor areas, where did people eat lunch?

HA: Well in the 704 building they had a lunchroom and then there was a lunchroom in the 105 building. So the— And of course the operator guys had a staged thing because somebody had to be in the control room all the time so they couldn't all go at once.

MS: Did they actually have like a little cafeteria thing?

HA: In 704 there's a cafeteria. In the lunchroom, they had a hotplate, a refrigerator and an ice machine, I guess. Yeah, eventually they had an ice machine. Most of the guys that worked in one zero— I always called it 105, it's really one zero five. When I worked in the 105, I always took my lunch. And we had a little locker we always kept some soup and stuff in case we had to work over and we had something to eat, because the cafeteria wasn't open—I don't think it was open past four or five o'clock. It might have closed at noon. I'm not sure, but afternoon.

MS: So they pretty much just did lunch?

HA: I think they just did lunch. And if you really wanted to get fancy, they had a very nice cafeteria in the Administration building in 703-A.

MS: The cafeteria over by A and M area. That's gone now. Yeah that's been gone for actually a couple of years now.

HA: Contractors are running the cafeterias in the other buildings, I think now. (unintelligible) noise. Maybe they're putting up roofing [contractors were reproofing the garage during the interview].

MS: Yeah, I haven't heard anything lately, so I think they stopped.

HA: Might have run out of nails. He didn't bring any nail guns or nail gun so I loaned him my nail gun and I only had a thousand nails. That's not nearly enough to put up thirty sheets of plywood.

MS: I heard that when you went into the reactor area, that you actually had to surrender your badge and then they gave you another badge, which they had back behind them, and that was done largely to be sure that you had business of being there or was that—

HA: I don't recall ever doing that. I remember in the last days when they had real tight security, I don't remember ever surrendering my badge. We had to go through a badge house—

MS: Maybe surrendering is not the right word, but actually just sort of like you turned in one set of badges and then you got another badge. And then of course you surrendered that when you came back out, and they gave you the one that you gave them originally.

HA: I don't remember doing that.

MS: That's what Mr. Merz was talking about.

HA: He may be right, but I don't remember that. There was extra security, you had to go through that thing, but I don't remember giving up my identification badge. We might have had to change our health protection badge. We had a little dosimeter that you always had to wear when you were in 105 building. I just don't remember doing that. Might have but I just don't remember.

MS: Talking about that dosimeter, how often did that get changed?

HA: Depends. If you were working in a radiation zone real high, you'd change it as soon as you came out. Normally we'd change it every month, for us guys that didn't work in the 105 regularly. The guys that worked in the

105, they might have changed it more frequently, I'm not sure. If you went into a radiation zone, you also had to leave a urine sample, take a test to see if you ingested any tritium. And then we had the—hand and foot counters. When you went in and you came out, you'd have to go through those things. In some areas, you'd have to do a scan of yourself or health protection guy would do a scan. Of course you'd change your clothing and have the radiation zone clothing.

MS: What was considered the worse type of contamination you could have in a reactor area?

HA: We didn't really have much contamination in the 105 building. It was amazingly clean. I remember I went to the 200 area one time and we had to do all this dressing out, and they were serious because they had nasty stuff all over the place. We didn't. Tritium is probably the worse thing that we could get there. Unless you're chipping concrete when you might get some cobalt-60 or something, but tritium was usually the worst problem that we ever had. We didn't really have a radiation problem to speak of. If you went up in the actuator tower early in the game, they found out if you had on a nylon necktie, for example, or nylon shoes, you come down, you'd get argon—is it argon-85 or something like that, that the— Apparently, nylon has a charge on it, had stuff that adhered to it. It decayed real quickly, but when you came down, my gosh, I'm really contaminated. That's what it was, just that argon, no big deal.

MS: You said it happened when they came down from the actuator?

HA: Actuator tower, yeah. The actuator tower went up what, 120 feet, something like that? That's the number I remember. You could go up to the top where the control rod motors and the safety rod motors were. They were way up above the reactor. They had these real long extensions. They would collapse when you raise the actuator, collapse 45 feet. So that— Ventilation up there wasn't all that great, I guess. The rod— was going down into the reactor, there was a 5 pound blanket gas thing that kept the water from coming up. So if the reactor's kind of open to the atmosphere then stuff was exposed to air and then argon gas would kind of work its way up to the top, so there's always some argon up there. I guess (unintelligible).

MS: Well out of curiosity, which reactor was your favorite reactor, or do you have one?

HA: I don't really have a favorite reactor. You know you have— When you're working in K Area, K's your favorite. When you're working in C, C's your favorite. So that's the only thing I ever thought. I didn't really have a favorite. I kind of liked C when it was running because it was the most efficient.

MS: I think I asked Mr. Merz that same question and he said—I think he said he kind of liked R.

HA: Well that's here he started.

MS: That's where he started, right.

HA: He helped get it started, so I can see why he'd think R— Just got a lot of camaraderie in the guys that worked in R, started in R.

MS: Were there any basic changes like in the organization of Reactor Technology over the years that was good or bad or is it just sort of like just different?

HA: Different people. We started off, we had essentially three groups, maybe four. I guess there were four. We had the technical assistant groups, they were the people actually stationed in the reactor buildings. You had the Reactor Engineering group, the Reactor Physics group. Then there was— A couple of the guys were specialists. There were some guys that specialized in mechanical problems. There were only two or three guys in that. There were some guys that kind of specialized in chemistry, like one or two guys, but they weren't officially in any group, and so they just sort of reported to the superintendent. That organization kind of stayed like that until Westinghouse came.
When Westinghouse came, they didn't believe— Like Du Pont always had a technical group and production group. And one of the guys told me— I was heading up the group that included Reactor Tech– they had done away with Reactor Tech. What are you talking about? He said, Well, that

Westinghouse guy is making this speech to DOE about the organization, he said, Reactor Tech don't show up on that. Well they called it Reactor Engineering. Reactor Tech typically had sixty-five and maybe as many as a hundred guys in it at the most. In Rector Engineering, we had five hundred guys. And we had three big groups, and Reactor Tech was just part of one group that I had, so I tried to maintain Reactor Tech.
But their idea was that Reactor Engineering is more of what we would have called Project department under Du Pont. That was all the little things that Project department would do—make modifications and write up the paperwork and get the money. It was totally different. When Du Pont ran it— Reactor Tech structure stayed basically the same, changed people but basically it stayed the same.

MS: Why did they elect to have Reactor Technology?

HA: It was DuPont's way of doing business. In all their production plants, they have a production group and a technical group. So when they came down here, their technical group for the reactor is called Reactor Tech. They had a Separations Tech, had a Heavy Water Tech, Raw Materials tech and any other production group, I can't think of any other one, but everybody had one. So we had a whole department called Works Technical. And the general superintendent and all the technical group superintendents reported to him.

MS: And it was just a—primarily just like a safeguard or a mechanism for making sure improvements got done?

HA: Right. It was for technical assistance and for safety. And typically for Du Pont, the production group was king and the technology group kind of got trod on. And that was the way it was out here except in Reactor Tech, Reactor Tech was king. Reactor Tech said squat. They'd get down and say, How many pounds you want sir? That's what it was, basically. They had more authority than Separations Tech guys, for example, or Raw Materials Tech guys.

MS: Why do you think that was?

HA: Because of reactor safety. The reactor guys were taught to run reactors, but they didn't really understand the process until the training got a lot better. So the technical guys understood the process and understood the significance of what everyone wanted. But that's just the way it was for reactors. It was kind of different.

MS: In Separations areas, for example, they probably had people that you couldn't operate it unless you knew the process and, therefore—

HA: Yeah, we had to get trained.

MS: Separation technology didn't have that leg up that they had in Reactors. That's interesting, I'd never heard that before. Well that covers all the questions that I've got on my list here, but then there are plenty more things that I have not thought to ask that if you could think if, if you want to contribute, please, we have plenty of tape.

HA: All I want to say is that when I went to work for Du Pont, I worked in the Power department. And after several years, I'd wake up, I didn't care whether I went to work or not. It wasn't as exciting. But everyday I went to work out there it was exciting, never got bored one single day that I worked out there. It was always something new, fascinating, challenging. That was the main thing, challenging. Not much challenge in the Power department, frankly. Once when they assigned me to a group called Power Technology. But that only lasted a year-and-a-half fortunately. (laugh)

MS: And that was your first job?

HA: I went in Reactor Tech as a rookie engineer. I didn't go into Power Tech until— I've been there twenty-some years I guess, so sixty—yeah about twenty years.

MS: Well let me ask this, I know that Du Pont had a thing about they liked to shift people around.

HA: That was the neat thing. You could be a failure in Reactor Tech but an all-star in E&I or an all-star in Reactor. And so it was one great big pool of people and they tried to fit the round pegs in round holes, and did a good job. I don't think it's like that anymore but that was really neat. You can be an all-star in E&I and flunk out somewhere else.

MS: Right. It was just a matter of finding your right niche.

HA: And if a guy couldn't handle people, you put him in the Technical group where he didn't have to handle operators. Handling technical people is a lot better—a lot easier, had a higher quality of people than some of the operators we had, I guarantee you.

MS: Right, yeah. Yeah I would think that would be a difficult chore to make something like Savannah River Site run smoothly. That would be—

HA: It's kind of funny, Dana got shut down in 1957 while I was way and some of the guys, they got shifted various places. And the word got back was, We didn't realize what good management we had until it disappeared and went somewhere else. Same thing happened out here. The guys found out— The didn't realize what good management we had until a different manager came in. But Du Pont did a very good job of managing that place, they really did.

MS: I think that's true from all I've heard. Well thanks again, I appreciate it. If there's any more you want to add, you're welcome too, but–

HA: No, I can't think of anything else. I say, I try to forget all of this stuff. I remembered more than I thought I did.

MS: Well now you remembered a lot more—yeah, I thought I would be able to, so that's certainly good. Well thank you very much, I appreciate it.

HA: You're sure welcome.

END OF INTERVIEW

Oral History Interview – Robert Anderson

Robert Anderson acquired a bachelor’s degree in chemistry and mathematics from Sam Houston State University, followed by a master’s degree from Texas A & M in physical chemistry, mathematics, and electrical engineering. He began working at Savannah River Plant in 1955 and worked there until 1991. During that time, he had occasion to work at each of the five reactor areas before being made superintendent of C area. At the time of his retirement, he was superintendent of L Area.

Interviewee: Robert Anderson

Interviewer: Mark Swanson

Date of Interview: September 14, 2006

MS: This is the 14th of September, 2006, and this is an interview with Mr. Bob Anderson. And Mr. Anderson worked in the reactors at Savannah River Site, and this is a study of additional information for the reactors. Mr. Anderson, if you would for the record, if you would just state your name and affiliation with Savannah River Site.

RA: My name's Robert Anderson and I was superintendent of L Area when I retired. I was superintendent of C Area at one time, and I worked in all five reactor areas at one time or another.

MS: And when did you start working at Savannah River Site?

RA: In 1955.

MS: And you worked until—

RA: 1991.

MS: What was a typical day like for you, if you can even say there was a typical day.

RA: Well, I was in to work by 7:30 at least and I went over all the night logs and the logs prior to me coming in that morning, and then I got together a morning report and gave the morning report to my boss, which was the superintendent of the Reactor department. And after that, why I looked into the things that we had scheduled for the day, made sure that they were consistent with the safety of the plant, and then I did the other things that was necessary to run the area. And sometimes that consisted of a number of meetings, plant people. Sometimes it consisted with the area people. And also I coordinated the effort of the construction forces.

MS: When was your normal day over?

RA: Well normally— (laugh) It was over officially at 4:15, but a lot of times it was— I got home after nine o'clock at night sometimes.

MS: Since you worked in all the reactors at one point or another, which reactor was your favorite, or did you have one?

RA: Well my favorite would have to be L Area because I was— L Area was taken out of service early on and it was out of service for a number of years and then I was the superintendent that put it back, re-did the reactor completely and put it back into service. And so I had really more understanding of L Area and what was in it than the others because I saw it all put together and refurbished, and had the L Area lake built.

MS: What had to be done to L-reactor to get it going again?

RA: Well every system was reworked, all the instrumentation, all the hydraulic systems, all the electric systems. Every system in the building was reworked. The physical building itself probably would hold up for hundreds of years without deteriorating, but the equipment that went in the building had to be all reworked.

MS: So that meant you had to replace all the pipes and stuff?

RA: No, we didn't replace them but they all were inspected, and all the equipment that was found defective had to be replaced. Of course, all the machinery had to be completely overhauled and put back into service.

MS: What about in the control room? Did they have to replace all that stuff

RA: Well they didn't replace all the stuff, but they took all the systems—the instrumentation and everything, out of service and reconditioned it and—everything was checked out a system at a time. And after it was checked out for operational then it was all calibrated and then the standard operating procedures was run on all of it.

MS: How long did L-reactor run after it was set up?

RA: Not long.
(tape pause)

RA: We closed down before '88. I'm not real sure when the last time we were operating.

MS: Right. I know with L Lake for example, they said that they could only run the reactor depending on the temperature of what was going on at L Lake.

RA: Yeah, we had to maintain L Lake at a certain temperature.

MS: Yeah, if it got too hot then they couldn't run that.

RA: Well we could run, but we had to run at a reduced power. You had to run at a power that the lake—that would keep the lake temperature a certain temperature.

MS: Did they have any alligators at L Lake?

RA: That I don't know. (laughter)

MS: I heard about this big alligator they had at Par Pond.

RA: Oh yeah, they had some out there, I know. But I don't know we ever had any at L Lake or not. I'm sure by this time they do.

MS: Yeah, that's probably correct. Did you have any dealings with any of the reactors in 777?

RA: Yes I did. I was in charge of the tech— I was in Reactor Technology before I was in the Reactor department. And the guy that provided technical assistance to the reactor at 305 worked for me. So I had limited—we'd provide technical support.

MS: And that was probably true for 305-M too?

RA: 305-M is the one that I had.

MS: Oh okay right.

RA: The others I did not. That was the only one up there that I had anything to do with.

MS: What was a typical reactor operating cycle like?

RA: Well—

MS: Let's say if you were producing plutonium, rather than some of the other things.

RA: Well, we had— Normally— I don't know really what you want with that question, but the—

MS: Yeah I was thinking about like how long it would take, how many days it took to cook that sort of thing.

RA: Cycle was normally two to three months.

MS: What were like the total range of products made in the reactors at Savannah River Site? And I know they got plutonium and tritium.

RA: We made some californium and neptunium. We made plutonium-238 for space craft. We made neptunium.

MS: Yeah I heard there was some cobalt-60.

RA: Oh yeah, we made some cobalt-60 and we made—that was pretty much it. Our primary purpose was to make plutonium-239, but we made these other things as a service to different government operations and research.

MS: I know that Glenn Seaborg, who is chairman of the AEC, he really wanted to do the transplutonium stuff, neptunium and californium and all that. And do you have any good stories about that episode or— I've heard there's some to be telled. (laugh)

RA: I could tell some good stories about different things, but I thought one of the biggest one of them one time was they kept wanting to irradiate special elements. So we had a fairly new component that was radiating and yet we were supposed to make a certain amount of plutonium. So people in Washington couldn't understand why when processed, it wasn't getting that amount of plutonium out of it. Of course they had asked us and we'd put in a bunch of special assemblies in the reactor to make other products. And of course— And so they came down to Savannah River and I guess they came down (unintelligible) y'all told us, you know. And turned out that when I put up on the board what all the things that we've made and the equivalent plutonium, we made exactly the amount of plutonium that they said. But when you got a bunch of assemblies in there with neptunium in them and other things that you were radiating, why it took away from the final product. But I enjoyed it—my operations and my association with the Department of Energy and the whole thing, good time.

MS: I know that when they brought things into the reactor to be irradiated, they brought them in by truck. And then when they left, they left by railroad car.

RA: That's right.

MS: Was that just because of the weight or they were just too hot or—

RA: When they brought them in, they could bring them in with minimal shielding because they were—when they left they had to be in casks that kept them cool, which meant they were surrounded by water, which was heavy and they was also surrounded by lead because it was radiated. So they had to leave by railroad car.

MS: How many people worked in the reactor area, like say an individual reactor area, let's say K or L or something like that?

RA: Well I'd say somewhere between 250 to 300 people. Plus we had a Power department, we had an electrical department, electrical and instrument department. We had a maintenance department. We had traffic and transportation. We had the Reactor people, we had Reactor Technology people, and then we had the clerical people and patrol. So we had somewhere between 250 to 350 people.

MS: In the early days before Wackenhut was there, what was involved in actually getting into the reactor areas? Did you just have to report to a patrol desk there?

RA: You had to first of all— You have two different clearances—one that would allow you to go into the hundred areas and one of them that would allow you to go into the reactor areas, where the reactor buildings were. So you had badges had— You have clearance on the badge, so you had to go through the outer gate to get into the area. And then you had to go into another gate to get into where the reactor was. Of course, the real difference—the major difference, was when we—Wackenhut come along, well we put up two wires. Instead of having one fence around the reactor building, we had two with a lot of instrumentation in between those two fences, and that provided additional security for the reactor building. Outside of the reactor building, it might have been additional controls in the area, but there were additional fences.

MS: I heard that when Wackenhut came in they had—security got much more closely— Actually, there were security people actually in the reactor buildings. Were there any other regards in which—ways in which security changed over time?

RA: Well yeah, we had practice exercises, to which they had—some forces acted as they was the enemy trying to get into the building and then they had reactor—the regular security people who intercepted them and we had exercises like that. And they normally took place at night. Of course, when we had one of them in the area, where I stayed over, make sure I was there, because I wanted to make sure that there was nothing that they were going to do that was going to interfere with my reactor operations, the safety of the building.

MS: What would they do, like land people on the reactor buildings?

RA: They never did that. They wanted to, but that was—would have provided—could possibly have had safety implications, so we never did that.

MS: What'd they do, just land inside the compound or—

RA: Well they came in from the woods and outside portions and scale the outside fences and got into the area itself and then they were trying to get into the reactor building. The security forces then met them and kept them from getting in the reactor building itself.

MS: Yeah. How did higher power levels affect the operation of the reactors? Did it make the job of running the reactors more dangerous or did moving it to higher power levels, was that pretty much an easy transition?

RA: What do you mean power levels?

MS: The actual power that was put into the reactors to get them to produce faster?

RA: Oh yeah. As long as you run the reactors according to the procedures and the textbook standards and the textbook specifications, why they was absolutely no danger to the reactor as far as operating at higher power. Those were all standards that were set that provide a cushion for the safety and as long as you met all the requirements, it was a safe operation.

MS: How long would it take to train somebody to run a reactor?

RA: (laughter) That is a good question—because you've got different levels of people. You got people who do the building things, like run your purification, prepare the fuel to go into the reactor, take the fuel out of the reactor, put it into disassembly basins, disassemble the fuel and ship it to Separations. And then you got the people that's actually in the control room. Well, the people that's actually in the control room had to know more and be actually trained in the nuclear process and what equipment was for and safety and all the specifications and the technical standards that they had to operate with and so forth and so it'd take longer to train people to do that. And it'd depend on the background of the people that you got, which is some people— Like anywhere you go where some people are just marter than other people. (laugh) So really the training was an ongoing process. But let me state right here that the people that we had training and we run the reactors with, I didn't have any trouble sleeping at night.

MS: That's good to know. I heard that it could take up to a year to train like a regular reactor control room operator.

RA: Oh yeah. That's—I think that's pretty accurate.

MS: What about that reactor simulator? I heard they had one—by some point in the eighties they brought one in and they had it set up, and if I'm not mistaken, at 707-C, 706-C.

RA: They might have had one.

MS: I mean it was used to train operators before they got to the reactor itself, but they didn't install it until the eighties, I don't think.

RA: I'm really not familiar with that operation.

MS: Okay, yeah. Unfortunately, I don't think they've got that anymore, I think that's been—years ago that was dismantled and it's gone away. It's too bad because it would be nice to keep that. How did the measures for reactor safety change over time?

RA: When you talk about measure for reactor safety, then you— The measure really was your procedures and the technical standards and the technical specifications. The technical standards was the level at which you run the reactor in, and the technical specifications was the specification that you never wanted to see it under in any condition. So those really didn't change over time. And so the level of operations— Now in latter days after Du Pont left, there was additional training went into the operations, but I don't think that additional training provided a measurable amount of safety for the engineer. It might have gave some people peace of mind.

MS: Were you involved, in any way, in the search for neutrinos?

RA: I was in P area at one time as the—when I was at Reactor Tech as the technical support people. And we also had the support of the people— The neutrino program actually doing any of the exercises that had to do with searching for the neutrinos, I did not—was not involved. If they needed something from the Reactor department or if they needed something from Technical Support, I was there to give it to them.

MS: How did that work out?

RA: I thought it worked out real well. I was told if they needed something to get it for them and I did.

MS: Was that Dr.—was it Reines?

RA: Yeah.

MS: And I've forgotten the other guy's name, but—

RA: I have too but— In fact, I couldn't have told you Reines, but when you mentioned it—

MS: So you met him then, right?

RA: Yes.

MS: How often were they there? I guess they were mostly at P-reactor, weren't they?

RA: They was mostly at P-reactor and sometimes they came in on off-shifts and so forth when I wasn't there, so I don't really know how often they was there. And if they really needed some help with something, they'd come in on the dayshift when I was there and I'd make sure they got it. Sometimes they came in late on the dayshift and I'd get it before they left.

MS: How many people were working on that thing? How many people were brought in to work on that neutrino work?

RA: I don't believe there was ever more than three or four.

MS: And did they have a lot of equipment with them?

RA: They had quite a bit of electronics.

MS: Was that mostly in the fifties that they did work there or did they work on neutrinos all the way through?

RA: No that was later on in the fifties. Some of that was done in the sixties and seventies.

MS: Why do you think they used P-reactor? Why was that chosen over the other reactors?

RA: I don't know that. I don't know why they chose P-reactor. Now you know, C-reactor was built different than the other reactors. And it had a bigger shield on the outside of it. And that might have made a difference as far as the neutrinos experiment, why it wasn't done in C area. But I don't really know why they chose P area.

MS: Were any of the reactors— Did any of the reactors have a reputation for being better at making certain products than other reactors? I've heard different stories. Some people say, No they all were used the same. Others say that, Yeah so-and-so was better for that, slightly better. All of them could make anything they wanted, but they said that some were a little bit better than others for a certain product.

RA: Well, I don't believe that one was better than the other for any product. The only real difference in the reactors as far as the loading and the (unintelligible) tank and so forth was concerned was C-reactor and it had a bigger shield. And it might have reflected more neutrons on the outer surfaces of the reactor than the other reactors and might have been better in something, but I don't really know at this point what that was.

MS: Okay, right. Were you involved any in the HWCTR project?

RA: Never was involved in HWCTR.

MS: Okay. Why was there so much steam around there?

RA: The steam was used— You're going to have steam when you're putting that much heat in the water and you're discharging the water because—

MS: I was thinking about like in the Powerhouses and stuff like that, they got those miles of steam lines all around Savannah River Site.

RA: Oh those? Well you had steam that operated the distillation system where we—maintained the purity of the heavy water. You had— I'm at a lost right now where the steam was used, besides—

MS: Since you mentioned that distillation thing, somebody else was talking about that too, how they had a little distillation unit right there at each reactor.

RA: Each reactor had their own distillation system, which they could maintain purity of the D_2O.

MS: How big a facility was that?

RA: Well, it wasn't extremely large. It had two large towers, and each tower had different levels of plates, in it to help take off from the distillation system and that's the way they removed light water from heavy water.

MS: I assume those things are gone now?

RA: (unintelligible). And those systems, during the early times that I—had asbestos insulation. That all may be gone, I don't know.

MS: That's a possibility. That could be. We've been talking about the transplutonium program. Were you involved with that directly or was it pretty much the same kind of thing with the neutrinos where— Were there people that came down to run the transplutonium program, or was that just something that AEC would say, we want this, do this.

RA: They gave us the assemblies, and we run it just like we'd run it with any other reactor load. I don't know how much you know about the history of the operations, but we run the C Area reactor one time with a small core and it run—the highest flux that's in a reactor ever been run at. And I was the technical manager on that operation. You run it to a small core and you run it to a real high burn-up—the fuel to a real high burn-up. It became— In the later stages, those operations became a difficult charge to keep operating.

MS: When did the first computers come in?

RA: The computers came in— I would imagine they came in, in the seventies. And they were a great improvement, because you monitored the temperatures of—effluent temperature of each assembly in the reactor. And if you had to take those readings by hand, you can imagine how long it would take you to take the readings. If you took them by computer, well you could get readings in a hurry and get a printout in a hurry. So it made the operations a whole lot easier and it made you more secure at running within your limits.

MS: I heard that they were basically just counting computers at the beginning, then later on they actually got to where they could actually control a lot of the operation.

RA: Well, that's true but they wasn't just counting computers for very long, I'll tell you that. They didn't ever control to the extent that they moved the control rods.

MS: In other words, the reactors were never automated.

RA: They were never automated, that's right.

MS: So it was always—

RA: Always dependent on the operator.

MS: Yeah, the computers just sort of aided him in doing what he had to do and interpreting—

RA: And they were a great aid to him.

MS: Right. How did the Savannah River Site reactors compare with other reactors in the DOE complex, or do you know anything about that?

RA: Well, of course we had heavy water reactors. The ones that was out in Hanford was graphite reactors. So operation in the two are— Although they're reactors and you're doing the same thing, there is a great deal of difference between the operation of a graphite reactor and a heavy water reactor. I don't know a lot about the other reactors. I've been to Hanford, Washington, but it was in the later times when they were really phasing out Hanford, so I never became familiar with those reactors.

MS: How long would it take to prepare a cycle? If you wanted to start a new cycle and all this stuff had to go into the reactor, how long would it take operators to put that stuff in the tanks?

RA: Oh we put stuff in the tank in about two or three shifts, and change out the control rods if they had to be changed out, do all the things that had to be done and had to run a tank top check and then once the reactor was charged, why you had to lower the actuator and connect the actuator and make sure that it'd run. A lot of times we had—you had to run a special test after the actuator was put down to check all the control rods worked right—I mean all the safety rods worked right. As you drop them, and time the drop in of them. And of course keep the hydraulics, everything else usually buttoned up by the time you got there and if there was anything was buttoned up well then you had to get all the hydraulics on and you had to run all your start-up DPSOL's, which take a shift. And prepare to run the reactor. You always had a— We had four senior reactor people in the area. We had the area superintendent, system area superintendent and two area supervisors. One of us was always present to start the reactor up.

MS: What's the big difference between a cycle and a subcycle?

RA: Well, a subcycle, you would run— You'd have your fuel in the reactor and then you'd have targets. And you'd normally run the fuel for two subcycles. So you would change out the targets only. Then you'd run another subcycle. And then the next time you'd probably change out the fuel and the targets.

MS: So it just depends on— You wouldn't change everything until the end of that cycle, at one time?

RA: At one time, yeah. And normally you didn't—hadn't burned up enough control rods or anything that you had to replace any of them during that time, during the subcycle.

MS: How long would the control rods last?

RA: Well we normally replaced control rods every cycle. I'm talking about— We would calculate how much exposure to those control rods. So if you didn't have all of them in the reactor, so you replaced some.

MS: What about reactor leaks? I heard that was a problem at some of the reactors, like R-reactor was closed down because of leaks.

RA: It had a crack.

MS: And C-reactor had a series of small leaks or something.

RA: I think their leaks was in the shield. C Area had a cracked tank, and they made a rather extensive effort to repair that and they never repaired it, never satisfactorily repaired it.

MS: What did they do to try to repair it? Did they try to drain it and fix it or—

RA: Well, yeah they tried to go in from— Westinghouse—that was before Westinghouse came to the plant. They had the contract to repair it, but I don't think they was very successful.

MS: What about the universal sleeve housing? When did that come in

RA: Well, the universal sleeve housing was— Well it— Yes, it came in when the— We went from— Trying to think. We had Mark V-R assemblies in the reactor, containing both fuel and targets. And when we went into the later cycles where we had the fuel position and target position, why we went in— I'm not sure when that was. It's been a long time.

MS: Yeah, that's true. It has been a while, that's true. Was that done kind of early on or was it like the middle of the reactor…?

RA: Oh I imagine it was done in 1960s, late 1960s, because I believe R area was closed down in 1968, wasn't it?

MS: I think R area was closed in '64.

RA: It was closed in '64, '65 and L Area was closed down.

MS: Yeah. L was closed, I know, later in the sixties, yeah.

RA: Yeah, L Area closed down in '68.

MS: Right and then they— And that was out of commission for over ten years before they tried to open it back up again.

RA: Yeah, before we started refurbishing.

MS: Right, yeah.

RA: I was present when they shut both of them down.

MS: How many people did it take to refurbish L?

RA: A bunch. (laughter) I'm not real sure because construction—had a large construction force within the area, and of course I didn't keep up with the number of people that they had in there. I don't know how many it took. We had not only the local construction people, and the local reactor and the other support group people, but we had a large number of people in the engineering department in Wilmington that provided support too.

MS: Yeah I can imagine it probably took a lot of people. If you wouldn't mind just real briefly kind of, what were the basic functions that went on in the reactor? Without having to go into— You don't have to worry about where they were making that stuff—making the fuel and target elements in 300 Area, because we won't worry about that. But assuming they're made in the 300 Area and they come to the reactor.

RA: They come to the Reactor Department. The targets were— They came as individual slugs. And they had inner slugs and outer slugs on the targets. You had to put them together. And then they had to stack them and make the target assembly. And then they had to be hung in the right compartments. Well, the fuel assemblies come in, and they all had to be not only hung, but they all had to be flow tested to allow water to go through them. They had the orifices on them and they put orifices on them, and then they flow tested them and those orifices was calculated for the Reactor Tech people—what orifices you would have going to have while running the charge. And once the assemblies were prepared, then they had to be moved to the presentation point, and once the reactor had been discharged, then these new assemblies had to be charged in.
Of course the discharge assemblies went to the disassembly basin. They was hung and there was regulations as to how many you could have on a hanger and how far they had to be apart. We had physical restrictions to keep that so that didn't have to rely on a human being. And of course with the assemblies in the reactor disassembly basin, that water had to be run through sand filters and all of that had to be (unintelligible). We had to maintain the chemical analysis of the water and disassembly basin. The outside facilities that had provided the cooling water was run by the Power department. They had to make sure that all their equipment was ready and tested and make sure that they wasn't going to have any problem there. When you're pumping 168,000 gallons per minute through a reactor, you have to have reliable equipment to do it.

MS: Right, yeah that's a lot of water, that's true.

RA: And then we had to—before anything was started up, every instrument that had to do with controlling the reactor had to be tested. We had safety equipment, like emergency cooling water system that had to have valves and they had to be tested periodically. And all of that had to be started up. We had monitoring instruments throughout the building for safety purposes, people had to be taken care of. All then instrumentation in the control room had to be calibrated and the check-out DPSOL's had to be run on. Of course, once the reactor charged, we had to put down the actuator and check out all the control rod systems and so forth. Purification had to be started up. You run through your deionizer, where you remove the radiation and turbidity in the moderator. And you had filters there besides the deionizer. And then we would get distillation started up and get it operating. Of course, we had people in the reactor building that had to maintain all the support facilities for the people who was doing operating, and make sure they had the proper clothing and—

MS: …grass around the reactor area. I bet that was a chore.

RA: Oh they did that in one day.

MS: Was that like a big riding lawnmower or did they do it—

RA: Yeah. And that was kind of a plant thing that they brought people in to do that. It wasn't my responsibility.

MS: Yeah, that made sense. Why was R-reactor different from the other reactors?

RA: R and P reactor was alike. And it was physical— What they did and everything was the same as K and L. But the arrangement of the equipment and so forth was different in R- and P-reactor than it was the other reactors. Of course R and P was the first reactors made, and I guess somebody in their wisdom saw some improvement they could make on the design and how things operated and they got that (unintelligible).

MS: Incorporate that into the later stuff?

RA: Yeah.

MS: Because I know that C is quite a bit different from—

RA: And C is different from—

MS: The others, yeah. And that was the last one to go in. I heard too that they had—there's a big facility out there, I think it's only at R and not at the other reactors, for all the river water that would come in, it would sit there and they had this clarification plant that was supposed to be for all the silt to drop out of the water in case they had to de-silt all the water and then run it through the reactor.

RA: That's 190 building?

MS: It's in the R Area, but it's only in R and not in the others.

RA: Now there's 190 building in every one of the reactor areas. Where that it was a big pool of water and where it'd come in and would come out of it?

MS: And this is the— But this is a different—another thing that's at R-reactor that's not found in the other ones. The 190 I think is found in all of them.

RA: 190 building is in all of them. I don't know—I'm not familiar with just what you're talking about.

MS: Well it was never used. There was like— It was built because they thought they were—they had a problem with the Savannah River water, they were going to have to de-silt it and they found out it didn't make any difference. And they said, Well in that case, we'll just run it on through the heat exchangers anyway. And so they did that. And so I don't think—

RA: That's probably why I didn't know.

MS: I don't think it was ever used because—

RA: I don't think I was ever involved with it.

MS: They got final word from CMX/TNX, CMX in particular, that they didn't have to worry about the silt in Savannah River because it wasn't a problem. And the reason they did that was apparently they had a problem in the—at Hanford with the Columbia River water. It looked clear, but when they ran it through the reactors and stuff like that, they would get this gelatinous buildup that was like in all the pipes and stuff.

RA: That where it would cut down on the heat transfer.

MS: Right, right. That's what they said, well we need to—we can't have stuff going through there that's going to be a problem. And so— I think when they did R, they hadn't gotten the final word as to whether—what the status of the Savannah River water was, and they just sort of like, just in case. And with the others, they didn't build it. But it was never used, obviously just did it there. I always ask this question—Out of all the reactors at Savannah River and let's say the amount of plutonium that was produced, how much are we talking about? Are we talking about some amount that's as big as this house or like this room or—

RA: A lot.

MS: A lot.? (laugh) I've seen some figures but because they're like in, I don't know, kilograms or something like that, doesn't mean too much to me.

RA: Yeah. A lot, is all I can tell you.

MS: Yeah. That'll work. What about— Now you were with Reactor Technology at the beginning, right?

RA: Yeah.

MS: How did Reactor Technology change over time, or did it?

RA: It didn't change a lot over the time. Services in Reactor Technology provided was associated with the design of the charges, and keeping up with the product made from the charges and providing the technical assistance to the Reactor department, to run the charges, solve problems, and provide– to make sure that the reactors was running safe.

MS: Talking about that, where was the HP [Health Physics] representative in the reactor areas?

RA: HP reactor were in the building.

MS: They were in 105?

RA: They was in 105. They was on zero level, 105 level. And they— When I mentioned all these people, I'd left them out. (laugh)

MS: Well there probably weren't too many at each reactor area, but I don't know.

RA: Well, there was some on every shift. Every shift was run by a shift supervisor in Reactor. HP and their bigger bosses was not in the area.

MS: Right. Well I have heard— I've heard it said that there was a—that by the end of the life of the reactors at Savannah River that there was a—that if they had to do it over again they might have reversed the flow of the reactors, the cooling water in the reactors and everything. It went from top to bottom, right?

RA: Yeah.

MS: And they said that later on, it would have been a better safety feature had it gone from bottom to top.

RA: I don't know about that. I wasn't involved in any study of that fashion.

MS: And it said, it's one of those things that was perfectly adequate for doing what it had to do, but they said in case you had an accident and you had some kind of like boiling situation going on in the reactor, that it'd be better for the water to go this way, because that would be the way that the steam would tend to go up anyway.

RA: I don't know.

MS: By that point, it was too late to change it so—

RA: I don't know about that. That would have— I don't know what that would do, but the temperature coefficients within the reactor itself, but all charges was designed to have negative temperature and moderator coefficients so if you had an accident, why as the temperature would go up it would shut the reactor down.

MS: Right. What about the size of the stacks and stuff like that? Was that stuff that was added to later on?

RA: The stacks was the same all the time I was at the reactor.

MS: Yeah I heard they added something to it just in case for like—for possible earthquake—

RA: Oh, they might have made a bunch of braces on it. I'm sure that they did that in later times, put braces on the stacks to make it stronger for earthquakes. Also when we started out, we didn't have all the filtration equipment that was up in the area where the stacks was. In case there was an accident, all those big filters was put on the roof of the stack area. And they were all removed—could be removed by crane and transported out of the area on flatcars, railroad.

MS: Oh okay, right. What about— Yeah as far— We talked about Reactor Technology, but as far as Reactor Operations go, how did that change, the organization of that? How did that change over time, or did it?

RA: Well it stayed pretty constant all the time I was there. I think it was fairly constant. The different— There might have been a different number of reactor operators and sometime along the way one way or the other, I don't know, might have been one added each shift (unintelligible) it remained fairly constant.

MS: Right. Well this is kind of like unusual question, but what did people do for lunch out there?

RA: Well we had a cafeteria in the area.

MS: Where was that?

RA: It was in 704 building, over in administrative building. And also there was a lot of people brought their own lunch and we had a lunchroom was in the reactor building. And it was with microwaves and—

MS: Not in the early days though.

RA: Not in the early days, no. And stove and refrigerator, where they could store their lunch. A lot of people brought their own lunch.

MS: Now they didn't do breakfast and dinner and stuff like that?

RA: They didn't do what?

MS: They didn't do breakfast and dinner over there, did they—at the cafeteria?

RA: No. I think maybe in the early days they did.

MS: Okay.

RA: I think in the early days they did breakfast. I know they did in some areas.

MS: Right. That kind of makes sense. They probably would have had bigger shifts that had early days, at night and off times and things like that.

RA: I got called in sometime and I know I ate in the cafeteria for breakfast and that's where I learned to eat grits. (laugh)

MS: Okay. If you don't mind me asking, where were you born?

RA: Texas. We eat potatoes in Texas for breakfast.

MS: I didn't know that. I figured that grits made it all the way to Texas too.

RA: Well there are some grits down in Texas. When we came here in the fifties they was—people pretty well ate potatoes in Texas.

MS: That's pretty good. I think that covers all the basic— If you don't mind, since we talked about where you're from in Texas, if you wouldn't mind just going into very briefly where you went to school.

RA: I got my bachelor's degree from Sam Houston State University, and I got my master's degree from Texas A&M.

MS: Okay. And what was that in, if you don't mind my asking?

RA: I got my bachelor's degree in chemistry and mathematics, and I got my master's degree in physical chemistry and mathematics and electrical engineering.

MS: I think you were qualified for your post then. And that covers all the basic questions that I've got, but if there's anything else that you want to bring up that I have failed to mention, we got plenty of—

RA: I think we've covered about all—

MS: We got more tape if you want.

RA: I don't know how they're going to use this information to decommission the reactors. (laugh)

MS: Well it's one of those things that it's part of what we're going to be doing. I think that we want to interview a number of people, not only in Reactor Technology, but in other aspects of the reactor area. And also too, we want to go through and do a final photography session at the reactors, and actually go through and make a final collection of artifacts. I mean there's still some that are in the reactor that are—that can be gotten that are not radioactive. They're thinking about creating some kind of a museum. There's this point of that, I think they want to— Right now the artifacts they've been collecting all over the years for this project, they've got in 105-C. And so that's not going to be the official home, though. I think they're— They're thinking of all kinds of ideas about what they're going to do with that so—

RA: I think the two cleanest reactor areas out there is L Area and K Area.

MS: Probably. And I think there's a—they want to— Well I can go and shut this off, we can talk about that— Anyway thanks again for the interview, I appreciate it, and I'll go ahead and turn this thing off.

END OF INTERVIEW

Oral History Interview – James Boswell

James Boswell was born in 1929 in Kentucky.* He later attended the University of Kentucky and it was there that he first heard of the Savannah River Plant. After being accepted for a position there, he came to work at the plant in June of 1953. After a brief stint in the 400 area, he spent the first 10 years of his career in the Reactor Technology section of the Works Technical Department. The following 26 years were served in various positions within the Technical Division.

Boswell served under A. A. Johnson, "A-Square," the fabled chief of Reactor Technology in the 1950s and early 1960s. Later, Boswell conducted research on the various fuel and target assemblies that were created at the plant. Boswell is probably more knowledgeable about the SRS reactors and their products than any other person alive today.

*Personal information has been removed from the transcription

Interviewee: Jim Boswell

Interviewer: Mark Swanson, Historian with New South Associates

Date of Interview: September 21, 1999

M. Swanson: This is an interview with Jim Boswell conducted by Mark Swanson, Historian with New South Associates, being conducted on the 21st of September, 1999. If you would, state your age and date of birth.

J. Boswell: I'm seventy years old.*

MS: And your relationship to Savannah River Site?

JB: Well I came to work at the Savannah River Site in June of 1953 and spent the first ten years in the Reactor Technology Section of the Works Technical Department, and the last twenty-six years in the Technical Division in various positions.

MS: Okay. The next series of questions deal with pre-acquisition area residents, and I guess you wouldn't want to say anything about that stuff. You weren't here before the—

JB: No, I wasn't here before—no.

MS: Okay.

JB: I was here before the first reactor started up, but not prior to the building of the plant.

MS: Okay, right. How did you find out about the project?

JB: One of my classmates at the University of Louisville, Edward Green, came to work at the Savannah River Plant, and he was a year ahead of me. And when he— He was a classmate and then I went into the army for a year, he went ahead and graduated, and so I graduated a year after he did. But he came back to Louisville on a vacation and I talked to him and he told

*Personal information has been removed from the transcription

me how great Savannah River was and it just sounded like a great place to work so I decided to interview the Du Pont Company and decided to accept it, even though I'd gotten several offers that paid more than Savannah River, this just looked more interesting.

MS: And where did you come from when you came here?

JB: Louisville, Kentucky.

MS: Louisville directly, okay. Was work at the plant considered attractive to those from outside the Southeast?

JB: I really can't say.

MS: (unintelligible) consider Louisville outside the Southeast? (laugh)

JB: Yeah, well and the only way I found out about it was from my classmate, my earlier classmate that had come to work here.

MS: Okay. When you first moved here, were you directed or encouraged to live in any particular place, let's say Aiken versus Augusta?

JB: No. In fact, we lived in North Augusta when I first came here. We lived in North Augusta, but then we saw that most of our friends that we had made were living in Aiken so we decided to move to Aiken.

MS: All right, yeah. How would you characterize local opinion about your arrival and local attitudes towards employees from other areas?

JB: Well it was a small town and I think a lot of the people somewhat resented people coming in from outside.

MS: Were you a Du Pont employee prior to coming to Savannah River Plant?

JB: No.

MS: And had you had any previous experience working at an industrial plant?

JB: No, only while I was in college. I had numerous jobs part time through the summer and part time even while I was going to college because I paid for three years of my five-year college education. Manufacturing companies like Castlewood Manufacturing Company made tables and things like that –I worked there and then I worked for Lamb Hardwood Flooring Company as a lathe operator. We made cast iron wheels to go on industrial skids. And then I worked for the University of Louisville, industrial research department where there was a big fish oil project there where they were experimenting with menhaden fish from the Atlantic Coast and taking the oil out of them and using what was left as fertilizer and taking the scales off and making something called Pearlight out of it, so it was a big job. Part of my job was to try to figure out how to catch the fish electronically.

MS: Okay. I didn't know you could do that. (laugh) When you came to the Aiken area, did you— You weren't married or were married?

JB: Yes, I was married. I graduated from the University of Louisville on June 8th, got married on June 12th and came to work for Savannah River on June 25th, so it was a pretty full June. (laugh)

MS: Yeah, sounds like it, yeah. When y'all moved here, how did you view the new communities that you were moving into? What was your initial impression of this place?

JB: Well of course they built a lot of housing just for people coming in and the housing was fairly inexpensive. A lot of people were buying houses with no down payment. We didn't do that, but a lot of people were doing that. I think it was favorable.

MS: Okay. Was it difficult to become part of the new community here?

JB: Well, when I— When I came down in June, my wife hadn't graduated from the University of Louisville, and so she came down a few months—two-and-a-half months later I guess. And I stayed in a—what you'd now call a boarding house, I suppose, with really old Aikenite people. And so I met quite a few of the old Aikenites that way and they were fairly friendly.

MS: Okay. What were living conditions like in Aiken, or for that matter in North Augusta during the construction era?

JB: Well it was difficult to get a haircut. There were long lines at the barber-shops because there were—I don't—I think 38,000 construction workers in the whole area. And of course that was a huge number of people to come into some fairly small towns. The grocery stores were crowded. Everything was crowded, seemed to me like.

MS: Were there trailer parks and dormitories?

JB: Oh yeah, there was a trailer park, Robbins Trailer Park here in Aiken that had a thousand trailers init. It was just a huge trailer park, construction workers.

MS: Okay. Were there many transient construction employees, or were most of them residents of surrounding areas?

JB: Oh no, most of them were transient, I believe. The local population were mostly cotton farmers and that sort of thing. They just didn't have the skills that it took to— I think the most interesting construction workers were the midgets they used to crawl inside the pipes to weld the pipes from the in-side.

MS: Oh yeah right, where did they get them from?

JB: I don't know.

MS: Were they Du Ponters, I guess, temporarily or whoever?

JB: Well they worked for Du Pont construction, yes.

MS: (unintelligible) wonder how you advertise for that. (laugh)

JB: I don't know.

MS: What were food supplies like? Were there any shortages?

JB: No I didn't— We didn't experience any shortages.

MS: Okay. What about traffic?

JB: A lot of traffic to and from the plant, very heavy.

MS: Speaking of traffic, especially in the early days, they've got a series of questions here about carpooling. Were you ever involved in a carpool?

JB: Oh yes.

MS: Was that urged on you, or was that left up to the individual as to whether you were going to participate?

JB: Well they suggested that we carpool, which was a good idea. We only had one car, and when my wife first came down she hadn't started working at the plant and so she needed a car while I was working so it worked out very well.

MS: Okay.

JB: I always enjoyed carpools anyway. I never liked to drive that much. I'd (unintelligible) rather have somebody else driving.

MS: All right. And most of the carpools they had, was it arranged so that every other person would—let's say if you had five people they would—like somebody'd take a Monday, Tuesday and just rotate it?

JB: Yeah. It was the same day, in our carpools anyway.

MS: Okay. Did anybody ever pay for a carpool?

JB: Well not— I don't know whether they did or not, not—

MS: Not in your carpool?

JB: Not in my carpool, no, any of my carpools.

MS: Were construction workers treated differently by local residents than the incoming operations staff?

JB: I really don't know. I wouldn't be surprised if they weren't, though.

MS: Yeah. Construction occurred when the South was segregated. How did this affect construction, or for that matter, how did that affect early DuPont operations in general?

JB: Well blacks just weren't—didn't operate anything. They were used as janitors and that sort of thing.

MS: When did that change?

JB: Well as the civil rights movement came through, of course, that changed. This was the government-owned operation so we had to follow whatever the government regulations were with respect to that.

MS: Right. Was there much crime during construction?

JB: I don't know. I don't remember.

MS: Yeah. What measures did DuPont, or for that matter, the AEC do to alleviate any of the construction problems, shortages or crowding?

JB: Well of course they—they built a lot of houses. I mean whole communities were built by the government, I mean financed by the government. I don't exactly know how that all worked out but it was Crosland Park and a number of communities like that in Aiken that—where there were just hundreds of houses built, and then you could buy the houses for very little price. For example, when we left Crosland Park in 1958, we could have brought the house that we were living in for $6500, and it was a three-bedroom house.

MS: It's too bad you can't have that today.

JB: Yeah.

MS: What about— Did superiors solicit contributions and suggestions from employees in those early days, especially during construction?

JB: Well only for the United Way as I recall, or whatever was equivalent to that. Yes, they did solicit money for that, but that was all.

MS: In those early days, how many hours a day did you work when you first came to work here at Du Pont?

JB: Well it was normally eight hours but oftentimes I'd work sixteen hours. One time I worked twenty-four hours, depending upon what kind of test we were running and that sort of thing. But I did a fair amount of overtime and wasn't paid for it, never paid for overtime.

MS: How were relations between labor and management?

JB: Always pretty good. We never had a union, so it—

MS: Were there any serious efforts to unionize?

JB: Yes. Yes there were, several times.

MS: How often, if at all, did you see foremen and engineers using models instead of blueprints?

JB: Quite extensively. In fact I— We used to use the models quite a bit, especially the piping models and things like that that are the 200 areas. I never got involved in that, but I know they had extensive piping models and—rather than—

MS: Was that from the earliest days?

JB: Yes, from the earliest days, yes.

MS: I've had people that have maintained that in the early days they didn't have the models, they only used blueprints, but then they saw models later, but—

JB: As far as I know, I remember a model of the reactor that had a cross-section in it and it was made out of—I think it was made out of stainless steel. I mean, it was a beautiful model. I don't know whether it still exists or not. But it was a model that was made—that I remember sitting around while they were still working on the reactors.

MS: So you were talking about there were a lot of models (unintelligible)?

JB: Yes, a lot of models.

MS: And they had models of the reactors from the early days?

JB: Yes, from the early days.

MS: It's too bad some of those aren't still around. Did you have anything to do with construction after the initial period?

JB: Not construction, but— Not construction, as such, but improvements. I had a lot to do with that.

MS: Okay. Yeah, we'll get to those in a little bit. Let's see, What did you do in your off hours during those early days?

JB: We had friends that had boats and we'd go to Clarks Hill, now Lake Thurman and that sort of thing. We went to— It wasn't very far to Florida, so we used to drive to Florida once in a while, to North Carolina to Lake Toxaway, places like that. We didn't have television when I first moved down here. They had to put the television towers up so—

MS: When did they get TV around here?

JB: Oh it must have been 1954 or '55, somewhere around, about that time.

MS: Where— (unintelligible) come out of Augusta?

JB: Yeah.

MS: Okay. Do you recall the big fire they had in Aiken? It was a drugstore fire or something?

JB: Yeah, ten people got killed. And that happened just before I came down here. I mean it was still demolished down there in that part of town when I first came, but it occurred— It must have occurred just a month or so before I came here.

MS: Do you remember anything about that, I mean, remember hearing about that?

JB: Oh yes. It was a gas explosion, as I recall.

MS: Okay. And did SRP loan a bunch of like material support to Aiken during that period, after the blast?

JB: I don't know.

MS: Okay. I know we've already gone into this but if you would just for the record state again when you first started working at Savannah River Plant?

JB: It was June 25, 1953.

MS: Were there any reasons for not wanting to work here?

JB: Well I think a lot of people probably wondered whether it was the right thing to do to make materials for atomic weapons and that crossed my mind, but the longer I worked and later in my career I began to believe that the very fact that we did that and had these atomic weapons has kept peace in the world rather than promoting war because people are afraid now to start a war because of atomic weapons, I think.

MS: Yeah. How much did you know about what the Savannah River Plant produced when you first started working here?

JB: Almost nothing. In fact, for about a month, I was in the 400 area where they made heavy water and my boss there said, You just stick to your job, don't even ask what the people working next to you are doing. I mean, it was just that compartmentalized at that time. And that was for security reasons. Of course I had later bosses said, Find out everything you can about everything around you everywhere that's going on because you're going to be more useful that way. So it—

MS: I guess it depended on how high up you were.

JB: I guess.

MS: Yeah. Was the mission of the plant a reason to work there or not to work there, at least in the beginning?

JB: I guess it was a reason to work here. I've never really thought about it, but I guess that's—was probably a reason to work here.

MS: What was your first job assignment here?

JB: When I first came down, as I said, I was in the 400 area, the heavy water production area. And I counted leakage from pump seals, drops of water. And it was a smelly place down there because of the H2S they used in the process, hot and there were gnats, and if I'd had enough money to quit and go someplace else, I would have done it at that time. But that soon changed because I was only there for about a month then went into the Reactor Technology, where I was in an air conditioned room and—(laugh) no smell, no H2S smell.

MS: Out of curiosity, How much air conditioning was there in the early days?

JB: Well there wasn't any in the buildings that—in the buildings out in the 400 area where I was, but the reactor buildings were all air conditioned, and so I actually was in the Reactor Building when I went into Reactor Technology.

MS: So in other words, were the reactors themselves—those reactor buildings, they were air conditioned?

JB: Oh yes. Now the air going through the— The air going through the reactor room itself wasn't air conditioned, I don't believe, because it was like 100,000 cubic feet a minute, so it wasn't air conditioned, but the offices all were.

MS: Okay. The next question deals with how many positions you've had and yeah if you want— You don't have to give me everything but—

JB: Well as I said when I first came down, I was in the Heavy Water Technology Section in the 400 area. And then in September— That was in June. And then in September in 1953 I went into the Reactor Technology Section. And in 1959 became a process supervisor, in 1962 a senior supervisor. In 1963, I came to the Savannah River Laboratory and into the Nuclear Materials Division for a short time and in 1964 into the Reactor Engineering Division. In 1965, I became a research supervisor of the Advanced Planning Group. In 1968, I went into the Advanced Operational Planning Division. In 1969, became research manager of the Reactor Engineering Division, in 1974 a research manager of the Advanced Operational Planning Division. In 1977, director of the Nuclear Reactor Technology Section. And then in 1981 to '82 I was on special assignment as technical advisor to the director of the Office of Nuclear Materials Production, U.S. Department of Energy in Germantown, Maryland. In 1982, I came back as director of the Nuclear Materials Production Support Group, and then finally ended my career as a principal consultant of AED planning, but I had two planning groups reporting to me at that time.

MS: Okay. How did you change positions? I think the— What we're getting out of this question is like, What was the process when you changed from one position to another? Was it something that you initiated or helped initiate, or was it something that was like pushed on to you?

JB: No it was all—came from above. I mean, I didn't initiate any (laugh) move. I never asked for a different position.

MS: Oh okay. What pressures were there to your job, if any, like production quotas or procedure you had to follow or information limitations?

JB: No, there weren't very many— There weren't very many restrictions or anything like that. There was a lot of pressure because, for a good bit of my career, I was responsible for reactor safety and things like that, which you take pretty seriously. And of course, one of my main responsibilities was trying to get more products and diversified products out of the reactor, so that I took seriously, obviously.

MS: What did you see as your most important responsibilities in your job, or jobs?

JB: Probably making sure that the people who worked for me got a fair shake and got paid for what they were worth and got promoted when they should have gotten promoted and things like that, spent an awful lot of time on that. I always figured if you took care of the people, they'd take care of the work.

MS: Okay. What did you think about Du Pont's and then Westinghouse's management of the plant while you worked there?

JB: I never worked for Westinghouse.

MS: Okay. You can talk about that, though, if you want to, just from what you (unintelligible).

JB: I thought Du Pont management was great. I mean, there were a very fine bunch of people, people like Dale Babcock, who was one of the inventors, with Carothers, of nylon, held a lot for patents on nylon, just very fine people. Some of the finest people I ever met came down from Wilmington. Now he never left Wilmington, he was always in Wilmington, but I had a lot of contact with him. And other people like that, that I just thought they were great.

MS: Westinghouse or—

JB: As I said, I never worked for Westinghouse, but from what my friends have told me that did work for Westinghouse, there was a huge difference.

Westinghouse just didn't have the same feeling toward people, I think, that most of the Du Pont had. Most of Du Pont, now every— Some people were just absolutely career conscious and didn't care for the people, but the majority of the people that I worked with were really very people oriented. I think that's one of the reasons why we never had a labor union in the plant, was the way that management treated people. For example—I'll give you an example. The plant manger never had a parking spot at Du Pont. I mean, (laugh) he came in. If he wanted to get up close to the 703 building, he had to come early. Soon as Westinghouse came in, why the head of Westinghouse had a designated parking place and all that sort of thing, and that didn't go over with the people at all well.

MS: Right.

JB: That's the kind of differences that— It was just a string of differences like that, that delineated, I think, Du Pont management from Westinghouse management.

MS: Right. Did you win any awards for safety or production suggestions or for any other actions or contributions?

JB: No, it was all part of my job. I got— Well, I got Du Pont bonuses regularly, but I mean if you want to call that a reward, I got— I started getting the bonuses early as you could. And we're not supposed to talk about that sort of thing.

MS: Oh okay. (laugh) What was the attitude toward safety at the plant among employees and managers?

JB: Safety was a condition of employment, period.

MS: Did attitude toward safety change through time?

JB: No. It was always, from the very beginning, it was—safety came first. DuPont wouldn't do a job that they couldn't do safely.

MS: What were the most important measures that were in place to insure your health protection while you worked at Savannah River Plant?

JB: Well it had a Health Protection Group that surveyed all the time to make sure that we weren't exposed to radiation and that sort of thing. And then, of course, they had the large medical department there that took care of that sort of thing too.

MS: Right. What was the attitude toward security at the plant, and how did that change over time?

JB: I don't think that ever changed either. It was there from the beginning and as far as Du Pont was concerned, why it was almost as important as safety.

MS: What about when Wackenhut took over? Was there any differences there?

JB: I don't really think so. I mean, I don't—I wasn't that close to it but— When Wackenhut took over I was in the Planning Business, so I really wasn't that involved in that sort of thing.

MS: I'd heard that one of the reasons that Wackenhut took over was that there was a greater threat of terrorist activity in the early eighties and Du Pont had decided they would not be responsible for shooting somebody—

JB: That's exactly right. And that was—

MS: —so they wanted to turn that over to somebody else.

JB: That was the vice president, Jerry Curtain, of Du Pont, that made that decision.

MS: Okay. How did contractors like Du Pont encourage safety and security as well as employee adherence to those guidelines?

JB: Well, for example on security, when I was in Reactor Technology, A-Squared Johnson was the superintendent. And if you forgot your badge, you had to go home and get it. I mean, he wouldn't let anybody come in that didn't have a badge. I think he'd fire you if you came in without a badge, tried to get in. He just said, You go home and get it. So— And that was typical, and if you got a security infraction, you had to write an essay on how that wouldn't (laugh)—how that wouldn't happen again, and I saw some pretty funny essays. And he told one guy, he said, You want to make light of this, you will work someplace else. (laugh)

MS: Okay. (laugh) I wonder how long an essay they had to write. (laugh)

JB: Well it was usually a page long. If you had a security infraction, you had to call the superintendent up and explain why you had it and what you were going to do to keep from ever having another one, besides writing the essay. I mean they were— He was tough on you. And safety was the same way. I mean you just— (laugh) You just better not hurt yourself.

MS: Right. Did you do any work at the plant prior to getting your security clearance?

JB: No. I had it when I came down.

MS: Did any security issues or concerns affect your life offsite, like social relations or travel or (unintelligible)?

JB: Well not really, but I didn't have enough money to go to any countries that (laugh)—where you have safety—I mean security problems.

MS: Was travel restricted if you worked here?

JB: Of course. Even until the time I left Du Pont, we had to report if we were going to visit someplace like Russia. I did go to Russia, so I had to report that before I went.

MS: When was that?

JB: I don't know, about six years ago.

MS: Oh okay. What major changes took place in the areas where you worked during your time there? Any that really stand out in your mind?

JB: Major changes that took place. Well they painted the offices colors instead of that battleship gray that everything was to begin with.

MS: When did they do that?

JB: Well just over a period of time they started painting green and light green and that sort of thing. A fellow by the name of Joe Tinkert was head of the Process Section in Wilmington when the plant was first built. And he said, We're going to be austere about this. Everything—all the offices are going to be painted battleship gray because that's the cheapest paint you can buy. And we're not going to waste the government's money. That was one thing that Du Pont was very concerned about, was wasting the government's money.

MS: Were there any major incidents in the areas that you worked in that you can recall?

JB: Well there were the thirty major incidents, or considered major incidents, out of the seven thousand incidents that were written up about the reactors, and they were categorized as to the most serious on down, but still none of them ever jeopardized people's health.

MS: Right.

JB: None of them were serious enough to really hurt anybody.

MS: We've already talked about carpools. Let's see, how did plant operations and management change when Du Pont left and Westinghouse took over?

JB: I don't know. I mean, no more than I've already told you because I wasn't—I never worked at Westinghouse. In fact, they offered me several opportunities to work for them even as a consultant and I wouldn't even do that.

MS: Okay. How did newer environmental legislation change operations or did it?

JB: Oh yes, it did. We had the— When the plant first started up, why the effluent water from the reactors just went through the existing streams on the plant site to the river. And people worry about heating the river up. When we looked at it from a technical point of view, the building at Clarks Hill Dam lowered the river temperature 3 degrees centigrade. And that was built just before the plant came. When all the reactors were operating and the effluent water was going into the river, it'd only raise the river water temperature something less than a degree. So I always said, We ought to operate the reactors to bring the environment back up to bring the river temperature back up to what its normal level would have been. (laugh)

MS: Yeah that's a good point.

JB: But then of course when the environmentalists came through they said, Well you're killing the alligators, so you've got— They built the L-Reactor cooling pond to keep from dumping the water directly in. And then the K-Reactor cooling tower—all that was a foolish waste of government money. The government also wanted sprinklers put in the reactor buildings, and Du Pont resisted that to the time they left. They said, It's foolish to put sprinklers into a concrete building, and that's a waste of government money.

MS: Right. The next series of questions deal with socioeconomic issues that are relatively general. How has the plant location in the CSRA impacted the economy in the area?

JB: Probably had a very positive impact on the economy because even in the early days, I think the payroll was like fifty million dollars. I mean when the plant first started up it was big.

MS: How has it impacted lifestyles in the area?

JB: Well, a lot of people who were cotton pickers, I guess, got pretty good jobs at the plant. So they probably— Their level of—standard of living rose dramatically. And if you look around Aiken, for example, just look at the cars, I mean there are a lot of Cadillacs and Mercedes and Lincolns, and even I've seen a couple of Rolls Royces and things like that you just don't see around in a lot of places, a lot of little towns. So the economy is very good here, and has been ever since the plant came in, I think.

MS: What about— Did the plant cause any swings in the area's economy, during boom and bust times out at the plant?

JB: Yeah when they were laying off people. I never noticed any, except there were houses on the market then, but outside of that, I never noticed any.

MS: What about housing shortages?

JB: Severe housing shortages at the beginning, but then that didn't last very long, just by 1955 or so I think most of that was over.

MS: What was done by communities and residents to provide places for employees and—well during that boom period? In other words, did people rent out rooms in their houses or—

JB: I think they did—

MS: —spaces for trailers and things like that?

JB: I guess they did. I really don't know, don't remember.

MS: How has education been impacted by the plant's location here?

JB: I really don't know.

MS: What about local politics? Has that changed any since the plant has been located here?

JB: Well yeah, I mean we've got a former plant employee as mayor. And then a lot of the people that are associated with the plant have been on the city council, black and white. Willard Hightower, Lessie Price, they're black, and they've worked at the plant, city council members. So it has affected the politics.

MS: What about the public participation in issues like nuclear power and the environment? Has that been on the increase?

JB: I don't know that there's been much of a public issue over nuclear power. South Carolina must be 50 percent nuclear, I guess, commercial power at least I guess it's that much. Environmental, I don't—I'm not aware of any particular impact.

MS: Okay. What about community services such as utilities and roads, police, fire protection? How have all of these been impacted?

JB: I don't know, really don't. Except if it was a big fire some place, I'm sure that the Savannah River would send fire trucks if it was close enough to help. I think they've done that previously.

MS: Right. How has entertainment changed? What about the Operations Recreation Association, ORA?

JB: Yeah.

MS: Does that— Was that pretty popular back in the fifties?

JB: It was, yes.

MS: The next series of questions are broad topics that deal with—for those who worked at the plant over long periods of time, which is just about everybody I've interviewed. Is there anything that stands out in your mind as the greatest achievement at the plant during its history?

JB: Well yes. I think the contribution that the plant people made to commercial reactor safety, in my opinion, was the greatest impact. A lot of the people that were originally in the Reactor Technology section were physicists, and they went on to the—well the old AEC and went into the safety aspects of the AEC. So a lot of the Du Pont safety principles about reactor operation, that sort of thing, went directly into the commercial industry through that. I think that's— I think that's one of the reasons why the commercial reactors in the U.S. have been as safe as they have been is the direct— For example, when they had that partial meltdown at Three Mile Island, Harold Denton was the guy that took President Carter through the facility. He was an old Reactor Technology buddy of ours. I mean, we worked with him. So I think that was number one. Number two was the—I think was the diversity of the production ability of the Savannah River reactors. We were able to— We were able to increase the flux level by a factor of 100 to make isotopes that couldn't have been made any other way, and the reactors were large enough that you could make significant quantifies of them, whereas most of the reactors that made isotopes were small and you couldn't make very much. The high-flux operation, achieving the highest flux, to my knowledge, ever achieved in a reactor up to that time. Now I haven't kept up with it since then, so I don't know whether it's ever been—the flux level's ever gotten higher in any reactor than that since then but up to that time, that was the highest flux ever achieved in any reactor regardless of its size. To me, those were the most significant achievements. Again, reactor safety, I think, is number one, because we've never had a major nuclear incident in the United States. Three Mile Island didn't hurt anybody.

MS: Okay. Does anything stand out as the greatest problem?

JB: Well there were a lot of problems in the early days and first that's what made the work interesting, but I don't know that any single one set out as a lot larger than the other problems.

MS: Right. Nothing that wasn't solvable or—

JB: No, we solved. We were able to solve most of the problems— We had a lot of them. For example, the moderator hot spot limited the reactor power for a long time. We didn't want the moderator to boil because that would give us reactivity transients. We had thermocouples in the moderator and they were eighth of an inch in diameter stainless steel clad. And it took us a couple of years to solve that problem, but the temperatures really weren't as high as the thermocouples were reading because gamma heating of the stainless steel caused the thermocouples to read about—some of them as much as 8 degrees too high, 8 degrees centigrade too high. It just took a long time to solve that problem, but that was one of the problems that kept us from going to this higher power as we would have in the earlier days.

MS: Okay. Do you feel that the plant operated more effectively during some periods than others?

JB: Oh there's no doubt about it.

MS: What periods would you say it operated most effectively?

JB: You want to turn your thing off there for a second and I can tell you?

MS: Um-hm.

(tape pause)

JB: In the early days, there were a lot of spurious reactor scrams due to the antiquated instrumentation that we had on the reactors then. And as we solved those problems, the efficiency went up. In the early 1960s, 1961 through '63, the efficiency was higher than it was earlier. And then again in the early 1967 it was high, it was over 80 percent, 83 percent. Then again in '72 and '73—'73 was about as high as it ever got. And then it started going down again after that to where it was very low. Nineteen eighty eight, for example, it was less than 50 percent, and a lot of that was because of the artificial imposed reactor power limits that were imposed on us by the government.

MS: Did that—this sort of like government-imposed limitations of reactors, did that start up in the seventies?

JB: I don't think it started— I don't recall it starting that soon because the efficiency was pretty good in the early seventies.

MS: Maybe like later in the seventies or— I know they had some concern about—

JB: Yeah, in the later seventies, that's right, from '75 on down, why it was—it deteriorated.

MS: Okay. Can you describe your feelings about your work or the aspect of your work that you identify most closely with, whether it's the plant itself, the contractor you worked with or the government, the mission?

JB: Well I always enjoyed my work. I always looked forward to going to work. Because we always had new challenges, it seemed like. I was always in a position where we had new things coming along to try to solve—new problems to try to solve or new things to try to make. I always enjoyed my relationship with Du Pont and most of the time with the government. I enjoyed my stay in Washington very much. The people up there were very nice, although there was always an animosity between the Washington people who controlled the money and the plant people down here. They tried to keep secrets from each other. Not secrets exactly, but they tried to keep their strategy from each other it seemed like. They weren't very cooperative. Whereas a different situation existed between Du Pont Wilmington management and the plant management down here, I always thought. I always thought it was a very close relationship.

MS: Right. We'll get into some of those in just a little bit. The next series of questions deal with the laboratory and research at the laboratory. What is the purpose, as you see it, of the Savannah River Laboratory?

JB: Well it was— The greatest purpose, I think, was to insure that the reactors operated safely and that the Separation facilities operated safely, the whole plant operated safely. That was number one. Number two is to improve the operation of both the reactors and the separation facilities, and I think they did that very well. The Technical Division was instrumental in developing all the extended fuel and target assemblies that allowed us to go to the very high power that we were able to achieve. The reactors were designed for 378 megawatts and we finally got up—the peak power was over 2900 megawatts in one reactor, and that was a direct result of the fuel and target assemblies developed by the laboratory.

MS: Was your research usually related to specific problems at the plant or to larger issues in nuclear physics?

JB: Both.

MS: Okay. Can you give a percentage for the mix?

JB: No, I don't think I can.

MS: Okay. What were the most valuable or rewarding research opportunities made available to you because of your job at the laboratory?

JB: Well I think perhaps the one that stands out the most is I was given free reign to look at all the different kinds of fuel and target assemblies that we could think of that could be built, and I was supported on anything we wanted to do, it seemed like, any new assembly that we wanted to develop I got support for. And obviously that had to be very rewarding. Because it was the fuel and target assemblies that allowed us to go to the higher powers and to make the variety of radioisotopes that we made.

MS: What do you feel was the most valuable research that you've contributed to or were involved in during your time at Savannah River Laboratory?

JB: Well again, I think it was the development of fuel and target assemblies or the various isotopes that we made.

MS: Did security issues impact the value of your research, or do you think that security issues made your research less valuable because it placed limits on dissemination?

JB: I don't think it really hurt a whole lot. I don't remember it really impacting anything very much.

MS: How about within the scientific community in general?

JB: Again, I don't think it really hurt a whole lot.

MS: Okay. Do you feel that your ability to contribute to your field was hampered or enhanced because you worked at Savannah River Laboratory?

JB: I'm not sure I understand your question there. What—

MS: The question was if you felt your ability to contribute in your field was hampered or enhanced because you worked at SRP?

JB: I guess the answer's no really because I wasn't a scientist. I didn't really have to interact with the scientific community. I wrote very few papers that were external papers. Nearly everything I wrote was internal, so it really didn't—I don't think it affected me very much.

MS: Okay that's— The next question, in fact, is, If it's possible to generalize, were you encouraged or discouraged from taking part in conferences, publishing findings or otherwise making research?

JB: We were encouraged— I was encouraged to, but I just didn't have a whole lot of interest in that, personal interest in it. I'd rather just get the job done than to be out in the scientific community. I just didn't want to go in that direction. Just like you said, Doug Leader wanted to stay as an engineer. I just didn't want to become a scientist as such.

MS: Right. Were there any research efforts that you were particularly pleased to have been involved with?

JB: All of them. I mean, I enjoyed everything I did. I didn't have any job I didn't like really.

MS: And were there any research avenues that you wish the laboratory had been able to pursue but didn't?

JB: I always felt like I was given a pretty free reign to do whatever I really thought was the right thing to do, so I don't feel like I was ever hampered in anything I wanted to do.

MS: Okay. Okay. The next series of questions deal with management at SRP and problems with that or achievements of. Why was Du Pont chosen instead of GE for example, as a contractor operator?

JB: I think for two reasons. One was that Du Pont had been chosen to build the Hanford Plant, and so they had a lot of people that were experienced with nuclear energy from the building of that plant. And number two, the engineering Department—I mean the Du Pont company had a vast engineering department that (unintelligible) and all the contacts, so they could go out to vendors and get things made. The engineering department had the prime responsibility for building the plant, but I mean they had vendors make a lot of different things, lot of the different parts. So I really feel that it was those two things, was their previous experience at Hanford and the fact that they had this huge engineering department.

MS: Why did Du Pont accept the project?

JB: Well because the president asked Crawford Greenewalt, who was then the president of the Du Pont company, to do it and he felt that it was—or he felt that it was in the national interest to do so. But of course it was under conditions. He didn't answer Truman's letter immediately. They went through a lot of contortions and finally decided that they didn't want any money for operating the plant, one dollar over the life of the contract, and that they wanted a free reign to do it their way and not be—have things imposed on them by the AEC. They— Du Pont ran things the way they thought it ought to be run, and if there were orders from the AEC or DOE that Du Pont didn't agree with, they just ignored them. Now Westinghouse didn't do that. I mean they wrote a different contract for Westinghouse. They had to follow the last dot and everything in the orders that came through but Du Pont didn't have to.

MS: Was that standard for contracts?

JB: No, I don't think so. I think it was unique. There may have been one other— Seems to me like somebody said that there was one other contract that was written that way but I've forgotten where it was now. But that was a condition under which Du Pont would accept the challenge, as I recall.

MS: Okay. How did the organization and management of Savannah River Plant differ from the practices of the contractor operators of commercial ventures, or commercial operations?

JB: In Du Pont?

MS: Yeah.

JB: As far as I know, it was the same. I mean, they treated the Savannah River employees just like Du Pont commercial employees for the same levels of—they paid them the same and the compensation and everything was the same. The opportunities were the same. Now for a long time, they didn't want to transfer anybody out of here because they felt like they needed them here, but after things got well established and everything, why there was a pretty good exchange between Du Pont commercial and the AED.

MS: Did the contract with the government offer certain advantages to Du Pont that were not available to—in its commercial ventures?

JB: Only thing I can think of is it helped them maintain a large engineering department longer than they probably would have otherwise. That's the only thing I can think of. I don't think Du Pont benefited any. There were a number of studies done by Du Pont commercial as to whether they ought to get into the commercial nuclear energy business or not and they all came out negative, stay out of it. And that was a wise decision, I think.

MS: Yeah in hindsight that is. What were the most important organizational structural changes that have taken place at SRP?

JB: Well most of those occurred in the plant, I think, and I'm not really intimately familiar with them. Those in the laboratory, the only structural change we ever had was going from a laboratory manager to three managers during a short period. And that didn't work very well, so we went back to one manager.

MS: When was that?

JB: You want to—

MS: Oh yeah.

(tape pause)

JB: That was in the timeframe of 1980 and then it only lasted for about a year. In '81 they went back to single manager again. They had three managers, Sam Mirshak and Joe Glass were directors of research and Al Peters was the laboratory manager. And that just didn't work. You just can't have a three-headed gargoyle trying to run an organization so—

MS: I'm sorry, that was Mirshak and—

JB: Mirshak and Joe Glass were research directors and Al Peters was the laboratory manager. It was an experiment that didn't work.

MS: Okay. What was the major problem with that, as far as it impacted— Did it impact the reactors at all?

JB: I don't think it impacted the reactors but they (laugh) every one of them really wanted to act as the manager of the laboratory, and of course that just didn't work.

MS: Right. Did this have any impact on safety?

JB: It didn't have any impact on safety. It had an impact on morale, I think.

MS: Okay.

JB: People like John Porter, who you mentioned, and I talked about it a lot. We didn't like that situation at all. We were both section directors then, and it just wasn't working.

MS: Right. Right. Why was that change made, do you think?

JB: Because the director of the Technical Division then, Bob Naylor—(laugh)

MS: So what were the strengths and weaknesses of the various management structures at the site?

JB: Well, part of the strength was that there was a Wilmington management which overviewed the plant management and advised them and that sort of thing. I certainly think that was a strength. It may have been a weakness too because perhaps too much of the direction came from Wilmington. Some of the people here in the local plant management thought that was the case. I never had any problem with it.

MS: Okay. Have there been any basic changes or trends in management philosophy during the history of the plant?

JB: I think so. The one we just talked about, having the three people controlling the laboratory was a change, a change that didn't work, but that was a change nevertheless.

MS: Right, yeah. What about basic changes or trends in the management of the various areas during the history of the plant

JB: Again, you're speaking to the plant more or less and most of my career I was in the laboratory, so I really didn't get involved in the plant management any. I thought Du Pont probably made some mistakes. They brought a plant manager in, John Granighan and then Dixie Hendricks as the assistant plant manager. Both those were from Du Pont commercial and they came in fairly close together, and I thought that wasn't a good idea to bring people from outside in the two top positions in the plant where they didn't know anything about atomic energy or the history of the plant.

MS: The next series of questions deal with heavy water. The first question is, Why was heavy water chosen over graphite and natural water for the SRP production reactors?

JB: Heavy water has a very good moderating effect. It slows neutrons down so they can be captured in the targets and captured in the U-235 to fission. It's got a very low absorption—neutron absorption characteristic so that you don't lose very many neutrons to heavy water. When natural uranium is used in a reactor, as it was in the initial phase of the Savannah River Plant, you had to have a moderator that won't absorb very many neutrons. Otherwise, there's not enough reactivity for the reactor to operate. And heavy water served that purpose. It was also used as a coolant in the Savannah River Reactor, and that's not the case with all reactors. Some reactors use heavy water as a moderator and light water as a coolant, but it worked very well as a coolant and moderator in the Savannah River reactors.

MS: How long did you work in the heavy water area?

JB: It was just a little over a month.

MS: Yeah. Had you had any experience at Dana?

JB: No.

MS: Okay. One article in the Savanna River Plant News dated to 1982 noted that D-Area was considered the free world's major source of heavy water? Is that how you thought about D-Area?

JB: Yes. It was. Dana had already been torn down and there wasn't any other in the United States to— As a matter of fact, Canada was getting heavy water from the United States for their CANDU reactors.

MS: That was CANDU, right?

JB: Yes. Pete Gray probably talked a lot about those reactors, too.

MS: Yeah, he did talk about those. The GS towers and flare tower were probably the most identifiable SRP feature known to the general public. How would you describe the assembly of these pieces, or was there any specially designed equipment that you were aware of?

JB: All I know is that the flare tower was 400 feet tall and that you could see the flare tower and the GS towers from the train when the train went through the Savannah River Site.

MS: What made working in this area unique?

JB: The 400 area?

MS: Um-hm.

JB: Well the H2S, I guess, which you can't smell and you have to be very careful of because it'll kill you. I think it's the fact they used H2S is the most unique thing in the process.

MS: Were there any special safety and security concerns, or any special training that was required to work there?

JB: Well, you couldn't go out alone. You always had to have a person with you so that if one person got in trouble with the H2S, which you couldn't smell or the other person could alarm—give the alarm, or whatever, to get help. I think that was a special case that I don't recall we had anything like that in other areas.

MS: What were your daily tasks when you worked there?

JB: As I said, I only worked there a short time and my main task was pump seal leakage—evaluate pump seal leakage.

MS: How was work handled on the towers?

JB: I don't know.

MS: What job in D-Area was considered the most—with the most status?

JB: I don't know. See I was there such a short time, I just don't—

MS: Right. Did both men and women work in the area, or were some jobs reserved for men only?

JB: I think there were women clerks, but there weren't any women in the—out where the—as I recall. Again, I'm recalling from almost fifty years ago so—so I—

MS: Yeah. Again this next question is sort of dealing with social life in D-area.

JB: I don't know. Again, I wasn't there long enough.

MS: What was your most memorable experience as a D-Area worker?

JB: I hated the smell, the gnats and the heat. And as I said, I would have quit the Du Pont company if I'd had enough money to leave with, but I—I—I didn't realize that DuPont paid by the month. I thought everybody paid by the week, and I came down with a week's worth of money and damned near starved to death before (laugh) I got paid the first time. That was my biggest shock.

MS: Why didn't heavy water play into the development of American power reactors as it did in Canada?

JB: Canada didn't have any enrichment facilities to enrich the U-235. And you really have to have enrichment facilities to enrich the— See, the power reactor fuel is enriched to about 3.5 percent U-235, whereas natural uranium is 0.71 percent U-235. They didn't have that, and they didn't want to rely on the United States or some other country to supply them with enrichment facilities, so that's the reason why they went that route and we went the other route to—

MS: Did people within the reactor community in this country see heavy water moderated reactors as a technological dead end?

JB: Well some people did, that's true, I think primarily the navy. Most of the power reactor business was not growth of naval reactors. Westinghouse was very heavy in that, as you know, and I think they didn't like heavy water reactors very much.

MS: Is that— Like the emphasis on commercial reactors on light water, is that pretty much from the—

JB: Navy I think. That's my impression anyway. We designed heavy water dual production reactors that would make both electricity and make nuclear products somewhat like the N-Reactor at Hanford. It was a dual purpose reactor. But we always decided that they really weren't that compatible.

And the reason for it is that there was a low Pu-240 content restriction for weapons material, and power reactors to operate most efficiently needed to operate for long periods of time. And that just wasn't compatible. I mean, if you operate for along period of time, you made plutonium that had a very high Pu-240 content.

MS: And therefore it'd be not suitable for weapons grade?

JB: Right. So they just weren't very compatible. The N-Reactor wasn't a real good reactor. I mean, it operated for a long time but it wasn't—

MS: N-Reactor at Hanford?

JB: At Hanford, yeah.

MS: The next series of questions deal with fuel and target production. Could you describe the role that this area played in the operation of the plant?

JB: Well it was crucial to both increasing the productivity of the plant and allowing the reactors to operate at a high power level. The reactors were designed for 378 megawatts, and through a lot of piping changes and motor changes, pump changes and things like that, we were able to get the external hydraulic system, increase it enough that we could operate at high power. But then we needed fuel and target assemblies that had enough flow area and enough heat transfer area to take care of the higher powers that the reactors were then able to go to. So we had a series—a very large series of designs, fuel and target designs, in order to match the hydraulic system. And productivity is made up from three things—power level, innage or operating days, if you will, and what we call a conversion ratio, and that's grams of product per megawatt day. So we worked on all three of those things to try to get the production as high as we could get it. One of the ways we got the conversion ratio higher was to put more U-235 in the reactor. The more U-235, the more neutrons get absorbed in the U-235 to make more neutrons, and the less neutrons that are able to leak out of the reactor. So it's crucial to have as much U-235 in as you can accommodate and still handle the reactivity. And we designed fuel and target assemblies to do that.

MS: Sounds like we've pretty much— The next question was, and it sounds like we covered that, what are some of the most important production problems that had to be overcome while you worked at fuel and targets during your experience at fuel and targets?

JB: Well of course there were manufacturing problems. The fuel is extruded. It's co-extruded, where the core is inside clad with aluminum directly when it's extruded and that was a big development job. A lot of that was developed offsite and brought into Savannah River. The original fuel was AlSi-bonded uranium slugs, where they take a bare uranium slug and dip it down into a hot batch of AlSi, which is silicon and aluminum melted together, and then slide it inside a can, an aluminum can, to act as cladding. Well we eventually got away from that and hot—first hot press bonded slugs and then die-sized bonds, die-sized-bonded slugs. All those were development efforts in order to come up with an increasingly better method of fabricating the fuel and targets.

MS: How did Operations and Fuel and Target Fabrication change over time, and what were some of the most important developments in Operations?

JB: I think the co-extrusion process was the greatest development, then the hot die-sizing process, which is what we ended up using for the targets was a very significant development.

MS: What procedures were changed to increase operational efficiency?

JB: One of the main things was getting rid of the spurious Scrams we had that were primarily instrument problems, and when those were solved, why the innage, which is one of the three factors that contributes to productivity, went up significantly.

MS: Were there any mark assemblies particularly interesting to work on?

JB: Well I think they all were. Each one had its different problems. The most efficient ones that we ever came up with were the last ones we had, the Mark-15 for plutonium production and the Mark-22 for tritium production. They were both compatible with the same housing—same sized housing tubes.

MS: Okay. What do you feel is the most important contribution of the M-Area work to the operation of the plant?

JB: I suspect the co-extrusion, I guess.

MS: Was there ever any consideration given to outsourcing the production of certain elements that went into fuel and target assemblies?

JB: Well parts of them were from the beginning. National Lead made the uranium cores and machined them and shipped them down here. They were already machined. Bare cores came into the area from there.

MS: National Lead, and that's located where?

JB: Ohio.

MS: Ohio, okay. Right. The next series of questions deal with reactors. Why was heavy water chosen over graphite or natural water for the SRP production reactor?

JB: I think we've already answered that.

MS: I think we've already done that one, yeah you're right. It was here twice. If you came here in 1953, were you present for any of the startups of the reactors?

JB: es. R-Reactor, P-Reactor.

MS: Were you actually there in the building?

JB: Yes, K-Reactor.

MS: Can you tell us some about how was that—what was that like to be there when that went critical?

JB: I wasn't in the control room. That wasn't my responsibility, but I was responsible for testing the fuel assemblies. Before they went in we hydraulically tested them in a test station to make sure that they'd flow with the right amount of water and that sort of thing. That's what I was responsible for during that time.

MS: What was it like that day when the reactor went critical?

JB: I don't remember whether I was physically in the building at the time it went critical or not. That was December 31st, I believe in 1953, and I don't remember. During that time, I was spending that time in the assembly area as a Works Technical support to the Production Department.

MS: Yeah I think Doug Leader told me that as a result of a promise that was made to President Eisenhower, they promised they would have a reactor online before the end of 1953, which is why they rushed to get R (unintelligible).

JB: Is that right? I don't remember that.

MS: He said it was a big deal when R-Reactor went critical with lots of dignitaries. It wasn't a secret and all that, but dignitaries were present. But he said, for the other reactors it wasn't—much less of a hoopla.

JB: Yeah. I just don't remember that.

MS: Okay. What about during subsequent runs as other reactors were brought to criticality, was there—do you remember anything special about those after R?

JB: No all I remember is P-Reactor operated a lot better than R. The innage was higher, it had fewer problems and everything. P ran very well. It was one of the best running reactors of the bunch.

MS: Why was that? Do you remember?

JB: don't know whether it had to do with management or not, but it just—things just seemed to run smoother. I'm just not really sure why. Again, I was in a low position, so I— (laugh) I really didn't know what the politics were or anything like that at that time.

MS: Right. What was the atmosphere like when the reactors were shut down for the last time, let's say R-Reactor in 1964 or any of the others that you might recall?

JB: Well of course we made a study to see which reactor should be shut down and we picked R at that time because it had some—it had a leak in the top shield and it had had a leak in one of the effluent nozzles. And as I recall, there was another leak developing in another effluent nozzle, so it looked like it was having enough structural problems that it ought to be the one that was taken out. And of course we did the same thing for L-Reactor, and I've forgotten exactly the reason why we took L-Reactor out. It— P-Reactor was just operating a whole lot better at the time. C-Reactor is bigger and could operate at a higher power. I say bigger. The core was the same size, but C had the reflector—had a bigger tank, had a reflector on the outside so that the neutron flux was flatter and it could operate at a higher power. But I don't remember anything particular about. I mean we were kind of sorry to see a reactor shut down, but outside of that there wasn't—I don't remember any big—

MS: No special deal when like say all the reactors were shut down for the last time, like in 1988?

JB: Well it was disappointing but— But at the same time, they really didn't need the nuclear materials—more nuclear materials then, so if you look at it from the point of view of the taxpayer, it was the right thing to do.

MS: Right, yeah. What did you look forward to doing in your job and what did you dislike as far as dealing with the reactors?

JB: I looked forward to all the new challenges as they came up, whatever they were, whether it was developing new fuel and target assemblies or solving operational problems. I don't know that I disliked anything very much. I mean, it was all part of the job and I just accepted it.

MS: How was versatility incorporated into the design of the reactors?

JB: I don't know that it was originally. They were designed very conservatively as Du Pont designed its plants at the time. All Du Pont plants would operate at well over the capacity that they were designed for, and they just designed the reac—the designers just designed the reactors that way. And so I don't know that the versatility was designed into them for making all the special isotopes and everything like that. That was just developed as we went along.

MS: Okay. What could have been done or what was done to make the reactors more versatile over time?

JB: Well the mixed lattice was one of the main inventions there. The fuel and target were in different positions and my boss likened that—and I thought it was a good analogy, to like an oven and the fuel assemblies were the heating elements in the oven and the targets were the different pies you wanted to make. I mean you make a pumpkin pie or an apple pie or whatever you wanted to put in. You put— You tailored the target material to whatever you wanted to make, and I think that was the most significant thing. And that was the one thing that caused the Savannah River reactors to continue operating, I believe, and the Hanford reactors shut down because the Hanford reactors couldn't make other isotopes very well. There just wasn't the versatility in the reactor design to do that, that we had when we developed the mixed lattice, because we could put dozens of different target materials in different target positions with the mixed lattice and make them simultaneously, whereas, they just didn't have the capability because of the design of those reactors to do that.

MS: Okay. Did the goal of versatility have a cost in terms of reducing other potential production goals?

JB: Oh yes. The mixed lattice wasn't—didn't make as much equivalent plutonium, if you want to look at it that way, as a charge that was designed just specifically to make plutonium or tritium. So there was a cost penalty.

MS: Were there any production programs that you were particularly interested in being involved in?

JB: Well I enjoyed them all really. High flux was extremely interesting. I mean, we achieved the highest flux ever achieved in any reactor. As I recall, a single fuel assembly that was only six feet long generated 21 megawatts, 21 million watts, which is a whale of a lot of power.

MS: What about—what were the most important changes to the reactors?

JB: Physical changes?

MS: Anything you want.

JB: Well the physical changes were putting bigger pumps in, bigger process water pumps, bigger pipes, more heat exchangers from the original design. (unintelligible) increasingly overpressure in the reactor from ten inches of water pressure to five psi, like a gas pressure. Those were the physical changes, primary physical changes to the reactors. Then on the cooling water side, increasing the number of river pumps, increasing the size of the impellers in the river pumps, building of Par Pond, and then the installation of double capacity pumps in the 190 buildings that pumped water over to the reactors. All those things were physical changes that helped us achieve higher power. Oh, the other physical change for safety, of course, was the confinement system, which we didn't have originally.

MS: Right. What was the impetus for getting that started, since you didn't have it originally?

JB: Well the power reactors, as they started being developed, all had containment domes over them, which would presumably hold the fission products in the dome if they had an accident. We didn't have anything like that. We had 100,000 cubic feet of air going through the reactor room, and if we had a—any melting or anything like that, that got out of the reactor into the room, it went right out into the environment.

MS: Okay. What were the major operational differences among the five reactors, if there were any?

JB: Well a major one was C had the D_2O reflector on the outside. The T-tank about two feet in diameter bigger than the other tanks. And that D_2O reflector flattened out—caused the flux level to flatten out so that the radial flux distribution was much more even than it was in the other reactors, and that allowed a power increase, because the outer elements in the reactor in C could operate at fairly close to the power of the center elements.

MS: Okay. Did any of the reactors develop a reputation for being better at producing certain products?

JB: Of course they were designed to produce plutonium and tritium and they were very good at that, but we could produce anything that they wanted really. Anything that was asked for, we were able to produce. I don't know— The situation is, it takes multiple neutrons to make some products like californium. I think it was twelve neutron captures. And it has a very short half-life. If you don't operate at a very high flux to make it in a hurry, why what you've made decays before you (laugh) get very much made. So you had to operate at high flux to make a product like that. But the reactors were good at doing that. They weren't nearly as efficient at making californium as they were in making other products because we had to reduce the amount of U-235 in the reactor so the leakage—neutron leakage went way up. So the conversion ratio was poor, relatively speaking, but it was good for californium production. It would have been poor for plutonium or tritium production but it was good for californium production. So I mean that's the kind of thing that we dealt with, or had to deal with. So I can't say that it was really— I guess it was best for making plutonium and tritium. That's what they were designed for and that's what they were the best for. Other things, we could make well but not in the quantities like we could make plutonium and tritium.

MS: Right, yeah. Why'd they push californium? We got that later on but (unintelligible)?

JB: Well it was Glenn Seaborg who really was the guy who discovered plutonium, as I understand it, was very interested in higher isotopes. And californium could be used for medical sources to make them into—make californium into needles that could be implanted in a tumor and it would affect the bad cells, the cancerous cells, far more than it affected the good cells. It could be used for that. They used it for oil well logging and well just a number of things like that. It had a short half-life, very high intensity. And it was a neutron emitter rather than a gamma emitter or a beta emitter like a lot of isotopes were. Its big disadvantage was its short half-life and the fact that it cost, back in 1960, sixty and seventy dollars, about a hundred million dollars to build up the inventory of material to make two grams of californium.

MS: Was it made primarily just to see if it could be done?

JB: No, no it was distributed to hospitals and loaned to universities and things like that.

MS: But was that sort of like an afterthought or—

JB: No that was intentioned.

MS: Oh it was? Okay.

JB: Yes. Unfortunately, the Department of Energy didn't want to keep all those—all the material—the curium and the americium and everything that we had made to use as target material for californium. They wanted to dump it in the waste tanks, which was a hundred million dollars worth of stuff that you couldn't make today. You couldn't operate reactors like we operated them then with all the safety and everything that they've gotten, all the regulations and everything, just couldn't operate them like that. So you could never reproduce that stuff. And they wanted to throw it away.

MS: Is any of this stuff being made now?

JB: Oh no.

MS: Not even at Oak Ridge or anything or—

JB: Well now they may be making some in the reactors at Oak Ridge, but it'd be small compared— They never had any reactors that had any capacity at Oak Ridge. The high flux isotope reactor at Oak Ridge had a core that was only five inches in diameter. And our high-flux core was six or seven feet in diameter. So you can see that volume-wise, how much more material we could irradiate than they could, and at the same neutron flux. So they could make very miniscule quantities of californium and einsteinium and those higher elements, but they couldn't make very much.

MS: Right. Is there much of a demand for (unintelligible)?

JB: No if there'd been a big demand, I guess we would have continued making it.

MS: Right, right. As far as dealing with the reactors, did any of the reactors develop a reputation for being better at producing certain products? I mean did— For example, C-Reactor, was it considered better for producing a certain material, anything along those lines?

JB: Just that it operated at a higher total power. I mean, you could make more plutonium and tritium in C than you could in the other reactors, but outside of that, why when it came to high flux operation, it wasn't any better than the other reactor, because you didn't take advantage of that reflector on the outside. You reduced the size of the core from six hundred to about a hundred assemblies, and so it was in the center of the reactor anyway so in any reactor you put that in you'd have a D_2O reflector on the outside. Because the rest of the positions were vacant and there was just D_2O out there.

MS: Right. What about— I'd heard that some of the reactors at different times were considered pilot reactors, more like the—like in the vanguard of producing a certain product.

JB: Well that was as we were raising power they did that, when went in increments of power and used one reactor at a time to pilot a higher power, to make sure we didn't run into some unforeseen problem. And different reactors were used for that. P-Reactor was used for it for a long time until the turbidity in the moderator from the corrosion of the aluminum built up so much that it was giving us a problem, and then they went to one of the other reactors, I think it was L, I'm not sure, and used it as a pilot. And then when they got the problem solved in P, they went back to P and used it as the pilot reactor. But that was just for reactor power, just to demonstrate that we could go to the (telephone ringing) next level of reactor power without any problem.

MS: Want me to—

JB: No. My wife will get it.

MS: How did security concerns affect the operation of the reactors, or did they?

JB: Security concerns—I don't remember them really affecting the reactor in the early days, and in the late day—just before the reactors were shut down and everybody's going nuts over security, and they were making installations inside the reactor area where somebody could sit in there with a gun and hold off people coming through passages and stuff like that. But that was all late after—real late in the operation.

MS: Right. Was there any appreciable rivalry between reactor personnel? For example, was there any rivalry between people that worked at C-Reactor versus R-Reactor?

JB: Oh I think so. I think everybody wanted to have a high innage. I mean all the—keep the reactor online as long as they could. I don't think they cared so much about what kind of charge was in the reactor, but they all wanted to have a high innage. I mean, that reflected directly on that crew.

MS: Yeah, right. What about rivalry between different shifts operating a reactor?

JB: Well you see, I wasn't in the Reactor Department never so I— There probably was but I just don't know. I mean, I can't say firsthand. There was rivalry between Hanford and Savannah River, awful lot of rivalry. I mean, reactors were being shut down and we wanted theirs to be shutdown rather than ours.

MS: Right. How did that normally work out?

JB: Well they got shut down, all but N-Reactor. Most of ours were still operating, or three of ours were anyway.

MS: I've heard it said that when it came to plutonium production over the entire life of Hanford and Savannah River Site that plutonium production was pretty much split evenly between the two places.

JB: It was pretty much.

MS: Okay. But of course tritium was—

JB: Primarily made at Savannah River.

MS: Primarily here, right. What about— How did reactor cycles change over time, and how did that affect operations such as downtime?

JB: Depended upon what we were making. For example, when they decided they wanted Pu-238. It's made from neptunium. Neptunium comes from U-236. Every sixth capture in U-235 makes—goes to U-236 and the other is fission, you know the other five fission (unintelligible) fission. And what we— What we wanted to do is to make more—concentrate the 236 so we could make more neptunium for the Pu-238 program. So we operated some reactors for very long cycles, like a year. A cycle would operate for a year, go to a very high U-235 burn up. We went to 70 percent U-235 burn up in what was called the Mark VI-E charges, and that was primarily for the Pu-238 program. So, I mean that was very high innage for a long time, a reactor could operate for many months without ever shutting down. You eventually had to shut down, take some Lithium targets out to gain enough reactivity to extend the exposure even longer, but it was—it'd operate for a long time. Some of the cycles operated for almost a year.

MS: Okay. How did that have an impact on safety procedures, or did it?

JB: I don't think it had any.

MS: Okay. One question I had was about tritium. This is just a general question, but since we're not making tritium anymore, where do we—what's the plan for making tritium in the future?

JB: Well they've looked at an accelerator, which I never thought was a very good idea. But I mean when we looked at it—and I had some of the best physicists working for me than anywhere in the country—invariably, they always said that was inferior to producing it in a reactor. In fact, some of the accelerators they looked at, you had to have like 800 megawatts to drive the thing, and that was equivalent to a commercial reactor. And so what they said was, Well you don't have fission products. Well if you put incremental capacity on, and that incremental capacity was a reactor to make the electricity to drive it, had to have a reactor. So I mean it just didn't make sense to us. And too, the neutrons were coming from what they called spallation neutrons, where they'd shoot a—they'd shoot lead or something like that with particles and the neutrons would spalliate off of the lead. It just looked like a crummy idea to us. We just didn't— And it wasn't that we liked reactors better, it's just they just didn't look like a good design to the people that we had look at it.

MS: That being the case, why didn't they just stick with the reactor if—or did they just not—at the present time are they not concerned about tritium?

JB: Well apparently they're not concerned about tritium. Tritium has a 12.4-year half-life, and of course, it's decaying away. But they're reducing the stockpile of weapons anyway, so I guess they've got enough to— Eventually if they want to continue to have a stockpile, they're going to have to make tritium.

MS: Right, yeah, okay. The next series of questions deal with health protection.

JB: I'm not going to be able to help you a lot on that. I just never got involved in it very much.

MS: These are kind of general, so—

JB: And it was an area that didn't interest me personally very much. (laugh)

MS: Yeah. Can you describe in general the health protection measures taken at SRP to provide safe working conditions?

JB: Well of course they always had health protection people come in with monitors to monitor any area where they thought there was any radioactivity. That was the main thing, I think.

(tape pause)

MS: Okay.

JB: They kept very accurate track of all the radiation people got, cumulative, and of course did numerous studies to find out whether the radiation was really affecting the incidence of cancer.

MS: Right. How have the safety measures—these health protection measures change over time or how do they change over time?

JB: Again, I'm really not intimately familiar with that. I really never paid too much attention to it.

MS: Okay. What powers did health protection workers have to locate, stop and change unsafe conditions?

JB: I think anybody, whether they were health protection or anybody else, if they saw an unsafe condition, they could—they had an obligation to tell whoever the boss was that was in charge of that operation. And he was obligated to shut it down until they figured out what the problem was. I've shut down facilities before when people have come to me and said they thought they were unsafe. And then, when you— In the fabrication laboratory where Doug Leader worked, we did casting in there where you'd have hot aluminum, molten aluminum, that you'd pour in the molds. And we had a—I had a fellow that came up to me one time, one of the workers, and he said, That's an unsafe condition. And I said, Okay. So I called down and said, Shut it down. They shut it down. We went down there and I said, Now explain to me why it's unsafe? And of course, he really couldn't do it. He didn't want to work down there where it was hot and with molten metal and everything, but with all the protection equipment and everything he had, it wasn't unsafe or we wouldn't have been operating that way. He just didn't want to operate in that environment.

MS: What happened? Did he get transferred? (laugh)

JB: No, he had to go back and operate there or go find another job with some other company.

MS: Right. Have management and organizational practices affected the ability to insure employee health and safety?

JB: Of course. I mean, that's where it came from. It was top management.

MS: Okay.

JB: In fact, a plant manager—a Du Pont plant manager—wouldn't stay a plant manager very long if he had very many accidents. They— That just is the way it was.

MS: Out of curiosity, since Du Pont was so careful about safety, yet at the same time in the early years the productivity was pretty high, how did they— To some degree that could be a problem. I mean one sort of works into the other one, and how did they work that out?

JB: Well it was still always safety came first. I mean if something was identified as— Du Pont said, We won't do any operation that's unsafe period. And as I said before, Safety is a condition of employment. I mean those were the things that they operated under and if anybody could identify something that was unsafe, why it either got fixed or they showed them that it was safe, one thing or the other.

MS: Okay.

JB: There wasn't any compromise on safety.

MS: So it was pretty much just by worker training and indoctrination or whatever that they (unintelligible).

JB: Yeah, when I first started working for Du Pont, I thought, I'll never remember all these safety rules. I just can't live under conditions like this. That was what was going through my mind, but you learn to do it and you learn that it's the thing to do because you don't want to hurt people and you don't want to get hurt yourself.

MS: Right, right. How did they work that out? Were you given like a list of conditions that had to be met?

JB: Well we had safety meetings all the time. I mean, once a month we had a safety meeting, once a month we had a security meting and went over all that stuff and then if it was anything identified that wasn't safe, you were supposed to— I mean, you were supposed to tell about it whenever you saw it, but I mean, we talked about things that might not be safe and that sort of thing. Everybody was involved in the safety meeting. Everybody had to give a safety talk, from the lowest person to the highest person in the organization.

MS: How often did they have safety meetings?

JB: Once a month.

MS: Did they have—

JB: Well some of the plant people had safety meetings every morning. I mean, it depended upon what you were doing in the plant and that sort of thing. And the construction people, they had a safety meeting every morning, as I understand it.

MS: I had seen some of the movies that were designed to be shown, I guess, at safety meetings. How often did you have to see movies? Do you recall? Not very much or—

JB: Well fairly often they had the movies as part of the safety meeting. That wasn't the whole safety meeting normally but they had—very often had movies as part of the safety meeting.

MS: Right. Let's see, the last batch of questions on the list here deal with the specific products that they made, aside from like the military materials. And we've talked about that to some degree, especially with californium, but other than the military products, what were the most important items made at SRP?

JB: Well cobalt-60, we made the highest specific activity cobalt-60 ever made in the world. It was over 700 curies per gram. And pure cobalt-60 is a little over 1140 curies per gram, so it was the highest specific activity cobalt ever made. And that was used in food irradiators and things like that. We made the most polonium-210 ever made anywhere in the world. We made about 500 grams of it as a demonstration. It was never used, but it was—could be made into a very intense heat source and we demonstrated we could make that. It has a fairly short half-life. We made Pu-238 that they used in the electrical generators that were left on the moon and that went to Mars and that are in the deep space probes after you get out in deep space where solar panels aren't effective, why they have to have a heat—a power source, and they use Pu-238 because it has a relatively long half-life, eighty—I think it's 89 years, I've forgotten exactly. It's eighty-something years. And I think Pu-238 was probably one of the most useful products that we made besides plutonium and tritium. Of course, there was curium-244, which was a substitute really for Pu-238. It was—had a much higher specific heat. It generated 2.5 watts per gram, as I recall, compared to about a half-a-watt per gram for Pu-238, but it had a short half-life, like eighteen years, a little over eighteen years. Let's see what some of the other products were that— Oh, we made uranium-233, which was made primarily for Admiral Rickover's experiments with breeder reactors. It could produce more fuel than it burned, like a plutonium breeder reactor could do. Let's see if there's not some more here that might be of interest. We made Pu-242. And that was a big program. I mean, it took years to make Pu-242.

MS: Okay.

JB: Let's see. We made a lot of just miscellaneous small isotopes for universities, but just in very small quantities of material (unintelligible) to make thulium, thallium, scandium, all kinds of things like that, that never amounted to anything but they wanted.

MS: Was there much of a market for californium?

JB: No. It didn't develop. We thought it would, but it just didn't develop.

MS: Was it just because it was simply too expensive to produce?

JB: Well they didn't charge anything really. They didn't really charge for it, because it was so expensive nobody would have bought it anyway. I mean, a hundred million dollars pumped into two grams, you can see how much—how expensive it would be, at least a hundred million dollars. And that was in dollars twenty, twenty-five years ago. Today that's probably closer to half a billion, maybe close to a billion dollars for the two grams that were made.

MS: Wow. Wow. Yeah so— Yeah I can see that it just wouldn't be— Unless it was really, really effective, it just wouldn't—wouldn't take off.

JB: Well I think it was somewhat effective, but I don't think it was as effective as they thought it was going to be compared to other means of treating cancers and things like that—

MS: Right, yeah.

JB: —or it would have developed if it had been very successful.

MS: Right. Okay. I'd like to take this opportunity to thank you for the information you've provided so far for the interview, and if there's anything you'd like to add, you're welcome to do so.

JB: No. Thank you.

MS: Okay. That'll conclude this interview.

END OF INTERVIEW

Oral History Interview – Fred Christensen

Fred Christensen began his career at Savannah River Plant in 1955, just as C reactor became critical for the first time. He worked at many of the SRP reactors, beginning at K reactor, where he served as supervisor. Christensen knew "A-Square" Johnson, the first head of Reactor Technology, and many of the early leaders at Du Pont, such as Dale Babcock. He was also at SRP during the period of power ascension, the high flux cycles, and even during the period of shut-down. His career virtually spanned the operational history of Savannah River.

Due to his pressing schedule, Christensen was not able to sit for a formal interview. He did, however, have a series of stories about his years at Savannah River Plant that were at least partially compiled for this project. He offered these stories as a worthy substitute.

Interviewee: Fred Christensen

Date: April 17, 2007

(these stories offered in lieu of a recorded interview)

SRP STORIES

May I offer here a daily routine of mine at the Savannah River Plant, in 1955 just after C Reactor went critical for the first time, just after I was hired at SRP.

My first job at the Savannah River Plant was operating the K reactor; that is, I became one of about twenty supervisors who with some sixty operators ran the reactor around the clock, seven days a week. SRP had five reactors labeled R, P, L, K and C. Each was essentially identical to the others. Each was housed in an immense reinforced concrete fort designed to withstand a near miss by a 1955 Russian atom bomb. The reactors were placed in a circle, each about five miles from its nearest neighbor, so that a nuclear hit on one would not destroy any of the others. An army contingent manned antiaircraft gun at various plant locations to shoot Russian aircraft.

SRP also had facilities that made fuel pieces for the reactors and other manufacturing areas that separated bomb materials (plutonium and tritium) form the stuff irradiated in the reactors.

The average age of those of us who started SRP in the 1950's was less than thirty. Idealism was rampant. A strong feeling prevailed that the job was vital if we were to survive opposite the Russians. Most people were directly involved in producing something. Many had been at SRP during the just-completed construction phase when some 35, 000 workers has descended on Aiken County and had completed the largest construction job in the history of this country.

Operating a reactor was much like being a fireman. Unless there was a fire, there was not much to do. Pumps spun. Waters flowed. Neutrons swarmed, produced heat in massive quantities and cooked up elements not seen on earth since the beginnings of time. All this happened while we, the crew, had very little to do, except watch gages and be ready to head off trouble. Compared to the wind tunnel (my previous job at Moffat Field, California), reactor operation was quiet; we lived in our concrete forts essentially isolated from the outside. We never knew if it stormed or if night came or if day broke. On night shifts a good story teller was popular.

During the just past construction times ten thousand of the newest and fastest cars raced home at quitting time, bumper to bumper well in excess of the speed limits, while the local police looked on from the roadside unable to even enter the stream of traffic. Slow pokes were prodded from behind up to some more reasonable speed like 75 miles per hour. Local sheriffs became multimillionaires. Du Pont was death on malingers; efficiency experts prowled the construction sites with the power to fire shirkers on the spot. If one had to go on an errand, one drove a wheelbarrow; barrow parking places were provided next the portable privies. The heat during the summer of 1952 broke records for weeks; engineers worked in the Ellenton school house in their underwear with paper taped to their forearms to prevent fouling their work with sweat. In later years, this experience allowed them to save the taxpayer untold millions when future underlings pleaded with them for office air conditioning.

Security was extremely tight. The best kept secret was that SRP was to produce tritium, the ingredient that make an atomic bomb into a 100-times-more-powerful hydrogen bomb. From the beginning SRP was called the H-bomb plant by the general public in South Carolina in some massive security slip perhaps common the best kept national secrets.

One of SRP's greatest achievements was the transformation of several thousand erstwhile cotton pickers, land surveyors and textile mechanics into reactor operators. Take gentle, powerful, competent Paul, our shift mechanic. He had grown up on a poor Sandhill farm during the depression. At seventeen his mother had packed his tin lunch pail with collards and cornbread and had gently suggested that it was time to leave home since six younger brothers and sisters overburdened the family resources. Paul had roamed the state in futile search of work, and in circumstances taken from the biblical story of the prodigal son, had determined to take himself home weeks later in desperate hunger. His mother's welcome and left-over biscuits with cold gravy filled his emptiness.

Paul became a loom mechanic in a local cotton mill and married. He made $4.00 a week and his wife earned $2.50. Their house rent was $2.00 a week. After other expenses, they had 50 cents a week for recreation. This bought a Saturday evening movie, a soda and left 10 cents for church. During the great war Paul became a merchant marine seaman; his stories of discovering sin in Galveston, Texas were the classic pathos of the unsophisticated country boy finding what people would do for a sailor's pleasures. When I know him, Paul was plump and proud of his wife's cooking. "Tonight I retched (sic) in my lunch box and pulled out a biscuit…", this followed by a contented belch and a shy smile. He took a shine to me being attracted by my semi truthful accounts of fraternity house courtship rituals. I am happy to report that Paul became a Baptist preacher in Williston; surely he has been forgiven his sins committed in Galveston. Another Paul came under the influence of a local preacher and decided to give up other women, than his wife. At the telling of the story, he boasted to the control room audience that he had so successfully put this sin of infidelity behind him that he had not been unfaithful to his wife for the last six weeks, a record for the two year period since he had reformed his ways. All seemed to agree that this was indeed goodness and virtue of a high and unusual degree.

Morgan was our shift electrician and was a committed, dedicated Christian man. In vain (and surely to my loss) he repeatedly invited me to join his bible study groups. His outlook was different. One cold, crisp, clear January dawn he remarked in our car pool, "Lot of people will die today." Then he sat back and drifted into a reverie with a smile on his face.

One of the jobs that Morgan and I did periodically involved changing large copper connectors that normally carried 600 volts. The connectors were as big as your wrists, were bare copper and were sudden death if the juice was on. Mr. Bunn, our previous electrician, went through a ritual of turning off the power, locking open the switch, putting on gloves, testing the bare connectors with his voltmeter and then looking very nervous and uneasy as he handled the bare copper.

Morgan was a much happier man as he did this job. We did lock open the switch, in part because I insisted. But his gloves and voltmeter stayed unused in his pocket. He hummed and smiled as he grasped those big copper wires with his bare hands.

Morgan did have a nemesis in the person of Jim the shift maintenance mechanic of that time. Jim was not able to say a single sentence without being sexually and blasphemously profane, and I noticed that he was inclined to put on a show for Morgan.

In one of the corridors in my below ground hydraulic empire I had a small pump driven by an electric motor. This rig was want to make grinding noises that my operators notices as they passed; these rumblings they duly noted on their log sheets. It fell my lot to fix the grinding noises, and I called Jim down to view the problem. "Why, ______ ______ it's Morgan's ________ electric motor, not my pump that makes the ______________ noise. Get Morgan down here." So down comes Morgan while Jim rehearses in his mind the most profane way to restate his case in Morgan's presence. He does himself proud. Morgan turns red in the face and has to grasp a piece of electric conduit for support. He gives the electric motor his close expert attention and concludes that Jim's Pump is really the problem.

This draws from Jim a masterful explosion. Morgan shuffles off down the corridor reading from his well-worn pocket bible. I return to the fish bowl and write an order to replace the electric motor, with the intention to replace the pump next if the problem continues and with the hope that further work in this area may fall to one of the other three hydraulics supervisors.

After operating at full power for about a week, each reactor contained about the same amount of nuclear poisons that would be released by a large thermonuclear warhead. These nuclear do-bads were held in the uranium fuel pieces in the reactor cores. Our main concern was to keep these poisons where they belongs and away from the real estate and people of South Carolina. This job was made difficult by the large amounts of heat inevitable generated while making plutonium and tritium and by the tendency of the uranium fuel pieces to burn if given half a chance.

Many redundant safety systems were built into the maize of pipes, pumps, wires, switches and assorted pieces of hardware located inside our concrete forts. I guess the key point in emergency medicine is to keep oxygenated blood flowing to the brain, otherwise in a few minutes the brain dies and cannot by resurrected. So in the reactor business cool water must be kept flowing to the reactor fuel or the fuel melts and perhaps burns releasing massive amounts of atomic poisons. In the newer reactors of today (1991) containment shells are built around nuclear reactors so that if the fuel melts and burns the do-bads are all kept inside the shell and away from the environment. But the SRP reactors of the 1950's had no such final barrier; if we had damaged fuel, much of the mess would have been blown out of our stacks into the atmosphere.

That is an oversimplified summary of reactor safety. Many things can cause fuel damage, and years of exposure to potential problems and details of how people, procedures and hardware interact are needed for bosses who have to decide whether to give the patient an aspirin or to shut down within seconds for major surgery. A most significant aspect of the problem is that really important events that require instant correct decisions may happen only once or twice in a man's career.

After three weeks apprenticeship I was made Hydraulics Supervisor on D shift for the K reactor. I was responsible for the pumps and pipes and motors and valves and instruments that made sure the heat from the fuel was dumped safely into the Savannah River. Two operators in the central control room and two operators 40 feet underground in the pump room were under my control. I was weighed down by my responsibilities, in large part because I had little idea of what was expected of me. After years in the safety business I now realize that Hydraulics Supervisor was a parking spot for young engineers, and the main responsibility was to keep the pump room operators awake on night shift. Some of my associates grasped this fact immediately and led relaxed lives. I spent a year pondering what should be done if this pipe should break or if that pump should stop.

The work period between midnight and 8 AM is called the Graveyard Shift, and we all worked Graveyard once a month, for seven days straight. Let me take you through a typical shift. The car pool comes by at 10:45 PM; I settle myself by the back window. Tom is picked up last and wedges his 220 pound self in the middle of the back seat. He thoroughly licks and then lights up his after breakfast cigar. All the windows are rolled down; the rider in front flicks his cigarette ashes out the front window and into the back onto me. I doze for the next hour amidst smoke and ashes, midnight summer breezes and occasional comments. Car pools last for years and are like families; companionship is comfortable.
The reactor building looms large in flood lights, resembling a very large stacked collection of rectangular children's blocks. Exhaust stacks for various engines stick out here and there. We can tell much about the status of things inside by what comes out of the stacks. Tonight the right three stacks belch diesel smoke; we infer that the reactor is up and all is well. We go through two security check points.

Shift turnover takes ten minutes and the retiring shift is gone shortly after midnight. We supervisors sit around the Fish Bowl, read logs, catch up on what lies ahead and gossip. The Fish Bowl is a glassed off portion of the central control room that is office for the shift boss; from his desk he can see most of what goes on in the central control room. I move off to the lunch room for coffee, two spoons of sugar and an inch of condensed milk. Raw Hide, the shift electrician is holding court. He tells of his latest adventure with the Plant Manager.
I infer that the Plant Manager has three tasks: to meet production schedules, to avoid hurting anybody and to keep labor unions out. Convincing potential union members like Raw Hide that the Company gives them more without a union than could be won with one is a major assignment for all supervisors of all levels. Raw Hide is well aware of the strong cards he holds, and is an accomplished artist at catching his foreman in the same room with one of the big bosses. He then runs up to the big boss, "Mr. Big, have you met Jim, my

foreman. Come here Jim and meet Mr. Big." Foreman Jim slinks over knowing he has been had. Raw Hide makes the introduction with excessive complements about what a fine boss Foreman Jim really is and then regales the big boss with some tale about how Foreman Jim only allows a ten minute coffee break when all the productions operators take twenty minute breaks, all this while Foreman Jim stands first on one foot then the other.

Tonight Raw Hide recounts the pinnacle of his career. He has caught the Biggest Boss in a crowded lunch room at high noon with his pet peeve, an ex-Navy Chief now a stickler of a foreman. The whole lunch room had fallen silent. Raw Hide had played to a packed and attentive house, and the Plant Manager had agreed to have lunch with the two of them while they worked out the fairness of some navy practices that the ex-Chief was attempting to implement at SRP.

Coffee done, I head downstairs to my pump room domain. I have found that my two pump cooperators get called on the building telephone system when I am seen headed their way. This is not all bad. I have but to yawn and mention the pump room and I know that they spend the next half hour alerted. But I must show up part of the time, and tonight I walk down six fights of stairs to the bottom floor of the reactor building 40 feet below the ground. Here six electric motors spin six pumps that remove the hot water form the reactor. The motors are the size of small automobiles and the whole floor hums and whines so that conversation is difficult. My two operators sit at an instrument that monitors all the important things going on inside the pumps and motors.

Last night had been a bad night for me. I had come down at 5 AM when sleep is almost irresistible with the training manual to train the three of us and to keep the three of us awake. We three had propped up against the wall in front of the monitor; I had opened the manual and had started reading to them. The motors had droned. The pen on the instruments had pecked away. The fried eggs and bacon recently consumed at the cafeteria had settled most comfortable into my gizzard. And the three of us had fallen sound asleep, all propped up, three in a row.

Tonight the topic of conversation is the new black operator on the shift that we have just relieved. Poor soul, it appears that he cannot read well, and so the procedures that he has filled out are a mess. He has entered data supposedly taken every half hour for the previous eight hours on his log sheet. Each number is exactly like the number above it taken half an hour earlier; the conclusion is almost inescapable that he never read the instruments but instead has copied data from the previous set of entries.
My operators also point out that some of the instruments that he reports that he read are

inside a spill area that requires special clothes for entry and that he has not signed the appropriate form for crossing the barriers. This is a most significant sin in itself. Several months ago we fired a white operator for entering data that he had not taken.

The black operator in question is one of the first in the reactor department, and I know that he is shielded from any criticism by chains of command that reach to Wilmington (Du Pont Company headquarters) and to Washington. I become somewhat wistful that more care was not taken to have the first blacks be smart. I report the business to Dave the shift boss.

Three AM lunch time approaches. We walk a block to the cafeteria and order scrambled eggs, bacon and grits. I eat with four golfers who begin to negotiate handicaps for their Saturday game. I have learned the routine. Forrest has hurt his back; his doctor has forbidden him to lift anything heavier than a fork full of grits and is suggesting disc surgery. Charlie may have to go into a leg brace in two days. The first time I went through this I was overcome with the crippling tragedies that had struck my close fiends so young in life. But I have learned that all this litany of miseries is directed to Saturday's golf handicap. The conversation moves on to the albino crows.

The ever-alert patrol force at the R reactor area some weeks ago had spotted an albino crow sitting on a power line with six black twins, looking like them, cawing like them, but at the same time being unmistakably white in the early dawn. The patrolmen had discussed this with their crew and had been accused of sleeping (and dreaming) on the job. The crow sighters had insisted that the albino crow existed and were fully vindicated when others including the patrol captain, a retired Chicago Police Inspector, saw the white crow too. This story had reached John, the head forester on the plant and a corresponding member of the Audubon Society. John had insisted that albino crows were impossible. The patrol captain had invited John out to R to see for himself.

Their trouble and vigilance was doubly rewarded when John in the company of two R patrolmen sighted not one buy two albino crows. John corresponded with the Audubon Society, and the bird world got all aflutter over genetic mutations being produced by all that nuclear business at Savannah River Plant. Yesterday the bubble burst when a red white and blue crow was spotted. Suspicions were aroused and the retired Chicago Inspector, exercising investigative skills honed to a fine cutting edge combating the Midwest's slickest criminals, caught the R power operators in the act of painting a crow with spray paint after catching him foraging in the Dempsey Dumpster for lunch crumbs.

Lunch over, we head back to the massive reactor building. Dave, the shift boss, patrols the control room. Two instruments that monitor radioactivity levels in the heavy water fuel coolant are inching upward. This is not too unusual, but we begin to worry that one of the thousands of fuel pieces has sprung a leak. These uranium fuel pieces are contained in thin-skinned tight-fitting aluminum cans. If a can springs a leak the heavy water coolant eats away at the uranium. The wound swells; cooling water flows go down and temperatures go up. The swelling accelerates. Boiling might start and a whole column of twenty fuel pieces might be damaged. This would be a first class mess.

Very extensive and complex instruments watch hundreds of flows and temperatures and stand ready to ring bells, blow horns or even automatically shut down the reactor if these unpleasant circumstances appear to approach. We need to be sure that these instruments are working, and we would like to shut down as soon as possible to minimize the mess. But there is the rub. Activity instruments frequently give false alarms. Shutdowns are very costly both to the government and to the carrots of overcautious shift bosses. And we must run until we can locate the leaking fuel piece or we will not know what to replace when we are shut down.

We pace the control room, first to the activity instruments, then to flow and temperature instruments, then back. The activity instruments inch upward; alarms bells begin to ring. Three fuel assemblies begin to look sick; in one the temperature eases up, in another the flow drops off a bit and in the third the temperature goes up and flow goes down. Then the activities ease down, but the third assembly looks sicker. Dave decides to call his boss at home; it is 5 AM. They talk while we pace between in the instruments. The activity instruments ease back up and high temperature alarms begin for the third fuel assembly. Dave and his fresh-waked-up boss decide to shut down.

This is an interesting lesson for me. Dave is a first class supervisor, quick minded and well versed in the rules of the Company game. His father is a plant manager for General Motors. Du Pont at this time owns 29% of GM, having bought this chunk of auto stock with cash from the sale of powder to blow away the Hun in the 1914 war. So by genetics, training and patronage Dave is well placed to be very effective in the Company structure. Until now I have viewed him as the prime decision maker. This telephone business shows me the shortness of his leash. His boss is called; his boss calls others and then Dave is told to shut down.

Roland, the control room supervisor, tells the console operator to slowly drive control rods into the reactor. Long thin aluminum rods containing lithium inch further into the reactor core. The lithium catches and holds neutrons that otherwise would split uranium atoms. Pens on the power instruments draw lines that slope downward. Then horns blow and lighted information plates tell us that the reactor has scrammed, that is, that automatic systems have taken over and have quickly shut down for us. The temperature of the heavy water coolant had decreased and it had contracted. A group of instruments had felt that we had sprung a big leak and had seen the need to take over and shut down quickly.

All this had been of great interest and entertainment to me, seeing my bosses make tough decisions, thinking about all that interesting science going on in the core and watching Roland goof and slide into a scram. I am propped back in my hydraulic corner of the control room watching the show when Dave briskly asks when I intend to shut down the hydraulics. We hurry out a sixteen page procedure all filled with valves to be closed and pumps to be stopped, all in specified sequences. This is my first time at this, and one of my two operators does not read very well. Dave stands behind my chair. I read off steps to the operators. Valves close. Pumps stop. Dave points out that I am about to skip a whole page and pump water who knows where, and that Clyde, my problem operator, is about to open the wrong valve. I do not cover myself in glory and feel a kinship with Roland and the unintended scram. In the midst of all this I look into the fishbowl behind me and see all of the day shift, big bosses and all, carefully watching.

The following night we spend eight unexciting hours removing the offending fuel assembly with the leaking fuel piece. When we arrive two nights later things are all put back together and we are ready to restart the reactor. The two preceding shifts have restarted all the pumps and have placed all the valves in the desired positions. Several hundred thousand gallons of heavy water squirts through heat exchanger and fuel pieces every minute in exactly the intended ways and amounts. Fifty gages display desired readings. My hydraulics job is done; I can watch Roland and his crew light off the nuclear fires in the reactor.

We do everything important by written, reviewed, approved procedures. The one for nuclear startup runs on for some eight close-typed pages. There are two basic jobs to do. We have to be sure that we count the neutrons that swarm in among the fuel in the core in ever-increasing numbers, and we must be careful that we remove the neutron poisons from the core slowly as we most carefully count neutrons. The big risk is that we remove too much neutron poison too quickly and that suddenly the neutron swarm overwhelms us as it catches up. This happened at an army reactor at Idaho. Some poor soul was attempting to pull a control rod up just a bit to attach it to its drive mechanism. It stuck, and he pulled harder. It suddenly came loose, and he snatched it out of the reactor core. The few neutrons lazily droning around in the core suddenly found it possible to multiply a million-fold, like fruit flies on a basket of spoiled peaches, only the neutrons do their breeding and multiplying a thousands of a second. All the billions of new neutrons split billions of fuel atoms. All this atom splitting boiled water in the rector tank into a big ball of very high pressure steam; this happened in a fraction of a second. The Idaho reactor burst and killed the four men working on its top.

I read that no rabbits lived in Australia when English settlers arrived. This meant that English foxes had little to eat, and English fox hunters had slim pickings. So rabbits were imported and released to feed foxes. With almost no natural enemies, Australia was engulfed in a rabbit explosion. This is somewhat like a reactor startup accident. Think of a safely shut down reactor as Australia with a hungry fox every square yard. Any rabbit that pops out of its hole is quickly eaten before it can produce little rabbits. If we suddenly snatched all the foxes up out of the country, a rabbit explosion would occur. If we wish to get into the rabbit business in an orderly way without and explosion we most carefully remove foxes while we diligently watch rabbits multiply.

Roland's crew eases out the safety rods a foot or so at a time. After each pull we stop and count neutrons. The neutron counter clicks very audibly every time it counts a bunch of neutrons. The clicks come every few seconds; as we ease the safety rods out, the clicks come noticeably closer together. We yawn, we pretend to be calm, but excitement mounts as the clicks pile up on each other. When the sixty safety rods are fully out of the reactor they remain posed to drop back into the core to suck up neutrons and stop the reactor if any of a number of things goes wrong. This is like having a whole trainload of foxes ready to dump into the rabbit heard if they appear to be getting out of hand. We can drop the safety rods ourselves by pushing a big red switch called the scram button; or a large number of instruments that watch things over our shoulders can drop them for us if we should hesitate or move too slowly.

We next begin to withdraw another set of poison rods. They are called control rods because some of them remain in the core at full power; we use them to control the number of neutrons in the core and thus the reactor power. We pull rods. We stop and count neutrons. We plot numbers of neutrons most carefully and compare neutron growth rates with safe limits. The clicks come ever faster. Other less sensitive neutron counters come to life and we switch our attention to them. We have snatched up about the right number of foxes, and the rabbit population approaches the desired numbers. The clicks come so fast that they blend into a continuous rattle. We drift into low power operation. A smooth show. We catch our breath, reset instruments and ease out the control rods a bit. The read line on the power calculator moves upward. We increase power to 10% of full power, full power being about 600 million watts or 600 megawatts. That is about the power required for a million light bulbs or ten thousand cars driving at the speed limit. That is a lot of power. My California wind tunnel used about 50 megawatts and shook the lower end of San Francisco Bay when it did. This reactor makes ten times the wind tunnel power with only a quiet whine from my pumps downstairs.

Another pause. Another inching out of the control rods. The neutron swarm doubles and triples. We read 400 megawatts. It is 6 AM. We sit around the fish bowl shuffling papers and getting set to write our logs. Roland flips through the first half of his startup procedure, stops, sits bolt upright and moans. He walks out into the control room, and looks over the shoulder of the operator responsible for moving control rods. He returns and tells Dave that he skipped a whole section of his procedure during startup and as a result, all the partial rods are on the bottom of the reactor tank. These partial poison rods should be hanging in the middle of the reactor to soak up neutrons there and hold down the power in the middle of the fuel. Without these rods, the fuel gets too hot in the middle and not hot enough in the ends. Because we have left the partial rods on the bottom, we are now making all of our power in the top half of the reactor while the bottom half lazes along doing nothing.

We have all sorts of limits to prevent overheating the uranium fuel and to avoid boiling around the aluminum skins of the fuel pieces. But all these limits are bases on the assumpti0on that the whole reactor is generating power, not just the top half. We do not know where we are. Radioactive levels in the coolant are normal so we probably have not melted or burned anything yet, but who knows what crazy things are happening in the hot cores of our uranium fuel pieces. Above certain temperatures, uranium metal grows and expands in ways that can crack open fuel pieces in large numbers. Dave and Roland decide to reduce the reactor power to one per cent and then ask for help and advice from the bosses.

At 7:30 I listen for an hour while Dave tells the bosses and technical crew what happened and what we have done. His performance is most impressive. He omits nothing. He passes out the blame fairly, holding his part of the bag. Yet he sounds like a hero when all is said and questioned and argues and settled. One is impressed by his alertness, his grasp of the problems and the things he did when he found our error.

As I have told elsewhere, and may include here, later, over the fifteen years from 1955 until 1970, I became one of the mid-level bosses in the reactor business at SRP. I played a role in the improvement of the safety systems that would have contained radioactive material in the unlikely event that extensive fuel damage occurred in one of the SRP reactors. For some years I was the technical boss of the C reactor, with my office actually in the reactor building, spending some 60 hours a week there.

In retrospect, I am amazed at the risks we ran in the 1950's. There was essentially no containment for the SRP reactors. In the beginning, reactor operating crews were essentially inexperience and untrained to handle emergencies. If we had damaged a reactor and the contained fuel pieces, the whole mess would have been blown, unfiltered, out of our stacks into the atmosphere and onto the countryside. We ran the five SRP reactors "in the national interest" to survive opposite Communist Russia. We all did the best we could, and we all ran risks together.

From 1955 until 1957 I work(ed) one of the shifts that operates the K reactor. My third son David is born. My family adjusts to my working at odd hours. Finally I am given a day job, still in K but working from 7:45 AM until 4:15 PM. My main jobs are relieving shift workers when they take their vacations and coordinating the continuous flow of modifications that make our reactors safer and more efficient. Shift workers generally plan their vacations to avoid graveyard shift so about half the time I work graveyard and about half the time I coordinate engineering projects on day shift.

One such job involved removing "all vestiges of segregation" from our reactor buildings. A deputation had come from Washington to inspect us and had found that the two main toilets in the reactor building has labels "MEN" on the door of one and "JANITORS" on the door of the other. In that all the janitors were black, they insisted that we address this problem. I responded by writing an order to change "JANITORS" to "MEN." This accomplished, I drafted a letter to the civil rights Washington people saying that we now had two men's rooms and no janitor's toilet.

We were again inspected. The chief inspector was a plump woman named Miss Irene with thick glasses, a high dedication to her job, and a consuming interest in toilets. This time she found that the toilet seats in the two toilet rooms were of different colors, the ex janitor's being white and the ex men's being black. She fixed me with her magnified eyes and required that we remedy this problem. I fear that I viewed all this as a more or less comic interlude in the endless serious job of keeping the reactor running, and I asked here whether the seats should be all white. She felt that black was beautiful, and so all the seats became black, by edict directly from Foggy Bottom (Washington, DC).

I drafted a second letter saying that all our seats were black. The Plant Manager changed a word or so and sent it on to Miss Irene. She returned for yet another inspection, and expressed concern that evil and reactionary people might undo all the good things were had accomplished just as soon as she turned her ample back. And there philosophizing about civil rights in the middle of the old janitor's toilet, inspiration struck me, and the concept of connected toilets was born. Why, I asked Miss Irene, could we not have a single grand toilet for ever and for all people? Why could we not cut a large walkway between the two toilet rooms, since they shared a common wall?

I knew full well the reason why such a grand promenade between toilets was impossible; the wall in question was concrete and was six feet thick, filled with reinforcing steel bars as thick as a baseball bat. That wall was designed to hold up the roof with Russian atom bombs exploding in the sky above. In puckish humor I had pitted the irresistible force of social change against an immovable wall. Miss Irene was neigh overcome by the merits of my proposal. She saw in me a secrete ally; she supported the unitary toilet concept completely.

I drafted the necessary orders and awaited the inevitable squeals of pain when cost estimates for the job hit the boss's desk. I was not disappointed, $80,000 for the job, and of course the other four reactor buildings had to follow suit. I began to get a name for myself as a close ally of Miss Irene and Company, and this job began to get more attention than I had intended. I felt strongly that Miss Irene and her crew had been riding too high, and I awaited with anticipated pleasure some clipping of their tail feathers when this absurd job got scuttled.

I had a lot to learn about civil rights. The money was approved without a batted eye and the highest priority was assigned to the job. Out came the jack hammers and cutting torches. For weeks we battered through steel and concrete. Some measure of protection from Russian bombs was sacrificed to prevent evil people from rolling back civil rights progress. And today a beautiful archway connects the two toilets in the SRP reactors.

Perhaps in recognition of my contributions to the progress of civil rights at SRP, I am transferred from the Reactor Department to the Reactor Technology Section. A word or so about SRP's organization may be helpful. The Reactor Department actually ran the reactors. They started them up and shut them down. The people who turned the switches and read the gages all worked for the Reactor Department. Most of the Reactor people were operators without much technical training; most were ex textile workers or cotton pickers or recent graduates from local high schools. The Reactor Technology Section provided technical support for reactor operation and was also responsible that the reactors ran safely. The Reactor Tech people made sure that flows were correctly specified, the correct fuel got charged into the reactors, that the needed alarm settings were provided and the like. Also they acted as on-the-spot spies to verify that procedures were indeed followed and that safety limits were met. They could speak and write to the big bosses directly if they so desired. All of the Reactor Tech people had technical degrees of one kind or another. The Reactor Tech bunch of that time was pretty high-powered, and many went on to positions of responsibility in the nuclear industry.

The head of Reactor Tech, Dr. J., dominated the group by both his intellect and his personality. He was a real tail-twister and probably the best boss that I ever had. He was SRP's Admiral Rickover. In the best of the Rickover tradition, he mercilessly badgered the big bosses into making safety changes promptly and correctly. He carried all of the technical details of the reactor operation in his head and in a small spiral notebook that lived in his back pocket. Early in the game I attempted to gloss over some uncertainties about a question put to me by the good Dr. J. with a guessed-at number.

"Now wait a minute, Fred. Two weeks ago you wrote in the Monthly Report that those flows were 22 gpm, and now you tell me that they are above 35?"

Quicker than my cowboy here, Tom Mix, with his six-gun, out comes the spiral notebook and I learn never to guess with Dr. J.

Dr. J defended two main principles to the death: tell it like it is and make the Wilmington bosses hold the bag with us who ran the plant locally. He was vital during the startup phases, and more that any single man he ran SRP. We saw problems; we presented them to Dr. J. If we passed his tests, and they were most thorough, our problems were quickly solved.

Dr. J's boys lived in an old construction pipe shed inside the C reactor fence. The floors were concrete. Bare I-beams stuck through the cheap fiber tile ceiling. Our window air conditioners had been scavenged from abandoned construction field offices, and on any given day in August only about half of them worked. We worked in glass-partitioned cubicles. About half the glass was missing, so it was somewhat of a zoo. It was hard not to become aware of the more interesting telephone calls.

"How is daddy's little sweetheart today. Yes, daddy loves you this much! No, Lynn, honey, Daddy doesn't have time to talk to Rover now. Lynn, honey, please don't cry. I just can't talk to the dog now. All right, Lynn put the dog on the telephone."

Pause. By this time the whole office has fallen silent. Somehow this most unusual conversation has penetrated our concentrations.

"Yes, Lynn honey, I did talk to Rover. Sure he heard me. You listened and couldn't hear what I said? Well, it was dog talk and I'm sure Rover understood. No, Lynn honey, I don't have time to say it again while you and Rover both listen. Lynn honey, please don't cry. All right, put Rover back on the telephone."

Pause.

"Arf! Arf! Arf! Woof! Woof! Yip! Yip! Ourrrooough!!! There honey, did both you and Rover understand?"

For the rest of the afternoon Frank's telephone rings off the hook as the story spreads over the plant and various of Rover's friends call Lynn's daddy with a variety of arfs, woofs and howls. The secretary delivers a stack of messages from Mr. Dogg, Mr. Poodle (accent on the last syllable) and their assorted associates, and someone claiming to be the head of the county Democrat party invites Frank to become animal control officer, he being able to speak the language.

At this time I cut my teeth on reactor safety studies.

At first, the AEC reactors at Hanford, Washington and at SRP were the only reactors of any size operating in the country. AEC reactors were the standards for safe operation, and we operated "in the national interest." That is, we did the best we could, and then the whole country took its chances in order to keep the Russians in check. But after five to ten years, new power reactors begin to spring up with new and improved safety standards. We come under increasing pressure from both ourselves and the outside world to keep up.

A major new feature required of power reactors was containment shells. A steel or reinforced concrete shell or can is built around the reactor of such a strength to more or less complete contain all the do-bads in case the reactor explodes in the worst possible way. It is like putting a tin can around a firecracker so that all you hear is a faint ping when it goes off and not one whiff of smoke gets out. The containment shell is what you see when you drive by a power reactor or see one from the outside on TV.

Three of us in Reactor Tech looked into building containment shells around the already constructed SRP reactors. After much suffering with the Du Pont Engineering Department, we reluctantly concluded that it was just not practical to back fit containment to our reactors. Instead we recommended a collection of changes that went part way that we called Partial Containment. These changes basically involved putting filters in the air exhaust ducts from the reactor building designs to catch and hold most but not all of the do-bads in case reactor fuel was damage in large amounts. With Dr. J. in charge, we never claimed that our partial system was as good as newer containment shells; his stand was that it was the best that could be done, that it was a whole lot better than the nothing that we had started with, and that so long as the country needed plutonium and tritium to survive, our only other choice was to build new contained reactors for a billion or so.

For several years we lived with calculations involving 20,000 deaths in Augusta and 20 billion (1965) dollars worth of damages to local real estate. We spent weeks following step by step what might happen if a pipe broke in just the worst place and then half the fuel melted and then the control room crew was killed or fled the scene and so on. Being a natural worrier, this job fit me well.

Some of the off shoots of these studies are interesting and amusing. Reactor procedure people, surely exercising some graveyard humor, produced Disaster Plans for use following major accidents. On section required that hundreds of workers assemble in the area parking lot and there await instructions form the plant patrol force. This presented several problems. Radiation rates in the parking lots could have been such that all would have been cooked to death in 10 to 15 minutes, and it staggered the imagination to contemplate that the patrol force could even assemble themselves and find the correct procedure in such a short time, much less herd 100 panic-stricken cars into a caravan before all were dead. When we reviewed these procedures with the patrol group, comments led me to believe that the more they understood the situation, the more likely was their most prompt departure for distant parts as soon as the alarms sounded.

Another section of the Disaster Plans actually suggested that workers seek cover in the nearest road culverts. When I read that, I made it a point to drive the roads within five miles of the C reactor and check on these recommended havens. Suffice it to say that the culverts would have been mighty crowded. My own plan was to quickly check the wind direction, the maximum risk being under the do-bads being blown down-wind from the reactor stack, and to run up wind cutting my way through the security chain link fences. For this purpose, I kept a pair of bolt cutters in my bottom desk drawer. One of our more alert assistants was of the opinion that the maximum risk was to slow movers between him and his new Chrysler automobile, and that once he reached his car his risks would be small unless the do-bads were being carried by 100 mile and hour winds.

The reactor central control room was full of alarm sounds, each with its own special meaning. One horn went "ARRRRRRRRR..." until it was silenced; it said that the reactor had automatically scrammed (quickly shut down). A loud continuous bell said that one of the main circulating pumps had failed. Another bell went "BING" pause "BING" pause..." indicating that a temperature was too high or a flow was too low. And so on. Some felt that a new and special sound was needed to show that something very serious was afoot, that fuel damage was present or likely, that emergency cooling systems ere activated and that everyone's attention was demanded. By this time our design crew had grown to include a representative from the reactor department, and the new sound concept was his.

My view was that the control room was too noisy already, and that if things really flew apart, the last thing we needed was a new and louder horn to further increase the chance of a heart attack in those few brave enough to remain. My boss pointed out that in commercial aircraft a soft an soothing female voice purred into the pilot's ear: "Your left engine is on fire. Please activate your fire extinguisher." My own suggestion was that a comforting rendition of the spiritual "Wading in the Water, Children" be piped into the control room speaker system whenever the emergency cooling water systems were actuated likely flooding the reactor building.

This new-sound debate continued for months with the reactor man the butt of much humor. We could not have a planning meeting without suggesting new and special sounds for his serious consideration. I was one of his chief tormentors. Finally an edict came down from on high that a new special sound was needed and that our design group should specify exactly what it should be. We delegated this selection to our reactor member, and he made a major thing of it. Six of us designers traveled frequently to the Du Pont Engineering headquarters in Wilmington, Delaware to iron out various design problems. On one such trip I was lured into one of the small test laboratories on some pretest and maneuvered over close to a test bench. Suddenly the world came to an end! Gabriel's horn sounded with and intensity that would untie your shoes. I climbed for the high ground, and reached the top of the work bench before the din ended.

I had just been given a blast of the new sound from the loudest truck air horn made in the free world, and the books had been balanced for six months of humor about soothing spirituals and seductive female voices.

After five years in Reactor Tech, I am promoted to Senior Supervisor and I am placed in charge of the Reactor Tech group actually station in the C reactor building. This was probably the best job that I had at SRP. About five of us were responsible for the safe operation of the C reactor, and during this time we did some very interesting things. We made large amounts of curium for power sources for space exploration, and we achieved the highest neutron fluxes ever produced, $3x10^{15}$ per square centimeter per second.

Unfortunately, Dr. J was removed from command about the time I went to C reactor. This was the beginning of major change. I did not realize this at the time, and things changed gradually. Frank, Dr. J's replacement, was also a exceptional man, but I suspect that he saw the handwriting on the wall in Dr. J's fall from power.

A course on how to get along in the large organization should be required in all of our colleges. Knowing no better, I began to get into big trouble.

After about a week in C on my new job, Otto, my new boss calls and asks with some metal in his voice:

"Fred, are you sure that you are meeting the Technical Standards in C?"

"No, Otto, I'm not."

"Why?"

"Because I have never read the Technical Standards."

It had not been an easy first week, and I had not been taking my ease in my new empire. But this was not the expected answer, nor the desired one. If I had but had that college course on how to get along, I would have assured Otto that I was thoroughly familiar with the Technical Standards and that we met each one of them. As soon as I got off the telephone I would have fished out the standards and boned up on them. This was Otto's intent. However the fat was in the fire.

"Fred, please stop everything and read and memorize the Technical Standards. Please make sure that you live by each one. Please write me a memorandum telling me how you know that you are doing this. Please have this memo on my desk by Friday. Please be aware that deviating from a Technical Standard is a most serious offense, and please call me immediately whenever you find yourself outside Technical Standard limits."
"Yes Sir."

I open my safe and rummage for my copy of reactor Technical Standards. I open it to the first standard. It says that no pit or imperfection in the aluminum skin of the uranium fuel pieces shall be more than ten mils deeps. It goes on to say that the reason for this limit is that the skin itself is only 25 mils thick and leaks in the skin can lead to a mess in t the reactor. That sounds reasonable. I close the book and return it to my safe.

I go over to the Maintenance tool bin and check out a depth micrometer, a tool for measuring the depths of scratches, pits and the like in metal surfaces. I go to the Assembly Area of C reactor and ask the reactor foreman there to fish out a box of slugs for me. Uranium fuel pieces called slugs are shipped to C for insertion into fuel assemblies which are subsequently loaded into the reactor. The fuel pieces are cylinders about a foot long and about and inch in diameter. I am given a typical box of fifty slugs. I take out the first slug and carefully begin to examine it for holes and scratches.

I find three holes more than 10 mils deep and a squashed area on an edge of an end almost half way through the cladding. I put the slug to one side. I look at about 25 slugs and reject about half of them because they do not meet the Technical Standard limit. I also find that serial numbers have been stamped on each slug that are 15 to 20 mils deep. I wonder why 10 mil scratches are bad and 20 mil deep serial numbers are fine.

"Otto, I find that about half of our slugs do not meet the Technical Standard limits. This is the immediate notification that you requested when we talked this morning."

Otto comes over and measures some slugs himself. He calls his boss. We wind up with a dozen bosses of various levels of various departments. Everybody takes a turn at slug inspection. After several hours it is concluded that while the standard says ten mils, it really means something else. I get a long lecture about how it is really within the standards to use the slugs with holes over ten mils, but not having had that college course on how to get along in the big company, I fail to understand.

I hear no more about meeting standards, and the Friday deadline for Otto's memo passes without notice. I miss the deposed Dr. J.

Every Friday the whole Reactor Tech staff meets to discuss the happenings of the week. Each of us from the five reactor areas reports on what has transpired in our particular reactor. In one such report I go over some error in C that resulted in part from not following on the thousands of procedures that had been prepared for all of our important jobs. Otto's boss has three favorite questions; he trucks out one of them for my benefit and education:
"Fred, don't you follow procedures in C area?"

The expected answer is:
"Yes Luke, we do, but in this case….squirm….excuses….evade… fix the blame elsewhere…."

Instead, not having had that college course on getting along, I find myself saying: "No Luke, we do not follow procedures in C area, and neither does anyone else."

A hush falls on the room. Luke turns red. I get an hour's session from Otto after the meeting on how we always follow procedures for everything and how this is the very basis for safe operation at SRP.

I return to C and for the next six weeks I and my staff of four spend most of our time auditing compliance with procedures. We limit our attention to what happens when an alarm sounds in the central control room requiring that certain so-called "emergency actions" be taken or check be made. We find that two thirds of the time procedures are not followed. I invite Luke and his boss, Dr. J's replacement, to a presentation of this data. They look glum and have us give a repeat performance for the reactor big bosses.

I am not asked about following procedures in C area again. I get a big black X behind my name. Oh, Dr. J where are you?

THE WILD MEN FROM CALIFORNIA

At the very top of the management heap are the Atomic Energy Commissioners. I think there are five of them. One of them, Dr. Glenn, is a wall-eyed super scientist form the state university in California where much of the nation's nuclear research is done. He feels that one of SRP's reactors should be diverted for a while and used as a research tool, and what Dr. Glenn wants, Dr. Glenn gets. The plan is to load up the C reactor such that we cook up the thickest neutron swarm possible.

The purpose of this high neutron flux is to make new elements that only last a second or so. This is very important and high-powered research, and can be done only by the most potent of nuclear physicists. A crew of these advanced thinkers descends upon staid, conservative SRP. Their leader, Dr. Harry, is an old-time buddy of Dr. Glenn, the AEC Commissioner, and the group includes a wild man from Norway.

The contrasts are startling and refreshing. SRP is ten years old, and we have an average age of about forty. Most of our youthful rough edges have been rubbed off, and we Du Ponters walk pretty much in lock step. We all wear big, round-toes, ugly safety shoes. We wear safety glasses almost everywhere we go. Horseplay is strictly forbidden. A pyramided, military-type discipline is very much in force. Conservative dress codes are the unquestioned rule. The California team arrives in open-toes sandals and one mechanic wears no socks. Hawaiian shirts of bright colors are worn with tails outside the pants. The Norwegian team member is want to go barefoot and spring to the top of a file cabinet, flap his arms and crow like a chicken. They are a dedicated, very likable, productive bunch, but they march to a different drum.

The area superintendent welcomes them and gives them a stern lecture about how we do things at SRP. I escort them to their work area and hang around to watch them hook their counters onto our rabbit. Basically, they will stick a small amount to Californium into the reactor where the neutrons are the thickest, cook it for a while there, and then snatch it out as fast as possible. The hope is that some of the Californium had been transformed into other new elements as yet unknown to man, and if they are quick enough, they may be able to detect the new elements before they disappear. For this work we have made a device like the one that takes your money to the bank teller form your car at the bank drive-in window. A small metal can dashes into a hold in the reactor, rests there for a while and then dashes back out. This machine is called a rabbit.

They work in the rabbit area until quitting time. I ask Dr. H if he has what he needs, and I go home. Dr. Harry and his crew work on into the night to be ready for tests the next day when the neutrons will be the thickest at the end of the rabbit hole in the middle of the reactor. At about the time I sit down to supper with my beloved family, Dr. H decides that he needs a special wrench, and asks one of our mechanics to get it for him from a locked cabinet. Now our mechanic has never seen such a wild looking bunch before, and he does not like to see bosses working with tools, such being forbidden at SRP as part of the package to keep labor unions out. The DuPont mechanic declines to get Dr. H the tool explaining that those tools belong to the day shift foreman and are not available to shift workers. He goes on to lecture Dr. H about how he takes bread out of the mouths of honest American workers be doing their work. He adds that he might feel compelled to call Mr. Bill the next day and report that he had seen Dr. H doing forbidden work.

Such a threat to one of us would have filled us with terror, and would have reduced us to trembling impotency opening visions of sessions with the Plant Manger and ruined careers. Unfortunately, Dr. H has none of our background on the compelling need to grovel when a worker mentions a labor union. In his ignorance of the system, Dr. H calls his buddy, Dr. Glenn, the AEC Commissioner, just in the middle of Dr. G's cocktail hour in Washington, DC. He tells Dr. G that Du Pont won't give him the wrench that he needs to discover new elements at SRP. The Chairman calls the Company President in his Du Pont mansion with sheep on the front lawn in Wilmington, Delaware; he calls the appropriate Vice President, and this message about the wrench tumbles down hill towards me at my supper table in Aiken.

Avalanche-like, the wrench message grows in volume and priority as it rolls down hill through about eight levels of supervision. My first indication of Dr. H's need for a wrench is the appearance of my boss at my front door demanding that I leave for the plant with him immediately.

We arrive in time to find the Superintendent of the Maintenance Department personally unlocking the cabinet in question and delivering the wrench into Dr. H's hands. I am told to spend the night with Dr. H, and to cater to his every wish. I am exposed to the ultimate in naked power. I have but to mention Dr. H's name and whole machine shops stop to build a modification for Dr. H's rabbit. The wild Norwegian loses his security badge and is taken into custody by the local patrol force. One call to the head patrolman springs him free. Our safety engineer makes threatening noises about stopping the rabbit work until people learn to wear the required safety equipment. I make on telephone call and the safety engineer disappears from the rabbit area for a week. I am fortunate that Dr. H promptly finds his new element and departs for California; lengthy exposure to such power would have corrupted me beyond redemption.

CONCLUSION

Oral History Interview – Mark Collins

Mark Collins is a native Georgian.* While working as a police officer, he put in an application several years before he was ultimately hired at Savannah River. His first job on site was as part of the L-Area start up, later transferring to K-area. During that period, from 1981 to 1984, he worked in the Reactor section. He then transferred to the tritium facilities, where he was a maintenance mechanic from 1984 to 1989. From 1989 to 1997, Collins was in charge of the off-site leasing program. During that period, he was construction liaison for all the off-site buildings. Since 1997, he has served as facility administrator in the SRTC area, and as facility administrator for F- and H-Areas.

*Personal information has been removed from the transcription

Interviewee: Mark Collins

Interviewer: Mark Swanson, Historian with New South Associates

Date of Interview: October 20, 1999

MS: This is an interview with Mark Collins, conducted by Mark Swanson, Historian, with New South Associates, being conducted on the 20th of October, 1999. This interview is being conducted as part of a Savannah River Site History Project, which is documenting the 50-year history of the Savannah River Site and its impact on the surrounding area and the people who lived in that area. The interview is being conducted at the SRS History Project Office. If you would, just for the record, state your age and date of birth.

MC: I'm forty-three.*

MS: And your relationship to Savannah River Site, I mean just what you do here work wise?

MC: Well I'm not sure. (laughter) What you mean, in what—

MS: Like what kind of work did you—I mean what kind of jobs have you had here?

MC: Oh okay, okay. Well I— When I first came in, I came into— I was hired as part of LSPT startup, which is L-Area start up, and I was hired in (unintelligible) as a general operator in production. And worked in Reactors from '81 to '84 and then went—and from—moved from Reactors to Tritium. From '84 I was a— In 1984 I went from there to 1989 as a maintenance mechanic in Tritium and I worked in there in the process and everything else out of that. And then from '89 to '97, I was in charge of the off-site leasing program when we moved off site. I was construction liaison for all the off-site buildings and— And then from '97 to the present I've been doing—been facility administrator in the SRTC area. Now I'm the facility administrator for F- and H-Area, taking care of all the admin facilities in those two areas.

*Personal information has been removed from the transcription

MS: Okay, how did you find out about the project at the beginning?

MC: Well, it wasn't really the project itself. I was—just trying to get a job out here. And I put in a application for several years before that, and they just happen to call my number. (laugh)

MS: Okay. If you were not already living in the area, where did you come from?

MC: I was— I lived in the area. I been living here all my life.

MS: Oh you did? Okay. Let's see— When you first moved here, were you living in the Aiken area?

MC: Yeah. Lived in Belvedere in North Augusta all my life.

MS: Okay. Okay.

MC: Home-grown.

MS: Okay. Okay, so we don't have to ask a lot of those questions. Had you ever worked for the Department of Energy or Atomic Energy Commission?

MC: No, not prior to coming here.

MS: Okay. When did you say you started working here?

MC: In 1981.

MS: 1981, okay. Were you a Du Pont employee prior to working here?

MC: Yes.

MS: Oh you were, okay. What did you do for Du Pont?

MC: Basically the same thing. I just transferred on into Westinghouse whenever they come over. All it was, was color of paycheck. (laugh)

MS: Oh okay. What color paycheck did they have? (laughter)

MC: I don't even remember. But uh—

MS: Those are the kind of details we don't get very often.

MC: No we just rolled over. I think the checks we had before were yellow they went up to blue. Blue and green, I think, a little bit of both of them.

MS: Had you had any previous experience working at an industrial plant prior to working here?

MC: No. I was a police officer before I came here.

MS: Okay. So you've been part of this community for a while then. The next series of questions pretty much deal with construction employees, and a lot of those will not be applicable. Did you have any experience with ongoing construction here at the site?

MC: No.

MS: Pass on those. Just for the record again, if you wouldn't mind stating when did you first start working at Savannah River Plant?

MC: 1981.

MS: These series of questions are for like all employees, technical and general operations. Why did you want to work here or were there any reasons for not wanting to work here?

MC: Well, the reason I came here was mainly for the money and the possibility of having some place to retire from, and I was in police work at the time and the pay (laugh) wasn't a whole lot and the future you wasn't really sure.

MS: Yeah I imagine. Where did you work, in Augusta or—

MC: Well I worked for North Augusta Public Safety for a while then I worked with Aiken County, and I left there to come here.

MS: How much did you know about the Savannah River Plant when, what it made here, when you first started working here?

MC: Well, my father-in-law had worked here prior and he was still out here when I first come on. And back then in the eighties, you didn't know a whole lot about the site. It was not publicized like it is now, where every time you open the paper you got a article in there. Back when I was first working here, everything was hush-hush. But you knew— You knew they made nuclear weapons out here—nuclear material for the weapons, that's about it. You heard all kind of stories (laugh) what went on out here, but never was really sure.

MS: Yeah, I'd imagine so. Was the mission of the plant—I guess the military mission—was that a reason to want to work here or not to work here?

MC: Well it made you feel good you was doing something for our country.

MS: Yeah. What was your very first job assignment?

MC: Well, I worked in the L-Area, in what they refer to as center section. That's where the operation of the building itself, valves (unintelligible). At the time, L-Area was down, it was dead, and we were just trying to get everything back into shape so we could open it up, and so it was—did a little bit of everything.

MS: Right, so you were there pretty much for the whole L restart effort and all. How many people did they have working on that, do you remember?

MC: Whew. I'm trying to remember. I'd say at least a couple hundred at a time, it was pretty crowded.

MS: Yeah. I know you've already gone through this, but just in sort of a general way, what were your major positions while you worked here at the plant?

MC: Well my major position was in the 100 areas, I was a component handler, what they call CH, worked in Component Handling. We handled the fuel and loading and unloading the reactors, preparing the load for the next—next trip through the reactor. And then from '84 to '89 I was a maintenance mechanic in Tritium. And from '89 to '97 I was the off-site manager for leasing, and then from this point on I've been facility administrator in Facilities and Services Department in F- and H-Area.

MS: Okay. How did you— Next question's kind of trying to get at like how people moved around from job to job within the plant. Was it something that you like put in a request for or was it sort of like—

MC: Yeah. If you was like in Maintenance, want to go to E&I or whatever, yeah you could put in a—a formal request. There's a form you had to fill out, I don't remember what it was. But you had to fill out a form that you were willing to switch over. You could go to E & I and within a few months you could be back in Maintenance or you could go to Health Physics or whatever else you want to do, you could move around pretty good in here.

MS: Okay.

MC: Now you can't do that. (laugh)

MS: Oh you can't do that?

MC: Um-um.

MS: Why not?

MC: You're basically locked in where you at.

MS: Oh really?

MC: Yeah. There was a lot of free movement at one time.

MS: Was that back in Du Pont times or—

MC: Yeah, back in Du Pont. I remember you could— We had a lot of people that came in as a— When I went through E&I school and got through with E&I school saying, this isn't what I want to do. And the very next day put in a thing (unintelligible) maintenance (unintelligible) or whatever. You had a lot of movement.

MS: Hm. Why did they lock it in later years?

MC: People switching. They spent so much time on training and money and then the next thing you know, you don't do it. And that (unintelligible).

MS: Du Pont was more tolerant of that?

MC: They were for a while. (laughter) They got tired of us moving around.

MS: Okay. That's good. What were the pressures to your job, if there were any, like production quotas or—strict adherence to procedure?

MC: Well, in the 100 areas it was—getting the load ready on time. In the I ended up in, it wouldn't— Once we left L-Area, because it was still being, getting worked on to get started up, I went to K-Area and they—the reactors there worked on a thirty-day cycle and you had to get the load ready in thirty days, have it ready to go into the reactor in thirty days, and that was— You had to load the slugs and the columns of slugs and the fuel and have it hanging, ready to go into the reactor within that thirty days and so— And it took you a full thirty days of loading. You'd get about thirty of them a day and it took like three hundred columns so you figure that and the fuel plus testing it, it took you right to the last minute. A lot of time we worked overtime to get it ready.

MS: Out of curiosity, how exactly did you do that? I mean, I've seen the inside of the reactors and I know roughly how, in theory, how it was done, but how do you load thirty a day?

MC: Well the material would come in crates. It was slugs and they were—a outer slug and a inner slug. Each one of them weighed— I don't know, I think the outer slug weighed twenty-six pounds, the inner slug fifteen, sixteen pounds.

MS: You talking about like a tube or something?

MC: Just a canister-looking thing about a foot long roughly. And they had a inner target, which is just a pole which resembles a chain link fence pole. And you'd load— In the reactor, you'd put the pole down into a test—what do they call those things—test capsule, and then you'd load the slugs on there and each column—each column took about eighteen slugs. And you had to put the— You'd put the outer slug on there and you slide the inner slug on there—outer, inner, all the way until you get to the top then you'd take it and you'd put it in a metal thing and pressure test it and see if you have any ruptures in the seals. And then you'd—that basically would test it. And you'd put it in—hang it in there in the room until time. Each of them had a number. They were all numbered. It had to go in a certain way and come out a certain way, and so you couldn't just randomly just stick them in there; you had to put them in order.

MS: Did y'all use the universal sleeve housing for that? I think that was like— That may have been just a device to lower it into the reactors. I can't remember the specifics.

MC: The C&D crane lowered it into the reactor. We loaded— We'd take it over to the, what do they call it, the point. And then the C&D crane would come over inside the containment room where the reactor is, pick up the load of slugs and take it over to the top of the rector to a certain position on the reactor and then drop it—they'd lower it down into it.

MS: Okay. And they make the— The universal sleeve housing I think is actually already in the reactor so that probably—

MC: Yeah, they'd lower it in to that—

MS: In that casing I guess or whatever.

MC: Then just take one out and then take a hot one and then bring it out and lower that straight into the water into the C&D canal and then go out into the disassembly basin.

MS: Oh, okay.

MC: (unintelligible) in disassembly, which is where all the water was. And he would take it and take it from where the crane would lower it into the canal. And he had to do some finagling there with the hand-held tool to catch the top of it, hook it onto a— I can't remember all these terms. But there was a—

MS: I never knew them so—

MC: He'd catch the top of it. I was really interesting how they had this— Somebody done some thinking a while back. (laugh) And it'd catch the top of this column. And these slugs— Those column, (unintelligible) weighs over a thousand pounds. I mean, all these slugs at one time and they're coming out and they're hot, still real radiated plus the actual touch is hot (unintelligible). And you'd take this and you'd lower it—hook it on a thing that you drop down into the water—pole you drop down into the water. You'd kind of like hook it onto that. And then you'd take it and transfer it into the basin into a position. And it'd hang there for so many days, like 180 days until it got cooled down enough you can handle it, radioactive wise. Then you'd take it and de-stack it into a bucket, ship it. The interesting things would happen when you dropped that column of slugs. Because that thing would hit the ground on the basin, which is about 40 feet down, and it'd crumble all up into a little ball, because these things are real hot. It just collapse it, total just collapse from all the weight.

MS: And that's what you wanted, right, it's—

MC: No that ain't what you wanted. If you didn't get it out of the floor in four hours, criticality—

MS: Oh okay, okay. Well how do you keep from that happening? You just don't want to drop it, is that the thing?

MC: Well, you don't want to drop it, but they did drop them. On a routine basis, they'd drop one or two almost every shutdown. And it's usually a panic mode when that happens and we had a procedure you follow when it did it. And you had— The main thing you had to do is get it off the basin floor, because if it didn't they'd go on through—just eat itself on through wherever. (laugh) But you had four hours to get it up off the floor. And you'd put some rope down there, you'd catch it, you'd bring it up off the floor and you just leave it hanging until you got a chance to go in there and put it on the cutting press and cut it into sections and take the slugs off a piece at a time, which it was a nightmare underwater, trying to do that.

MS: What kind of equipment was used to do that? Did you have like—I guess—

MC: Well we had underwater saws and chainsaws. Mostly it was (unintelligible).

MS: Did you have like mechanical arms that would go down in there to—

MC: Most of the stuff we had was tongs, what they call tongs. And they'd be like 20-foot long tongs and stuff like that, with a little handle at the top. And you'd use like that. Now (unintelligible) you'd use a chainsaw for stuff like that. But far as taking something light under water, you'd use the tongs and you'd reach down and grab it and— This guy here on the site invented that, invented those tongs. He realized he could patent that and make a lot more money offsite, so he took his little idea offsite and sold it back to the site and made a killing.

MS: Oh really? (laughter)

MC: A lot of technology went off the site back during those times and people would sell it back to the site.

MS: Yeah, wow that was pretty good. I'm surprised that Du Pont didn't insist on keeping that stuff.

MC: Well they tried to in a lot of cases, but sometimes these guys would get—be gone before they would and they could patent it and—before the site. But now they got some laws out where they can capture that before you get a chance to do it.

MS: Yeah right.

MC: A lot of people used to pick (unintelligible).

MS: It may have been that— I can't remember now the details but Atomic Energy Commission may have like made that a—well by that point Department of Energy—may have been a no-no (unintelligible). Okay. I'm trying to think of any other questions it'd be good to ask about changing and— When it comes to this— Talking about fuel targets that were put into the reactors and everything, you're talking about loading them up into— Now this— Each of these have got—are they like tubes? Are these tubular elements that you're talking about or—

MC: Yeah they're almost like—

MS: (unintelligible).

MC: Almost like— Well you get your pole, which is the inner target and that basically was—in most cases was scrap at the end of the pro—at the end of the cycle. You take that and you cut those up and you just destroy them, smash them up and get rid of them. But the slug is what you would keep, a Mark—that's a Mark 31 slug. And they're basically I'd say about a foot long, near—just round. And then on the inside there you had the inner target. And on the inner target they got little like wings. They kept them away from (unintelligible).

MS: Yeah, keep (unintelligible) their channels.

MC: Keep it in channels. And it looked basically like pottery, that's what it looked like, except it was just heavy, like lead pottery. But—canisters. I think outside of it was cadmium.

MS: So when those things are stacked up and everything, they were set up so the water could channel through.

MC: Yeah. They'd be right on top of each other and just— And then you got the pole in the middle and you got the tube at the top. And then you'd lower them. You'd grab the top of them— The C&D thing would grab it and just (unintelligible) straight into an address, the position on the tank, and take out another one and just one big cycle (unintelligible). And then you have some Mark 51-As and stuff like that (unintelligible) targets, which is just a— It looks like the part you throw away, but it's—actually it was a keeper. And that's where you get the tritium out of and stuff like that. They'd extract tritium out of those, lithium, stuff like—lithium.

MS: Yeah, lithium-6 I think or—

MC: Yeah. Control rods and— You got control rods in there (unintelligible).

MS: Yeah. In the old days, that was the only way they could make tritium, I think, was in the control rods and then they— Of course they did it differently later. What they had Mark 22s, I think, was a big one for tritium production.

MC: Um-hm, yeah Mark 22—

MS: Were there any differences, like in the different marks that—in the loading process?

MC: Well different reactors had different loads. P-Area had the bigger tank. The reactor tank was deeper there than it was the rest of the areas. It was about two foot longer, and it handled a certain load. And I can't remember if it was— I think it handled the Mark 22s. It was the load that took 180 days to go through a cycle, whereas our— And most of the loads, like in K-Area and C-Area is 30-day cycles. That was because they had the slugs mostly and the shorter tanks. And the Mark 22s, I'm pretty sure—I think the Mark 22s were in the P-Area reactor tank, because they had the longer tank. And it took the tube—the actual fuel rod was longer than the (unintelligible) by about a couple of feet. Otherwise, (unintelligible) the top.

MS: Okay. What do you see as your most important responsibility in your job? These questions are kind of general.

MC: What in the reactor, I guess?

MS: Yeah.

MC: Probably getting the product ready for the next cycle. And then we had— That was an assembly, then you had disassembly. (unintelligible) two different factories—one was getting the part ready, the other one was taking the part and shipping it. So it's either taking a part and shipping it and—or getting it ready or doing the actual shutdown. That's basically the three parts of my job.

MS: Okay. What did you think about Du Pont's management of the plant when you worked there?

MC: They were people oriented. They were really concerned about your safety and I think they meant it, personally. I'm not so sure if Westinghouse feels that way. They talk it. But— They were a good company. West—I mean DuPont was a good company. I hated to see them go.

MS: What about Westinghouse's management?

MC: Well, I guess they had a different philosophy. I know when they first came in here it was hire, hire, hire, and—and then right after that, it's fire, fire, fire. (laughter) They were known for that, bringing in a lot of people and then next thing you know turning—cutting them loose. And they did. We ramped up to 25,000 out here and then right after that they had about ten thousand cut. So—

MS: Yeah right—

MC: They hired for a lot of projects that never happened.

MS: Right, yeah. Did you win any awards for safety or production suggestions or anything like that?

MC: Well during my time I've won a lot of awards for safety excellence.

MS: What was the attitude toward safety at the plant among the employees and among managers?

MC: Du Pont?

MS: Yeah, we'll start with Du Pont.

MC: Well that was first, as their priority, safety and— I don't know, I believe it's on Westinghouse's list, just not sure it's at the top.

MS: Right. The other part of the question was, Did that attitude change over time?

MC: I think it has. They don't put it much— It don't seem like I see as much talk about safety as I do at Du Pont. Du Pont had the flags flying in the areas of safety and the bulletin boards all over, everywhere (laugh) on safety. I mean, almost nauseating, with so much of it. They did, they almost brainwashed you to think safety, (unintelligible).

MS: What were the most important measures that were in place to insure the protection of your health? This can be either during Du Pont, Westinghouse or just in general—

MC: Say that again.

MS: Yes, some of the questions aren't phrased real well. (laughter) What were the most important measures that were in place to protect your health, whether it was like the little things that (unintelligible).

MC: Well we had the TLD badges and different dosimeters and stuff like that to keep up with your—how much rate you got.

MS: How often did they check that stuff, or were you required to check it yourself?

MC: Well we checked ourselves and then monthly had to turn them in. And a lot of times when you go on a job they would have (unintelligible) side by side and they'd check you with the different meters and stuff. You'd be walking around here in a plastic suit with rubber gloves. They'd be behind you and they don't have anything on but a lab coat that they (unintelligible) they took pills to keep from getting the radiation (unintelligible).

MS: Yeah that'll work, yeah.

MC: And they'd be right behind— (unintelligible) with a meter. And here you are sitting there working on something, you got five pair of rubber gloves on. You looking back and just shaking your head.

MS: And this pill would take care of that? (laugh)

MC: (unintelligible) take pills you don't get no radiation. Yeah that was (unintelligible).

MS: (laugh) What did they just think they were immune or—

MC: I think so. I (unintelligible) imagine them (unintelligible).

MS: (laughter) What was the attitude toward security at the plant, and how did that change over time?

MC: Well, I think they had Du Pont Patrol out here and they was kind of like, I don't know, Andy of Mayberry. Then they went to Wackenhut, which is a lot more stricter and a lot more of them. I think it got a little tougher, security wise. It's kind of eased off a little bit in the last few years as the Cold Wars kind of fell off. But they still check you pretty good in the operating areas.

MS: How did the contractors, like DuPont or Westinghouse, how did they encourage safety and security and how did they get employees to adhere to those kind of guidelines?

MC: Well it was part of your employment. It was a condition of employment. They would hold that over your head.

MS: Right, yeah if you didn't do it—

MC: Didn't do it you're gone.

MS: Right. Did you do any work at the plant prior to getting a security clearance?

MC: Um-um.

MS: How long did it take to get that? Do they— Was it one of those things that you—

MC: It was— I remember I started out red badging, it wasn't— It seemed like two or three weeks I had a blue badge, Q clearance. Back then everybody—you was either red badge or Q cleared, top clearance, whether you needed it or not.

MS: Somebody told me that. Yeah, they said in the old days, it was like everybody had Q clearance.

MC: That's right.

MS: One thing I never—I forgot to ask somebody was whether I wonder in the construction era, people were out there like working in D-Area, like in the (unintelligible) or something. I wonder did all the construction people have to have Q clearances?

MC: (unintelligible).

MS: That would have taken the FBI a long time (unintelligible).

MC: I don't know how they did it back then, but they used to—every time you—everybody you saw had a blue badge, which meant Q clearance at the time. Very few did you see that was not Q cleared, it was either one or the other.

MS: Yeah, right. Yeah, that would have been difficult. Did any security issues or concerns impact your life off site, or did working at the plant affect—

MC: Well you wasn't supposed to talk about your job off the site.

MS: Yeah. What major changes took place in the areas where you worked during your time there?

MC: Major changes.

MS: (unintelligible) like—like in the operations of the reactors or anything along those lines?

MC: I can't think of any major changes.

MS: Okay. Were there any like major incidents that occurred in your areas while you worked there, that you can remember—any reactor accidents or anything like that?

MC: No, other than we dropped the fuel in disassembly (laugh) and had to get it up off the floor pretty fast. That's about the only incident we really ever had in hundred (unintelligible).

MS: You said that happened in like a—

MC: Routinely. (laugh) Yeah. (unintelligible) it's hard when you're working under water. You're way down there and it's—and you got this pole with a clip on the end of it, it's made on there. And you got a catch on the top of this pole (unintelligible), and you can misjudge it and you think you on that but it's above it and it's not hooked into it but it's not on there real good and then you free it up from the thing that's really holding all the weight (unintelligible). Hello. (laughter) Goodbye. (unintelligible) on the floor. Oh God, I don't need this. Here it is three o'clock in the morning, you don't want to do this. You're calling your boss up and say, Hey look cap, we messed up. He'd be out there pretty shortly. That (unintelligible) drew a lot of attention.

MS: Oh really?

MC: Yeah.

MS: What happened then? You had to have your supervisor come out?

MC: They'd come out and you'd have HP and then everybody'd point fingers for a while and then you try—try to figure out what you're going to do to get it off the floor, chainsaws and stuff like that. You call in maintenance or whoever you need to call in to help get it up off the floor. I mean whoever you had to call, you had to call them. Didn't matter what time because you had to get it up. You only had four hours, that thing starts deteriorating. (unintelligible). Especially all that fuel in the basin.

MS: Yeah, yeah I guess that's true.

MC: And that's just physical work. I mean that's awkward trying to hook something from forty feet up with a chainsaw. (unintelligible) hook.

MS: Yeah that's true. That would be kind of difficult to— Just trying to visualize how you get that done.

MC: Anything you can hook on, just trying to wrap it around it. That's why you just hold it off the floor and take some tongs and something maybe separate the column just enough where you got a little gap in there where you got something you can hook to, because it's nothing on there but a pole.

MS: Right, right. Yeah that would be pretty tough.

MC: And just working under water in general—

MS: Why did that happen so often? It seems to me like that was a possible engineering design flaw or something.

MC: It was engineering design.

MS: They should have made something that would have been a little bit easier to deal with.

MC: They didn't. They never did.

MS: And that was just primarily in the discharge where you—

MC: The discharge.

MS: Had that thing— Changing the subject somewhat, did you normally ride to work in a carpool or was that—

MC: Yeah—

MS: Oh you did?

MC: Um-hm.

MS: Do you still ride to work in a carpool?

MC: No.

MS: When did that sort of fall by the wayside?

MC: For me or for everybody? (laugh)

MS: Well (unintelligible). I get the impression it has generally gone by the wayside.

MC: It did with me about '89 when I started working offsite because I didn't want to tie up somebody, I can come and go as I wanted to. I think in general the whole site about late eighties it started changing a little bit. People started driving in when more compact cars were being built (unintelligible) for a whole week on a tank of gas.

MS: Yeah right. Yeah, that's true. I was wondering too if it made any difference at all the switchover from Du Pont to Westinghouse?

MC: No, I don't think that affected it. I think the smaller cars might have been more— People got a little Honda or something, that's what I got. I can drive all week on a tank so—

MS: Right. So it's not that big a deal.

MC: Plus if you get out until four o'clock and they don't get out until four thirty, you got to sit around and wait on them and stuff like that. And if you need to run somewhere after work you don't have to worry about taking them home and then going back. Get a little more inconvenience in a carpool.

MS: That's true. Back in the old days, how were carpools organized? Did the company have anything to do with organizing them or was it pretty much you did it on your own?

MC: Well, you basically did it on your own, but they would put something in the plant paper or you could put it in the plant paper about trying to set up a carpool.

MS: Right.

MC: If anybody's coming from Aiken or North Augusta, whatever.

MS: Right. Somebody told me that there was a— I can't think of the exact details now but that it was Norm Baumann, who used to work in the laboratory, said that there was one of the assistants to the director of the laboratory had a file where they kept some information on car pools, and that if somebody needed some assistance and they did have some— That's the only contact that I've heard of that sounded halfway official, where they had some official working at the plant who actually had some information on carpools and was willing to give it to people if they wanted it, but for the most part, everybody said that it was something you did on your own.

MC: On your own, yeah.

MS: How did plant operations and management change when Du Pont left and Westinghouse took over? I know we've gone over that a little bit but—

MC: Well like I said, Westinghouse came in and would hire (unintelligible) and a lot of the programs or projects they thought they was going to get, they didn't get. Then they had to come back right after that and start laying them all off. They thought they was— The NPR project, they thought they was going to get that about late eighties, early nineties. And they never—that didn't materialize and they had to lay off a lot of people as a result of that.

MS: You mentioned—

MC: NPR.

MS: New Production Reactor.

MC: Yeah. Because some of the off-site facilities, off-site buildings were designed for the New Production Reactor centennial. One of those we even had a computer floor set up for them to operate computers off of and stuff like that and it never happened. We spent a lot of money to get it ready and it never—never materialized. And Naval Fuels fell under. It never really mattered. (laugh)

MS: What was the story with Naval Fuels? I've heard of it, but that's about— Is that something like in the early eighties?

MC: Yeah. They build that for the subs and stuff and at one time they was—had dreams, I guess, (laugh) of bringing the subs up Savannah River and taking the reactors out of them and taking out the naval fuels and taking some reactors—not reactors I guess. I don't know what they call them things, but the cores.

MS: The core, yeah.

MC: And then put it into the sub. Send it back out to sea. And it had to come that far inland to do what it's got to do. (laugh) That never did happen but that was—they were talking about doing that, bringing it in. They were looking at dredging the canal and making it deeper for subs, nuclear subs. (unintelligible). And then the naval fuels itself, the engineering on it was terrible and it never did—it didn't work out, I don't know, and that just canceled the project.

MS: Yeah. Yeah, I heard it was—never worked out. What about— How did environmental legislation changes—how did that change operations?

MC: Well, all the environmental stuff cost us the cooling tower out there in L-Area, and create L-Lake, which was supposed to catch all the hot water coming out because of the little stuff that it hurt downstream—birds or fish or whatever. (laugh) It was too hot for the—for the outfalls. And so they (unintelligible) the cooling tower, which never really took place either. (unintelligible) some big monument standing out there.

MS: Pretty impressive. I heard it cost like $120 million.

MC: Probably more than that, almost a billion. It's huge. It's humongous.

MS: Yeah it's big, I've seen it.

MC: You stand inside that thing, you really get a feel how tall that thing is.

MS: It's really pretty—

MC: It's a monster.

MS: I'd say it's one of the most impressive buildings out here. Never got used.

MC: No. I heard they're still running water in it. I think I've heard water is still running in it.

MS: The time I saw it, I've seen water down in the base, in that concrete basin down there, where they got all the columns and everything. There's water down there. I don't know how deep it is, but I had a feeling it's not too deep but—

MC: That's pretty neat.

MS: But if they ran water, I didn't see it, but then I was only there just one time. It is pretty impressive. The next series of questions deal with socioeconomic issues. And they're kind of general. Some of these we can skip. A lot of them are kind of general questions, but they're kind of fun sometimes. How has the plant location in the CSRA impacted the economy of the area?

MC: (unintelligible) location?

MS: Um-hm.

MC: Well, location I guess they had to put it somewhere. (laughter) And it had to be far away, I guess from a major city. So I guess that's how they determine. I don't know how they determine where to put it, but—

MS: Yeah. I think a lot of it was because of chemical composition of the Savannah River was such that it was more favorable than some of the other locations they looked at.

MC: See you know more about it than I do.

MS: Okay. Were there any problems locally caused by boom and bust cycle of hiring here at the plant? Like for example at one point they had 20,000-plus employees and then it dropped down to about ten.

MC: Well the local economy was affected by SRS and if we got layoffs out here it affects everything. When it's booming out here, everybody's sales. They'd always time their sales off site, like in Augusta and stuff like that, on the same days we get our paychecks. All these little brochures come out in the paper the same day you get your paycheck on Friday or whenever it was, and it was timed for that purpose, for Westinghouse. And when Du Pont left and Westinghouse came on, a lot of people—it was written in the contract that they would get money from Du Pont, from the government. If Du Pont ever left, everybody would get some severance pay and—but still keep your job. And so a lot of people got a lot of money and didn't ever lose their job. (laugh) (unintelligible) For every year you were hired here after a year—I don't know, up to a certain year, up to like '85 and some of these guys come here like 1950 and you get a week's pay for every year you was out here up to '85. And then—then the next day you still got your job. So it ain't like you got fired. These guys are getting thirty-five weeks of pay for nothing. You didn't have to do anything. And so they were— A lot of the car dealerships stayed up around here twenty-four hours a day.

Because these people go straight out of here and buying brand new cars and mobile homes, houses. I mean, it was unbelievable. Credit union open twenty-four hours a day, which is pretty unusual, for a bank to stay open all day long.

MS: That is pretty—

MC: It was pretty wild. I got some, but I was only out here four or five years.

MS: Right yeah. That was just during the transition from DuPont to Westinghouse?

MC: Um-hm.

MS: I've heard they had something like that, but I didn't know what the ramifications were.

MC: It was kind of weird. Everybody getting their check— They're all lined up at the door. They'd pick up their checks and stuff like that, it was kind of neat. And not even lose your job, you're still working. You just— Here you go, give me money.

MS: Because I guess technically they were— I mean they were leaving DuPont's employ so they went to—

MC: Yeah. And I think it cost the government like $75 million to pay us off. (laugh) I think they sued DuPont. I don't know if they ever got it or not. I know they did - they sued them for the money back.

MS: Oh the government did?

MC: Yeah. When DuPont—tied up in court. I don't know whatever happened to it, but I know it was tied up in court for over three years. Say, hey it was written in the contract. (unintelligible).

MS: Well I heard a story that— I'll turn this off. (tape pause)

MC: That's what they did (unintelligible).

MS: Yeah, right.

MC: Westinghouse don't feel like that. They don't feel that generous.

MS: Yeah. Right. How has education been impacted by the plant's location in this area?

MC: I think the local college has been affected by all these people being around here, USC Aiken, that's the college. The plus of Westinghouse and DuPont give a lot of money to these local colleges, grants, a lot of the libraries and stuff were built by us. Ruth Patrick Library over there at USC Aiken was built with money from Westinghouse. Plus all the schools, local school and stuff, high schools and whatnot are supported by Westinghouse real good.

MS: Right. What about— How have local politics been influenced by the plant being located here?

MC: Well most everybody around here who's a mayor is a Westinghouse employee (laugh) just about, at one time or another. Fred Cavanaugh is the mayor of Aiken right now. He was out here for years in Westinghouse and DuPont. Mayor Green used to be out here. He's not there (unintelligible) out of it, but he was— Just all down the line, there's always been somebody from the site, so they control a lot of it.

MS: Yeah, so I guess it has been a great influence. What about community services, such as utilities, roads, police and fire protection? Have any of those been impacted by Savannah River Site being here?

MC: I know the fire department helps out in the local communities and stuff like that. If they have a fire, they have a mutual agreement. I don't know about the police (unintelligible). I'm sure Jackson's made a fortunate off of us riding back and forth (unintelligible) tickets and stuff going through the 30 mile an hour zone 70 miles an hour. But–

MS: True, I hadn't thought of that, yeah.

MC: Jackson's bad.

MS: A little speed trap.

MC: h man, a little (unintelligible). I mean that—the guy sits in the middle of that median there and he just—he just (unintelligible) circle.

MS: Really? (laugh)

MC: (unintelligible) just as bad.

MS: Who was that?

MC: Yeah, Jackson and (unintelligible).

MS: What was the name that you mentioned?

MC: A town in Georgia, (unintelligible), Georgia?

MS: Never heard of it.

MC: You never heard of (unintelligible)?

MS: Um-um.

MC: Yeah. I don't know if I can spell it or not. But there's a town down in Georgia, and I don't know if it is anymore or not, but called (unintelligible). It used to be a real bad speed trap. Matter of fact, it was in the Internet, stay away from it. (laugh)

MS: So it's not like around here then?

MC: No. It's in Georgia. They compared it to that.

MS: Yeah, I hadn't heard of that.
MC: I know that ain't right.

MS: I can look at that later. It's one of the things that we're trying to get— (tape pause) Has crime ever increased or decreased due to boom conditions out here?

MC: Well more people, more crime. That's (unintelligible).

MS: Right. Yeah. What about— How has entertainment changed out here? Like— Well actually let's say, how has entertainment in town changed or has there been much of a change that you— Like whenever changes were going (unintelligible).

MC: About the only changes I can—I'm aware of is they bought some semi-pro teams to Augusta, and one of them being hockey. And I think then people from here, must have been from Pittsburgh. So they'd played hockey a lot of them did, and I think it influenced them bringing hock—

END TAPE 1, OF 1, SIDE A

BEGIN TAPE 1 OF 1, SIDE B

MC: Okay. Because we had a bunch of northerners here mixed in, I think, they liked hockey. From Pittsburgh, that's a big thing, that and the Steelers.

MS: Right. This next series of questions deal with sort of like broad topics for those who work at the plant. Is there anything that stands out in your mind as the greatest accomplishment at the plant during its history?

MC: During its history? That it's always met its production goals, on time. They were real proud of the fact they could get—they never missed a production schedule, when they had to put out a production. And I think that's the—that was the tritium and the Plutonium and stuff that they never missed a schedule. I think that's part of their biggest thing, that they always were there for military.

MS: Right. Does anything stand out as like the greatest problem?

MC: (laugh) (unintelligible) management. (laughter) I think the biggest problem now— I don't know— Du Pont it wasn't so much a problem, but right now it is. I think not having a mission and not really knowing what the mission is. I think that people would like to know that they got a common goal to work on, and right now I don't think they got that.

MS: Yeah. Right. This may already be somewhat answered, but do you feel the plant operated more effectively during some periods than at other times?

MC: I think it did during the DuPont era. Everybody knew their roles and everybody did their roles and everything just (unintelligible) on until they said, We don't need anymore bombs (laugh) and we still wondering when we're going to use the ones we got. (laugh) Need to go test these things.

MS: Right. What aspect of your work do you most closely identify with? Is it the plant itself, the contractor, the government, or the mission? If you—in fact, you can separate all that stuff out.

MC: Probably just the plant itself. I work at SRS. Not necessarily contractor so much because they subject to change. Used to be— When DuPont was here, you was a DuPont'er. You kind of— You basically working for the company then, like DuPont. But since DuPont left, not so much— You're not really bragging to everybody you work for Westinghouse. (laugh) Now you work for SRS.

MS: Okay, right. Yeah. Were there any like organizational changes that took place at SRS that stand out in your mind, besides the obvious from DuPont to Westinghouse?

MC: Well the name change of the supervisors was a big change. Used to be people was known as—you had a direct supervisor, then you had a senor supervisor, then you used to have a area supervisor, then a area superintendent, and then a plant manager, a general manager and that was the head man at the plant. But when Westinghouse came on, they all changed the names and everything and it's now 1, 2, 3, 4's—Level 4, Level 3, and then plant president. Because I remember one time when Westinghouse first came on board, the president was walking around, or—(laugh) president. And he come walking by in Tritium. And somebody said, I want to introduce you to the—Mr. Moore, Jim Moore. And they said, This is the new president. And I said, You mean the plant manager? And he said, Oh (laugh) no. He said, He's the president of this company. And he don't never want to be called plant manager or anything like that. That was a big thing, (unintelligible) titles.

MS: Okay. Why were those changes made? Was there any reason?

MC: That was—just Westinghouse.

MS: Okay. Was there any basic— Were there any basic changes or trends in management philosophy during your time at the plant? This is one of those questions that's normally for like the upper level management but sometimes everybody's got some opinion about it, where they— Sometimes they say, Well I don't remember anything, but sometimes they do.

MC: I don't have anything on that.

MS: Okay. Next we'll go to the Fuel and Target stuff. You did work in Fuel and Targets?

MC: Um-hm.

MS: Could you describe the role that that area played in the operation for the plant?

MC: Now you talk about—

MS: Actually I'm talking about like 300 area.

MC: No, I didn't work in 300 area.

MS: Okay.

MC: And my connection was, was after they created it, they sent it out to us in Reactors and we handled it out there.

MS: Okay. Okay this is— We can skip on down to reactor stuff.

MC: Yeah. Yeah, that and raw materials.

MS: Okay.

MC: My father-in-law was in that. He was a metallurgist.

MS: Oh okay.

MC: That's who you need to talk to. He knows (laugh) this stuff.

MS: Yeah. What was it like here when they shut down the reactors, I guess in '88?

MC: Disappointment and (unintelligible). They (unintelligible) don't need to shut them down and she shut them down anyway just to prove a point that she could do it. He was mad. They thought they should have just kept them running. At least, keep them idle where you can crank them up without a lot of trouble.

MS: We're talking about now like in the early nineties, right, I guess?

MC: Yeah.

MS: What was it like even earlier when they shut them down in '88?

MC: You talking about for good or—

MS: No this is under— I guess this is when Du Pont was still here but they were on the way out. But they may not have been— They may have just been—

MC: Well they shut them down one time— I want to say when Jimmy Carter was here too, they shut them down for a while, seven years. I don't know, (unintelligible) and he shut them down for some reason. And I don't know, people like to see them running (unintelligible) down here, because that was a sign that we were up and operating. When they were down, it reflected the emotions of the people out here.

MS: Yeah, right. As far as working in the reactors, what did you look forward to doing in your job and what did you dislike about it?

MC: Hmm— I liked the loading portion, loading the reactor. The shutdown was interesting. Dislike was working in disassembly because it was hot. It was no air conditioner in there and it was old water and it was always muggy, conditions.

MS: What part of the reactors were air conditioned, if any?

MC: The assembly area where you (laugh) (unintelligible) and—that was not too bad area.

MS: What kind of shift work was done out there at the reactors?

MC: Well, four shifts. Well, Center Section worked four-shift, around the clock. And CH worked straight days ,except when we had a shutdown then you go on shift for a week, and it was every so often you go— You (unintelligible) go on shutdown every week— Every time it went down they'd only take X amount of people. You have, say, sixty operators, it only take twenty of them to do the shutdown so the other forty would just keep loading and unloading other areas.

MS: Right. So you didn't have any—like a particular shift that you worked like if it was like— I always heard they had like three shifts out there, like morning, afternoon and night or something?

MC: Well they had—that was what they call four shift. It was day shift, evening and midnights. But then the fourth person was off. The fourth shift you're off and then you rotate around. You work evening shift for seven days and then you get off a couple days, then you work day shift, you be off every five or six days.

MS: Oh okay.

MC: And then you'd work evening—

MS: So you didn't work a particular shift all the way through, like always had like the morning shift or something?

MC: No. They got so many shifts on this site. (laugh) Somebody said they got sixty-four different shifts on this site, so I mean I don't know. There's no telling what they got. I'm on four ten's, and there's people here on nine eighties. There's— Oh Lord, there's—(laugh) it's a mess of them.

MS: Is there anything that you recall or can think of that would have made the reactors more versatile than what they were?

MC: I can't think of nothing.

MS: Yeah. It sounds like you were pointing out that engineering problem—

MC: Yeah—

MS: —with the discharge. That certainly—

MC: We had a lot of engineers out here at the time that thought they knew everything. And they didn't listen to the people who weren't engineers, and that was a lot of problem. We had several people that was real good with designing stuff. In fact, they weren't engineers. The engineers wouldn't listen to them. But they would take what they had and beef it up just a little bit and claim it and steal ideas from people who weren't engineers.

MS: Was that a problem under Du Pont or is that in Westinghouse?

MC: That's mainly Du Pont.

MS: Du Pont?

MC: Yeah.

MS: Because it sounds like they—the problem you're describing about having to pick up the discharged fuel and stuff under—off the floor, sounds like a definite problem.

MC: Oh yeah. They never did correct that as long as those reactors were running. It never was— The design was never corrected on that. It should have been. It really should never been left up to human error. It should have been some kind of machine cut off points to where, Hey if it's not on there a light comes on or something. But (unintelligible) man you hook that thing in there, you just had a feeling, Yeah it feel like it's on there. You release the catch and then—you got a fish and (unintelligible) it's off.

MS: That sounded like—

MC: Some of the stuff wasn't hard to get off the floor, it was light stuff. Some of the stuff was the control rods, you'd move it and you'd have a whole batch of them (unintelligible). You'd move it one time it'd be like fifteen or twenty hanging from a thing that you move around. And some of them— If you weren't careful, they weren't on there all the way and (unintelligible) they'd float off. (unintelligible) lying on the floor, you had to get those up. But that was pretty light, you'd just grab them up, put it back on there. But they would break. They were real brittle. (unintelligible) careful you'd break them (unintelligible).

MS: What kind of suits did you have to wear when you worked in—

MC: Whites. Just whites, no plastic suit.

MS: Okay. That's because the water was—

MC: Um-hm, the water was your protection. And then you had the dosimeter and stuff like that to tell if you're picking up anything. Generally, you didn't pick up much.

MS: So were there any production programs that were particularly interesting to have been involved with?

MC: I can't think of (unintelligible).

MS: Some of the more exotic stuff was probably already—already done like before you got to work—

MC: Um-hm.

MS: —was real big in the sixties and seventies, I think, when they were working on the special products and stuff. What were the most important changes that you saw to the reactors while you were working there, or were there any?

MC: Well the only real major improvement I saw when I was there, they built earthquake towers around the top of them on the high hat.

MS: High hat?

MC: That's what they called (unintelligible). For the—I guess for the control rods to go up and down in the reactor, you know, the mother control, controlling this big tall— And they had the (unintelligible) towers, earthquake protection on top of them so they wouldn't—

MS: Right, yeah.

MC: —lose—uncover the core.

MS: Right. What were the major operational differences among the five reactors, if there were any?

MC: Just the type fuel they can handle. Like I said, P-Area could handle—mostly handle the fuel targets, like Mark 22s, and then the other reactors handled the Mark 31s, the slugs and stuff. That's basically the difference in type fuel.

MS: Right. Yeah and the other question's sort of related to that. Did any of the reactors develop a reputation for being better producing certain things? Were they sort of like—

MC: Well each of them produced, like I said, the slugs and they were noted for that. I mean, but—

MS: Like C-Reactor wasn't known as making better stuff or—than any other ones?

MC: No they all— They all put out at the same time and on their cycle and made their quota. I mean, it was pretty routine. It was just, put it in, spit it out and ship it, just around the clock.

MS: How did reactor operators and other personnel feel about the reactors where they worked, especially when there were like designated pilot reactors, like the first one to do a particular product? Was that any— Was that particularly significant or no?

MC: Well yeah they'd get attached to a area. He's from C –Area, he thinks he's better than reactor operator from K-Area. There's this, I don't know, mindset.

MS: Yeah. Was there any rivalry between like the crews on different reactors?

MC: A lot of them didn't like to work in other reactors. They had their own special reactor they liked to work in, they were familiar with it and they didn't like to work in the other reactors—other control rooms.

MS: But most people worked in like a single reactor over a long haul?

MC: Yeah. About the only time you go to another reactor is if they really was shorthanded and they needed to get the load up and (unintelligible) overtime or a shutdown.

MS: Somebody told me that crane operators, for example, did not operate—did not work at a single—were not stationed at a single reactor, but sort of like shifted all around because it wasn't that much of a demand for a crane operator at any one given reactor.

MC: In I-Area they more or less stayed at the same reactor all the time.

MS: Oh okay.

MC: And they'd (unintelligible) reactors during shutdowns and stuff like that.

MS: What reactor did you like to work at or did you work at mostly?

MC: Probably K, K-Reactor. Because L really never— We never really cranked up. I think they did it briefly one cycle, just (unintelligible) cycle.

MS: Yeah, I think that— I'm not—

MC: It was a real short cycle. They didn't— I don't think they kept it on very long, a few months.

MS: Yeah, um-hm, right.

MC: But not like years or anything like that.

MS: Right, yeah. How did security affect the operation of the reactors?

MC: Well—

MS: I mean, did you have to— I guess they had guards there at the reactor building and you had to go through that.

MC: Yeah. A lot of badging in and out, lot of high-tech stuff, hand geometry and stuff like that, that just kind of slowed you down getting in and out, that's about it. More of a inconvenience than anything. (laugh)

MS: Well you had to like take the radioactive material that came out of the rector and it had to go to, I assume, to Separations. Did they have like guards that went with it?

MC: Um-um. No we— Once we take it out and ship it, they put—everything's under water. And then you raise it up and put it in a cask car and close up the cask and make sure it was sealed of course. And then you put it on a train and they ship it and—from one area to the next. I don't know if— I don't recall ever seeing any major security around it, following it from one area to the next. I guess it could have been a breach of security if somebody want to— Maybe they— Probably the train people notify them that we're moving. It wasn't a big deal. It was more of a big deal when Tritium.

MS: Oh really?

MC: Yeah, the security.

MS: How do they do that?

MC: Well you know, when they'd come pick up the canisters of tritium, they'd bring in the couriers. And they'd bring—they had the tractor trailer, that loading all the stuff that go in. Then they had the Suburbans in the front and back of it and they would— When they were bringing the stuff out to load into H-Area Old Manufacturing Facility they would take and have these little— It's a little—like a tank, but it's not a tank and it just had the machine gun on top of it. And he would sit there watching it and plus the guys in the couriers and Suburbans, they were pretty tough. You couldn't get near them. They were sitting there with machine guns and pistols on both sides. These guys were crazy. I mean, they wouldn't even talk to you. You walk by there and they— And the first thing they do is just walk towards you with that gun until you (unintelligible). I mean (unintelligible), they just walk toward you. And they'd shoot— We all had a fear that they would shoot you (laugh), because they just act like they crazy.

MS: And that's at Tritium facility.

MC: Tritium, yeah. They— You'd hear some tales about the tractor trailer, what—what the capabilities of the trailer, the tires explodes off the trailer, explosions and— And it—as it pulls out into a government—a state highway, the air force sends up the jet and follows it all the way.

MS: Really? Wow. This is when it went from—like when it left Savannah River Site to go—

MC: Wherever, yeah.

MS: Rocky Flats or wherever.

MC: Um-hm.

MS: And— Okay.

MC: And they would put up a jet and it'd follow that (unintelligible) all the way. And that truck didn't stop unless everybody—it was an agreed upon route and all this stuff, it was—for gas. It was pretty wild.

MS: Who handled that kind of work? It was going off site. Was that Wackenhut or was that—

MC: Not that was—

MS: Totally different?

MC: That was just federal couriers, I'm not sure. Probably worked for DOE. But they were just—truck drivers basically, but they were trying to kill us. (laughter)

MS: Never heard about that one. We've probably gone into this to some degree, but talking about reactor cycles, How did those change over time? How long were those?

MC: Well most of the reactors had 30-day cycles. The only one I knew that didn't have one was P-Area, and they had like a—I want to say 180-day cycle. It was six months. And they stayed that way, unless they changed the material in it.

MS: Okay.

MC: Like I say, it was a longer tank and it had—it would hold that different kind of fuel, whereas some of the other tanks wouldn't hold it, so they used (unintelligible). (unintelligible), I don't know. (laugh)

MS: Yeah. I know that C was a larger tank. I didn't know that P was.

MC: Yeah P was the largest tank. That was the one that had the long cycle. And it would hold the Mark 22s, the fuel, and the rest of them just made for slugs, different type of material, plutonium.

MS: Right. Okay. How did power ascension affect the operations? I'm not sure— I know that was a big deal in the fifties and sixties when they were first (unintelligible).

MC: (unintelligible) between 95 and 100 percent and stuff like that?

MS: Yeah, yeah, that kind of stuff. I'm not sure what they did in the eighties.

MC: I don't know. I didn't keep up with that that much.

MS: Okay, yeah.

MC: That was mostly for the control room and stuff. I didn't mess with that.

MS: Right, right. My next series of questions deal with separations, which we don't need to get into, but I do (unintelligible) that's where the Tritium facility was. What did you do in the Tritium facility?

MC: House maintenance mechanic. And mostly with the change out of different type of Tritium-related beds and stuff like that—Z-beds, Mack beds and stuff like that. It traps the Tritium and stuff. And every so often you had to change those out and change that—mercury vapor pumps and stuff like that and pieces of the equipment gases go bad. You'd change out the gaskets and the valves and stuff like that.

MS: Was security appreciably tighter in the Tritium facility than it was in (unintelligible).

MC: Yeah, probably the tightest security on the site. Yeah we had a double gate—double fence coming in there with the rocks and the stuff and the infrared and all this stuff and hand geometry and it was a lot to get in the gate and a pain in the butt to get out too. (laugh) So it was (unintelligible) code on the doors. It was whew, one thing after another (laugh) and anything they could do to slow you down to get in there, (unintelligible), hey, let's come up with something else.

MS: In the Tritium facility were there— What aspects of your job did you find most enjoyable and which ones did you find less so?

MC: I liked working on the pumps, that wasn't too bad. That was— It took a certain amount of skill to do it, what we had to do. And I guess stuff I didn't care doing as much was changing filters. (laugh) Changing filters, that was—that wasn't too much fun.

MS: What was that like?

MC: Just drudgery. I mean, just changing out filters is boring. You got eleven dozen filters in there, you got to change out and you have to cut the filters to make it fit, and so it was just a pain. You're in a plastic suit and— And you got ten different locations to go to and each location you got to change out of the plastic suit and get in another plastic suit to go do it, because you can't go from one room to the next.

MS: Oh with the same suit?

MC: Yeah.

MS: Yeah. Is that for safety reasons?

MC: Contamination.

MS: Okay. Okay.

MC: Your suit probably have some on it. So you throw the suit away and you go put on another suit. And you had to make the suit yourself. So you—

MS: Oh so you had to tape it, yeah.

MC: You had to tape it, you had to build it, put little air holes in it, just— And then you go in another room and then you—

MS: How many— How many can you do in a day, if you got to do all that stuff?

MC: Well, it'd take you a couple days to do all the filters.

MS: Okay.

MC: Even about four or five (unintelligible) a day.

MS: Yeah that would be kind of labor intensive.

MC: Boring. (Unintelligible) boring work.

MS: Was—

MC: That's the problem with Du Pont when they came in here. Unless you was a engineer, they didn't put you in any kind of management position or whatever. Because a lot of— I came in here, I got a master's in psychology. And they didn't even consider that. I mean it's like you don't exist. You're not an engineer, I don't care. We don't need no psychologists out here. I very—I beg to differ. But I say, You do, you got a bunch of nuts out here. And—and they didn't never put you in a management position. When Westinghouse came in they did honor that and if you had a degree they'll look at you, try to put you in a good a position, a professional. But that's one thing I didn't like about DuPont was they didn't honor any degree but a engineering degree, period. I don't care if you got whatever.

MS: They just didn't see it as a—as a—

MC: If you weren't a engineer (unintelligible). That wasn't an advantage for the company, considering they'd bring in their people and they'd train them and they'd send them somewhere else to a company—one of their companies and then they'd—every two years they just swap them out. And that's free training for them at government expense.

MS: Yeah that is–that's true, yeah. Was there any rivalry or competition between like F and H employees?

MC: No, not that I know of.

MS: Yeah. What about like between Wet Chemistry and Tritium operators?

MC: No, not really, no rivalry.

MS: I'll ask you anyway since—but it's kind of dealing with Separation, but it's sort of a comparison between Reactors and Separations. It seems the general public tends to hear more about reactor operations than separations in the nuclear industry. Does— Do separations people sort of feel like they've been slighted as a result of that? Most people have always heard of reactors but separations, most people have never heard of.

MC: Not— I've never talked— I've never seen where they feel slighted. They always feel like they're just important or more important than reactors, because they're actually the one who put—spit out the product.

MS: Yeah, right.

MC: But I don't see where they feel slighted, no.

MS: Yeah, okay. Can you describe— This is health protection series of questions. Can you describe in general the health protection measures taken at SRS to provide safe working conditions?

MC: Well, the Bioassay Program, take the samples, and the—the TLD badges.

MS: Did I spell that right?

MC: Yeah that's correct. That's probably the biggest thing, the Bioassay Program. And then like I said, the TLD badges.

MS: The—

MC: TLD. TLD. Thermolu—Thermoluscent Dosimetry Badges, TLD.

MS: Okay yeah.
MC: Thermolucent—something like that. (laugh)

MS: Yeah, they can use an acronym. (laugh)

MC: But different badges. Other than that—and then the detection mechanisms—hand and foot counter, the alpha defector, the wands.

MS: Right. Yeah, what are those, QD pies or whatever?

MC: Yeah, QD pies, there you go.

MS: What were the most important measures that were taken to insure worker health and safety? Of course, we may have just already gone over that—

MC: (unintelligible).

MS: How have any of those measures changed over time or have they? (unintelligible) decide to make the health protection measures more strict over time or—

MC: Hmm, I think just upgrading technology, equipment. (unintelligible) equipment (unintelligible) twenty years ago. They still got the same Bioassay Program, generally about the same as it was when I came in here. And TLD badges are the same, still once a month, and just technology of the equipment.

MS: Yeah. What about— What powers did health protection workers have to locate, stop and change unsafe conditions?

MC: They had to the power to shut the job down.

MS: Okay. Yeah I heard that. Did a regular worker have that same—

MC: Um-hm.

MS: Did you—

MC: Yeah if you find something unsafe, you can stop the job no matter what it is. That's one thing they do give you out here. They may give you a rash of crap, but you can stop the job.

MS: Okay. How have management and organizational practices affected the ability to insure employee health and safety? I'll see if I can rephrase that. What management or organizational practices guaranteed employee safety or work towards guaranteeing that? Safety meetings and that kind—

MC: Yeah, we had safety routine, safety meeting.

MS: Did that change any between Du Pont and Westinghouse?

MC: No, (unintelligible) monthly safety meetings. And the procedures they got in place, AQ procedures and safety procedures and stuff like that, that you can get access to and you're supposed to follow, yeah there's a whole bunch of them.

MS: Okay. Well I think— I think we're done. (laughter) Unless there's anything else you want to add. I got plenty of—still got some tape if you wanted to add anything.

MC: I'm fine. I'm going to get out of here about four thirty.

MS: Oh okay, okay. One more favor, if you don't mind, let me get—snap a quick picture. We can step out here if you want to, the light's probably better. Shut this thing off. Let me take an opportunity to—thanks for coming in for—

MC: Enjoyed it.

END OF INTERVIEW

Oral History Interview – Bill Dallis

Interviewee: Bill Dallis

Interviewers: Terri Gillett, Mark Swanson

Date of Interview: February 5, 2007

This was a digital recording made during a tour of C Reactor. Also present were Linda Perry and Steve Ashe, photographer for SRS.

B. Dallis: Forty is the motor ring. That's the AC motors. Now when you go into 108 you'll see the DC motors. (unintelligible). Twenty is where the heat exchangers are. Now outside the -20 is just piping. So that's not real interesting.

M. Swanson: Well we've got a lot of like processed piping. They took a zillion shots of that over the years in the fifties, sixties even in the seventies for every single reactor. But I'm not sure how useful that's going to be for our historic stuff because it shows a little bit of heat exchanger stuff then it goes to just pipes. A lot of times they're not well labeled at all, so you don't know where they are.

T. Gillett: So that's basically what -20 is, is pipes?

MS: What they don't have pictures, of except I think in restricted and classified and B-wing is like images of like C- and D-Areas and any of that kind of stuff. They just don't seem to have that many—

TG: D-Area.

MS: I mean—

BD: Charge and discharge.

MS: Oh yeah well.

BD: We can go into the— That's probably classified, but its pretty dark. In fact, the only one hazard that we have here is in (unintelligible) buckling out. (unintelligible) fail so—

L. Perry: Well, when we go into L and K and even C, you'll see more of that (unintelligible) better.

MS: Yeah because I imagine there's not going to be much left here to see.

BD: Right. This is kind of like the bare bones, and that's one reason I wanted to come here first to kind of show you, this is what we started with, okay, and then we'll go to C-Area which has a few—little more upgrades and then L-Area has a little more. K-Area of course, K and L on about the same basis. They've done a little bit more modification in the K-Area. But to kind of show you a progressive, what it was then and—

MS: And K they actually had plans to restart that in the early nineties.

BD: Yeah we did—

LP: We did restart (unintelligible) twenty-four hours. (laughter) Blew my mind.

BD: A billion dollars later and about five minutes. Well we're done. (laughter) Different condition of safety equipment, safety features and stuff. Very little paint here on the outside and the inside, which turned out to be good.

LP: This is basically a (unintelligible).

TG: There's very little equipment left in here?

BD: Very little. I mean, compared to what it was at that day, it's probably still here. A lot of it's been taken apart. That was one of the first things to happen when an area shut down—

LP: Scavanged—

BD: —and then when another area went down on long shutdown, they would—anything that they need, they would go get it from another (unintelligible). Pickings were— They just wasn't manufactured— (unintelligible). Figure we're going to need this building exterior like we did (unintelligible), walk around and shot high definition—

TG: We'll have to do that.

BD: —digital images, exterior (unintelligible).

TG: Yeah, definitely. And I have a—

BD: The reason for the flashlights, we've come in and tried to— We do minimum light, enough to get through. So we come over, done some relamping but there's still areas that—like the 108s, may be minimal lighting where flashlights are needed to really see. As far as safety, the uranium oxide drums over on the back side in assembly, they're still there. Of course, if we see anything there, we'll have to turn around and leave. Disassembly is (unintelligible) required to enter. They've drained that basin to about five foot of water in it and they going (unintelligible) it in place next year.

LP: And that's part of the D&D thing.

BD: And they've done all they can do—they're going do this year. All their money is focused toward P-Area and F-Area.

LP: The D&D, I just got a (unintelligible), we're accelerating R-Area.

BD: But if some reason we do lose 151, it's going go dark.

LP: And that's one of the buildings they've got on their list to take out.

BD: And (unintelligible) another power line in here.

LP: Okay.

BD: I mean that— In P-Area they've got to do that.

LP: Yeah.

BD: In fact, the work that you see up on C-(unintelligible) by the fire department is to run that line, individual line, into P-Area and they'll cut loose the 151s (unintelligible) dark. That's one of the first things they do (unintelligible).

LP: And that's what they're wanting to do with this one. So that's why I said, Let's go ahead now and consider this (unintelligible).

TG: Okay.

LP: And I can go ahead and (unintelligible) we've done this. And the only support facilities left here are what, 151-1 and what else?

BD: That's it.

LP: That's it. What about— You still got the 106, the 109?

BD: 109 has been filled in and capped. 106 is still— In fact, today they're supposed to move those tops off the lid up there today so they can get in to sample. That's their next one to do.

LP: Okay so we've got the 106 still (unintelligible) the 107?

BD: 107, nothing's (unintelligible).

LP: But it's not—nothing's been done to it? Because D&D's looking at doing the 107, 106, same thing they did in P-Area, 105. The 109 we've already done because we stared at that hole for nine months because of (unintelligible). Remember that?

BD: (unintelligible).

LP: It was bad. Anyway, we couldn't get (unintelligible) to understand what grout meant.

TG: What does it mean?

LP: Cement mixture, just gunk they put in.

BD: Solidified. (unintelligible).

LP: So the only standing building is the 151-1, that's (unintelligible).

MS: And I can promise you we have a lot of historic photos of 151-1. They're like (unintelligible) going into it, you have the substation, you have whatever—all the little buildings around it.

BD: That's— 151 the transformer yards, that's separate. That's a DOE contract and that's (unintelligible). Westinghouse does not have— We have to give them access to this area.

LP: Because you remember (unintelligible) 151-1s in C-area? No in P-Area.

TG: (unintelligible) P.

LP: And these, the same ones. Now we've already taken down the 151-2 building here during the big sweep about two years ago. So they're looking at coming in here and doing the same thing. Now—

TG: Why are the 151s in C different?

BD: They're not.

LP: I found out. Yeah they are, they're shaped different. I found out. I called and got old power guys call me. I've got five hundred replies to my e-mail (laugh) I sent out. But it's because the batteries in there, he told me, are more compact. And he said that that the other 151s did not have this compact battery, so that's why they had to put that T on them. And that's the only reason I got. (unintelligible). But— (unintelligible) was wanting to know why the shape was different.

TG: Yeah I was looking at that on the atlas (unintelligible).

LP: And it didn't tell me a whole lot, so I just sent a, please tell me, out to the old folks.

TG: Okay.

LP: Well okay. We're ready I guess.

TG: Okay is there a particular like sequence that we need to walk through this thing, like maybe the way the materials did or is that possible or—

BD: Well what we'll do is just like on zero level here, we can't go toward this way, we can't go to Disassembly. We just kind of go through it straight ahead out into the corridor by the transformer, the only operable transformer in (unintelligible), come up the corridor, go through Crane Maintenance area, go across, go in Assembly where the drums are, go out through the (unintelligible) room where the other transformer room's at and then either that's where we need to go up if you want to go up to the roof, or you could just go up to the one level 48 and if you want to go out on the roof it's kind of wet. You can only go to (unintelligible).

TG: Okay.

BD: So (unintelligible).

TG: Now we can't— What did you say? We cannot go to Disassembly on this level?

BD: Right, you can't go in Disassembly.

TG: And that's because it's—

BD: It's rad.

TG: It's rad, okay.

BD: And its radiation area, too, like I said (unintelligible) that level.

TG: I just wanted to make sure why we can't get in that area.

LP: (unintelligible) should have a lot of old photographs (unintelligible).

TG: And Mark's taking notes for me, which is lovely. (laughter)

BD: (unintelligible) same thing in C-Area. If we had RCO, we could go in C-Area. It's a clean area but it's locked up (unintelligible) control since we don't go over there.

TG: You want to— I mean if maybe— I mean, if you can work it out, that'd be great. But I—

LP: Can you get an RCO (unintelligible)?

BD: I'll have to see because we just started—

TG: Late notice—

BD: (unintelligible) in L-Area and RCO or (unintelligible). I can see. I can see when I get back and let you know (unintelligible).

LP: Well they'd only need it for about, what, thirty minutes, (unintelligible), forty-five minutes (unintelligible).

TG: I guess, (unintelligible) that area.

BD: We may could get the outside person—(unintelligible) having to use the outside person to do some sampling of paint chips in C-Area this morning. So if he's available tomorrow—

LP: We can hit that real quick (unintelligible).

BD: I'll check on that.

TG: Well great.

LP: All right, (unintelligible). This is (unintelligible) health physics office is right here. Was it? These were the Health Physics offices (unintelligible) monitor room.

BD: You can't— The water level you can see how (unintelligible) where the level is— That's thirty feet deep and it's down to five feet.

LP: And you— during operations you could see fuel tubes hanging down and then the water would be up to the levels like right there. And you'd walk along there and check things.

BD: Typically the water level during operation from that floor right there.

LP: Thirty-two?

BD: Sixteen.

LP: Sixteen?

BD: During operation. Sixteen inches below that level, floor level.

LP: When we take readings, we put -16. And if it was ever low, we'd have to add water to the basin and we would have to add chemicals to the basin and then alum (unintelligible)?

BD: (unintelligible) two years ago (unintelligible). (laughter) They still— (unintelligible) sand filters (unintelligible) it's crystal clear.

LP: And yeah when it got really yucky we had to put it through the sand filter. But we backwashed (unintelligible) shield?

BD: Typically would backwash once the sand (unintelligible) gets (unintelligible) pressure as it gets clogged up. Once it gets up to a pressure (unintelligible), then you'd backwash.

LP: And then we'd (unintelligible) through the deionizers?

BD: (unintelligible) radioactive (unintelligible). Your sand filters remove your (unintelligible) clarity and your deionizers (unintelligible). Some guy that (unintelligible) actual gamma but it's got a name for it.

MS: Yeah, I can't think of—

LP: (unintelligible) you'd have— And the health physics office is right here and you have a lot of (unintelligible) recorders here to where it was measuring what, tritium, (unintelligible)?

BD: Well this is for the whole building, not only for tritium but radiation (unintelligible) from -40 all the way to 66 purification everything. Everything you had a (unintelligible) health monitor chamber (unintelligible).

LP: Okay.

BD: And this panel was (unintelligible) the control room (unintelligible) where alarm went off here and also went off over there. (unintelligible) normally (unintelligible) here (unintelligible) they may not be here (unintelligible) may not be here. Somebody (unintelligible) may not be here so it was (unintelligible).

LP: (unintelligible).

BD: (unintelligible) not much paint inside, where the other areas are—where they're painted, and all this was over this P-Area. (unintelligible) covered over and modernized in later years, but this would be the only one (unintelligible).

TG: Well that's the kind of thing we need to look at a photograph to document, anything that's unique about this reactor or about any reactor that we go in, that's different.

BD: And like here the—up on fifteen where the computers went in P-Area in later years, the old locker room, not many people saw it as a locker room like it is up here.

TG: Okay. Can you point that out when we get there? Okay, so the exposed brick on zero grade, we need to photograph.

MS: Well definitely (unintelligible).

BD: Bring a tripod and that high-definition camera, get a good shot (unintelligible).

LP: And I bet you'll notice that there's probably no women's room in here.

BD: Just like P-Area.

LP: Is it just like P, got a ladies room, too.

MS: Now that I think about it, I've been to R-Area before, but I don't think I've been in here. I don't think that (unintelligible).

BD: Some of the older operators and supervisors that actually started this reactor up (unintelligible). In fact, (unintelligible) and they were setting up here at fifteen on the console talking about it, just two of them, when it started up.

TG: Is that—Did John Breck have that?

BD: Yeah he would. There's also a virtual tour video of this place that I (unintelligible) did years ago.

LP: Well Mary Beth should have all that. She (unintelligible).

BD: I don't know. It's (unintelligible) she's done. But John did that production of the fifty-year anniversary thing. He talked to the old guys.

LP: He— Yeah he— He did the (unintelligible) yeah, he's got all that.

TG: Okay well that'd be great.

BD: And that other stuff is like a virtual tour of the place. They walked in here with a video camera. I don't know if there's narration.

LP: I think I've got the CD SRS at 50 with Mary Beth. Surely she'd have that wouldn't she?

BD: (unintelligible) is totally separate.

LP: Okay well then on her SRS at 50 stuff she ought to have a lot of.

TG: We have the book, I mean the book she wrote. Is that what you're talking about? I've just never seen the video. I've never seen—

LP: Okay. We've got an R-Area video that John Breck (unintelligible).

TG: (unintelligible).

LP: He can make her a copy—make them a copy.

BD: That's like a nice production, but that other thing would just be a bare—

TG: I'd like both of them.

BD: A bare bones kind of, Here we are, Welcome to the (unintelligible).

LP: Can we get that for her?

BD: I'll ask Rick (unintelligible), okay and L-Area's our alternate (unintelligible). Six months ago they had an exercise and they brought DOE. They'd go to different places every year, do a training (unintelligible). This year was the (unintelligible), so they brought them here. It was a lot of activity going on for a couple of weeks. You'll see (unintelligible). This is stuff that they put down. They paid to come in and do (unintelligible). (unintelligible) of some sort. I don't know (unintelligible).

MS: (unintelligible) this little thing right there or—

TG: The (unintelligible)?

MS: Oh okay.

TG: It separates the parts of the buildings.

BD: And all that, it goes into the length of the basin and it's open all the way to -40.

TG: Okay.

BD: And if any basin water or cracks, any water gets into that open cavity there, it runs to a (unintelligible) down on 40, which is monitored. So if that (unintelligible) starts increasing, this is a possible source that you've got a basin that's cracked (unintelligible).

MS: And you're saying this was not (unintelligible) the other reactors?

BD: Only this area and P-Area.

TG: (unintelligible).

LP: (unintelligible).

BD: (unintelligible), separate.

LP: I know but didn't (unintelligible) and— Okay, well maybe it's not.

BD: That goes to the emergency pump.

LP: Okay yeah okay.

BD: (unintelligible) pumps.

LP: Well now another thing that's different is the—is that railing? Because in the other areas it's boards, it's wood planks.

BD: Over inside there?

LP: Yeah. The walkway see, these walkways.

BD: Those are solid (unintelligible). Only the boards are in the—back towards the middle part, back door the machine basin section. But all those walkways are cement and all—

LP: They are? Okay, I remember boards.

BD: There's boards in the middle.

LP: Okay that's it, okay.

BD: That goes back out to the (unintelligible).

MS: (unintelligible).

LP: Where?

MS: I can't read that. Four pieces of sheet metal. It's from 105-P Crane Equipment room. Maybe that's two 105-R (unintelligible) storage room.

TG: I thought (unintelligible).
(loud noise)

BD: See that (unintelligible)?

TG: Uh-huh.

BD: (unintelligible) wasn't inside of that.

MS: Are you talking about septifoil?

BD: Yeah. The septifoil is what actually supplied the (unintelligible) to each one of those control rods. And you bring it out just like it is now (unintelligible). (unintelligible) and you bring it out here and you replace O-rings and stuff like that underneath it and then you (unintelligible) set it back down.

LP: And it sits down on top of the crane.

BD: And it— Then you drive the rods back down and guide them back through these tubes, and then come down and latch back up. And then you can bring the— Then you can lift this up all the way up to the ceiling in the process room and that will allow these cranes to go up underneath it. Typically this was pulled—was lifted up to the ceiling.

LP: And it wasn't always during shutdown. And it wasn't always brought out like this.

TG: Is this the best opportunity that we're going to have? Are we going to get any closer to one than this one right here?

BD: You'll get—you'll see one sitting on the tank in L-Area.

TG: Okay.

BD: You'll— In L-Area the process room, which is that room right there, has been rolled back and painted (unintelligible) but they went in and painted it, fixed it so you can walk in, in your street clothes as close as— You'll be able to get as—this close to the reactor. You'll be able to see the reactor.

TG: Excellent. Okay.

LP: If you'll look up here, you see how it's kind of a—at the bottom there's a pattern (unintelligible) like that.

BD: That's the (unintelligible).

LP: Yeah. In the control room you see—see what I'm talking (unintelligible)?

TG: Yeah.

LP: In the control room, and we'll show it to you when we get to one, there's—

TG: I've seen those—

LP: (unintelligible) of that up there. They correlate with the clusters. And then also the safety rods in the control room (unintelligible) the other side, and that correlates with the safety rods that are down here, to let you know when they're latched or up or down or whatever. And—

BD: You (unintelligible) that up on sixty-six.

LP: Yeah, well that's true. I'm talking about in the control room where the (unintelligible) panel is.

BD: Where you're pulling partial (unintelligible) panels there in sectors, but you can't tell. They're (unintelligible) and so many of these clusters are in one sector. And then you've got gang one, gang two, gang three, and that's how you control your control rods.

LP: And up there in the control room at the console—

TG: Do not break the plane.

LP: Up there in the control room on the console—

BD: (unintelligible) you took it off computer control. You done it manually.

LP: Startup, things like that.

BD: Never (unintelligible) startup. That's your most critical part of operation for startup (unintelligible). That was your most crucial step. And it was (unintelligible) manually and it was monitored. I mean it was— That was the most crucial part. If there was ever was going to be a problem with criticality, that's where it was going to be when you were up and started, starting up. And that's what got P-Area in a problem back years ago (unintelligible), which was a—is a poison like xenon. And when you would shut down, engineering would give you a chart or give you a time of xenon (unintelligible) it equalizes. If you tried to start up before then, that would be too much xenon in the tank and you couldn't get—you'd pull every—all your rods out and couldn't go critical. So they say you had to be shut down and xenon time was sixty hours, ninety hours, and you couldn't start until that time. This particular (unintelligible) they had that time, but at the same time it did not take into consideration (unintelligible) buildup and it acted like xenon buildup, didn't know what was going on, because it wasn't acting like (unintelligible) when we start up by not knowing what was going on. We shut down and not— And since we didn't know what was going on we got—kind of got a—DOE got kind of like a black eye. That's what we learned about that.

TG: So how often did you start up and shut down? It wasn't just— I guess I was under the impression that it was just a constant on.

BD: No. You would— You'd have to replenish. You'd have to shut down. You'd have a planned shutdown.

LP: (unintelligible).

BD: 907.

LP: 907. This— Well—

BD: You'd have a planned outage to replenish (unintelligible) running a (unintelligible) charge (unintelligible) plutonium charge or you're running a tritium charge. Plutonium charge was shorter, it'd run about forty-five days. Then you shut down. You done a (unintelligible) shutdown. And then go in (unintelligible) recharge it back, start back.

TG: How much— How long did it take like when you were (unintelligible)?

BD: To do a discharge, and again how many you're changing now comes into play too. A typical shutdown—If you didn't have any repairs you want to go in and do it, anywhere from a week, two weeks. And then you start back up. But then you may have a Scram, which is a unscheduled shutdown, which would— The compute or a safety circuit would shut you down. And of course then if you had that to happen whether it be a power failure shut you down or loss of coolant or anything. Something that would— And you'll see those plates. Red ones indicate emergency shutdown, blue ones are reversals to lower you down. Now if you got one of those, then you got— Unless you know what did it, you had a power blip offsite and it saw a reduction, it saw it, the (unintelligible) saw it, it shut you down.

TG: Okay.

BD: But later years that happened a few times and they kind of got wise to that so they put in what they called (unintelligible) that would even that out, that would monitor it. If it was just a blip, it wouldn't shut you down. But if it was actually true, then it would actually start shutting down every nonessential equipment.

LP: Remember the main thing we were concerned, well one of the main things was coolant—to make sure we had power to operate the pumps to get it from the river, from the basin to get the water over here to cool. And so whenever you had any kind of threat to power whatsoever, that's when it would shut you down to get the rods into the tank.

TG: Okay. Gotcha.

LP: And that— You know what— Now— We've always called it Scram. Now they call it Trip. When our outside people came in and showed us how to do everything back in the late eighties and early nineties they called it Trip. But Scram is safety control rod (unintelligible). The reason that is, is way, way back the very first reactors in Hanford or wherever, that's how they used to get the rods in if they had an (unintelligible) up there (unintelligible) ropes.

TG: Oh okay.

LP: (unintelligible) way, way back.

BD: (unintelligible) purification in this area.

TG: Okay.

LP: Now why do they call it the plenum (unintelligible)?

BD: It's not a (unintelligible).

LP: Okay.

TG: So that big— Why is it enclosed like that?

BD: Heated coils, steam coils in it, and that's the only reason it's (unintelligible) is you got steam within that case. And it pulls air from that—the ductwork the other side of that wall, the stack area. It pulled in air from the outside across the steam coils, the heat. It didn't have any coolant. It wasn't cooling.

TG: So it was just a heater, it's a big heater.

BD: Yeah. (unintelligible).

TG: Our cooling was chillers. I guess they're (unintelligible)?

BD: Purification that went through the deionizers. It went through (unintelligible) distillation that kept (unintelligible). You didn't want anything affecting your reactivity that you could not control. If your purity of your water kept deteriorating down, that affected reactivity. So if you kept that side stream coming off and going through what we call distillation, it kept purifying that water, keeping the purity of it. Like we have— It had to be like 99.50 percent, which is actually up around 99.7 (unintelligible) percent. And it had— We had to keep the— We sampled it and that side stream going off the distillation, it would boil it off. Distillation would boil it off, and the heavier water—that's why you hear it called heavy, would fall down, and that would be your higher purity stuff and it (unintelligible). So that high purity (unintelligible) kept going back into the system that was higher than what we want. So it kept the purity up. And also it went through deionizers that was taken out, and an assembly to have a failure it took out those (unintelligible). It also (unintelligible) any other isotopes. Those were (unintelligible). When they changed (unintelligible) deionizer or evaporator they (unintelligible). They (unintelligible) radioactive and just kept consolidating (unintelligible), and it just got hotter and hotter. And see that (unintelligible) deionizers are out back here (unintelligible) evaporate. In fact, (unintelligible) has a rate, it's like 30 mrem (unintelligible).

MS: Could we go back over here? What is it?

TG: What is it?

BD: Well we call -14. This area had— I don't even know the purpose of it, but (unintelligible).

MS: On the door they said something about refrigeration (unintelligible).

BD: Right. Refrigeration. I really don't even know the purpose of it. (unintelligible) done away with it years and years ago. It was done away with shortly— It was gone before the seventies.

MS: Okay.

BD: It was done away with. In fact, they removed them in P-Area. They were never put in.

TG: So this is the only place that we'd find it is here?

BD: Yes.

TG: Because I mean we've got to document that (unintelligible) back to the very—the dirty beginnings.

BD: This one's still here in P-Area. They removed it. They D&R'd it, took it all out.

LP: (unintelligible) refrigeration?

MS: Was it originally in all the reactors (unintelligible).

BD: (unintelligible) P-Area and (unintelligible).

TG: Now aren't we on +5 right now, on this level?

BD: Yes.

TG: But +14 would be down (unintelligible).

BD: Minus-14 we would go down the stairs.

TG: Down these stairs. So what's this stuff?

BD: You back on (unintelligible) zero level. That's ground level through that door.

TG: Is this the refrigeration stuff or is it down—farther down—

BD: Refrigeration stuff (unintelligible).

TG: And what's down there?

BD: (unintelligible), bunch of piping.

TG: So what's (unintelligible), all the way down or—

BD: That's the same in this area and P-Area. It's a little different in L and K, the way the (unintelligible) had that also (unintelligible) -14, so that's not— What's still unique to these refrigeration units, they're still installed over here.

TG: Okay so I'm going to put it's at zero level right before (unintelligible) before

BD: Where it's ground level out to where distillation.

TG: Okay.

BD: And distillation columns are all (unintelligible).

LP: We don't know (unintelligible).

TG: Refrigeration equipment, right?

END OF INTERVIEW

Oral History Interview – Woody Daspit

Woody Daspit was born and raised in Louisiana. He attended Louisiana State University for a brief period before serving in the Marine Corps during World War II. After the war he returned to LSU to finish his degree in physics. After a brief stint at the Naval Ordinance Test Station in California, he returned to LSU for a second degree. In 1952, he took a job with Du Pont, starting out at the Argonne National Laboratory.

After eight months at Argonne, Daspit transferred to Savannah River Plant in April of 1953. His first position there was with the Savannah River Laboratory, working for about two or three years on the Process Development Pile (PDP) in Building 777-M. He was then transferred to L area. There he worked in Reactor Technology, and he spent the rest of his career in Reactor Tech. Daspit retired from SRS in 1986, and currently lives in Aiken, South Carolina.

Interviewee: Woodson B. "Woody" Daspit

Interviewer: Mark Swanson

Date of Interview: September 13, 2006

M. Swanson: This is an interview with Mr. Woody Daspit. Is that correct? This is the 13th of September, 2006, and it's an interview about the reactors at Savannah River Site. Mr. Daspit, if you would, please state your name and your affiliation with Savannah River Site.

W. Daspit: I'm Woodson B. Daspit. I arrived at Savannah River Site in April, 1953, having served eight months at Argonne National Laboratory, preparatory to coming here because we had no facilities. And I worked in the Savannah River Laboratory at the Process Development Pile, PDP, for about two or three years, and then they transferred me to the plant into the Reactor Technology group, and that was in mid-'55, I think. And I stayed there the rest of my career, had almost every job there was there except the manager.

MS: And you were there until when, at Savannah River Site?

WD: I retired the end of March, '86.

MS: Okay. If you would just, for the record, where were you born?

WD: I was born in Louisiana.*

MS: I'm from Louisiana—not from Louisiana, but I lived there for eight years.

WD: Where?

MS: In Pollock, Louisiana, near Alexandria?

WD: I'm familiar with Alexandria, but not Pollock.

MS: *Anyway, you mentioned something about having worked at 777, right?

*Personal information has been removed from the transcription

WD: Yes.

MS: What reactors did you work at for the most part? All of them or just—

WD: I was never assigned to R-reactor. I was assigned to P, L, K and C.

MS: And out of those reactors, which one was your favorite? Or did you have one?

WD: The last one I was at. (laughter) The first time I moved. No, I had no favorite one. I would say that just a normal thing that some of the people I didn't get along with as well as I did at other reactors, but that's beside the point.

MS: Right. When you worked with the reactors, what was a typical day like and if you could even describe a typical day.

WD: Well, starting at the— That's a tough one. I went to the Reactor Technology group and stayed in their—headquarters, let me put it that way, because our superintendent was up in the main building. But in the plant—when the C-reactor—was the building, the 8300-C, which was an old construction building, and that's where we were headquartered, and headed up— When I left SRL, I was a low-level supervisor out there and had a few people working for me. We had various assignments, you know, What do you think, we've got radioactivity in metal, in some facility—how do you think it got there, and that sort of thing. So we looked that over and we looked at the water. We had the basin where they stored fuel and water flowed over through it continuously, went through the river.

And I will say that one of the things that we were not able to do in the early days is monitor the radioactivity because we did not have instrumentation that was capable of detecting it. We were looking at parts—one part per thousand and parts per million and later on parts per billion, I guess, what they're looking at. And this is the thing where they point and say, Hey you didn't do your job. We couldn't do the job. We didn't know how to do it. Anyway, this was what I did there and finally, they transferred me to— where to—that was L Area I guess.

MS: When was that?

WD: That was in late '55. And I spent— The Reactor Technology group there was a supervisor and two supervisors—an engineering supervisor and a physics supervisor, and I was the physics supervisor there. We had two of each of those and we were watching the process. Our job was to make sure that they did the work properly, safely, followed the procedures, and of course we had oodles of procedures. The procedures for P and R were different—not the same as for the other three because the facilities were— For example, our— Where the heavy water was stored— I'm losing my technology right now. But anyway, different facilities were built—designed and built for R and P than they were for L, K, C. So if you looked for valve number A, B, C in R, it was X, Y, Z in the other three reactors. And the people who wrote the procedures—the initial procedures were in P and R area. So have to change it. So we'd have to get the procedures changed. Somebody said, Hey we can't do this. We don't have that valve. It was something else. So we had to get the procedures changed. So procedures were in a constant state of upheaval. We tell people (unintelligible). Anyway, we had to do that.

We had to watch what the people were doing. I don't know how much you're familiar with the reactors, but we had to look at—we had to operate the reactors and our physicists were looking at what was going on in the reactor. And we tried to control the—what was going on with—what the flux distribution looked like in the reactor. And we had—it involved some of the stuff there and it was— And of course we worked hand in glove with the people in the 8300-C, those groups, and all of these groups were working with the people in the laboratory, Savannah River Laboratory, the physics group there, and engineering groups and so forth.

MS: What school did you go to, sort of backtracking a little bit?

WD: At the ripe old age of sixteen, I arrived at LSU, Louisiana State University, and stayed there until I got drafted. I was drafted in the navy pool, and I was told to report to the place in New Orleans where I was to report. And here comes a marine sergeant, says I need three volunteers for the Marine Corps. I ended up in the Marine Corps and went to the Pacific and into China for a period of time after the war. And came back and went to LSU and got a degree in physics. And we were a small group, probably about twenty people, majoring in physics. And I was not the smart guy. I was—did all right, but by the time I graduated I was looking for a job and I was the only one that had a job offer. I went to work at the Naval Ordinance Test Station in California doing ordinance work, I guess, experimentation, and then went— My supervisor— Well, I was on a training program there. My supervisor, the last one, was an SOB, not to me, indirectly yes. He was— He'd tell me, Well, Woody, he said, Go talk to Joe Blow, he knows more about this than I do. He said, Go talk to him. I said, I'll go talk to this guy. Called up and made an appointment. He said, What you doing now? He said, Who do you work for? I told him. He said, I tell you what, I don't help that SOB. I'm not going to answer your question; I'm not going to help you. It was time for me to leave. So I went back and got another degree in physics at LSU. In '52 I went to work for Du Pont, starting out at the Argonne National Lab.

MS: Going back talking about Argonne, what exactly did you do at Argonne?

WD: Wait. (laughter) We had lectures, technical lectures. As far as the technical work—experimental work I did, we were assigned to a group there. What you want to work on? I said, Oh I like to do this, so I'd work on it. We had the reactor there—the graphite reactor, move from the lab when it first went critical in the University of Chicago and out to Palos Park, I believe it was called.

MS: You talking about CP-1, that very first reactor?

WD: That was CP-1 and it was CP-2 when they moved it. And then there was a reactor out there, heavy water reactor, I think. And—

MS: Yeah they had— I've heard that one of the prototypes for the heavy water reactors at Savannah River Site was Zero Power Reactor-2, ZPR-2?

WD: That was a different one. The one that was out at Palos Park was a graphite reactor and I wanted to do some work and looked at something, I forgot what it was. And I put some things in the goat holes, they called them. And nothing ever worked out right. The ZPR-1, Zero Power Reactor-1, was a mockup for the Nautilus submarine reactor. ZPR-2 was for reactor SRP. And it was—there was an area there. It would bring it critical. It was small, but they did an awful lot of work with— Had a fuel element, which was 50 feet long with only—only 15 feet long there, something was— I'm exaggerating things. It was a very small thing. And we had a group there and I was not lucky enough to get in on it. (laugh) But we had— I think there were four of us waiting around, going to these classes, and whatever we wanted to do we could do.

MS: Right. And then you got transferred from there to Savannah River Site?

WD: Savannah River Site, yeah, into the laboratory.

MS: Right, and that's when you started working at 777?

WD: Yeah.

MS: And how long did you work at 777?

WD: Couple of years. Let's see, must have been— I came there in '53 and left out what's—two years.

MS: So you were there from '53 to '55?

WD: Um-hm.

MS: Who did you work with at 777, just out of curiosity?

WD: Well, at what level?

MS: I was trying to think of like, Tom Gorrell?

WD: I worked with Tom, yes. Tom worked— When I retired, Tom was working for me.

MS: Oh okay. We had to interview him on occasion, like a year ago so—

WD: I was in the PDP and there was another reactor there.

MS: SP, SE?

WD: Something of sort, yeah. I've forgotten. It was a Westinghouse design. I think it was Westinghouse.

MS: GE.

WD: It was GE?

MS: I think it was, yeah.

WD: Okay. (unintelligible) reactor.

MS: The little graphite reactor, the SP? I think that was a GE thing. But it had a tank above it, that was the SE. And—

WD: The reactor was a source of neutrons, the tank above was what the neutrons were doing.

MS: Right.

WD: My supervisor was Jack Crandall. Jack reported to Gerhard Dessauer. Gerhard was promoted and Jack took his job and George O'Neil took over the running of the PDP. I had an interesting one there. We were doing things that we didn't know what the story was yet. And we had our instruments trying to start up the place. And I was assigned a job looking at the safety circuits. The safety circuits were relays and so forth and looking at instrumentation. I got all the electrical stuff done, and had another group trying to figure out what to do with the instrumentation. We were looking at the nano-area of signal and the instrumentation was do this, do this, and if it did that it'd scram the reactor, so we never would do anything.
So I finished this and I asked Jack Crandall, I said, Well Jack I finished that, what you want me to do? He said, Well, go help the guys who are working on this, getting the instrumentation. I went there and talked to him. I says, Well, what you want? He said, This is our list. I looked down and I says, Well, let's put at the top of the list— Oh no, what you're going to

do is on the bottom of the list. What's on top of the list? I says on the top of the list you want to look at something called ground— I can't remember the terminology. Anyway, you connect it to a ground system. And you're talking in the nano-area for current, and if you had this motor over here and this ventilation system, and I was connected to the ground over here, this would have a slight thing there. And one of the construction foremen says, You've got ground loops. I said, What's that? He explained it to me. So I went there and I told him, They're going to do ground loops. Says okay. So the bottom of the list, had to go through about five people. And I wanted to go to Washington to visit up there, take a few days off. We were working 16-hour shifts to get the place going. So I turned around and said, Well I tell you, y'all go to lunch and I'll fix this out while I'm going. I went and took all the grounds out except one and brought it in as well, and said, Well, there it is and we fixed it just like that. And the reactors had—ions caused ground loops all over, and had to go back and do that, so it was interesting. Of course Jack Crandall said, Woody, when you want to go to Washington? (laughter) That happened a bunch of times. Okay. That was interesting, I enjoyed that. Okay, I digressed here.

MS: Oh yeah, that's no problem. But anyway— What was a typical reactor operating cycle like? And I realize that depends on what kind of material you were irradiating.

WD: Well—

MS: Let's say if you were doing plutonium or planning on making plutonium.

WD: I was not in the reactor buildings when they made the first loading. I was there when they unloaded it piece by piece and as they pulled a piece out, they put another one in. And that was done with the instrument—with the equipment we had, very sophisticated, robots really, in a way, to some extent. And there was good design. AMF did it, American Machine and Foundry did a lot of the work there for the— Anyway, we monitored what they were doing. It was around-the-clock operation, obviously. You don't want to set it down and start up again the next day. We did that with the PDP, you understand, zero power.

But we watched what they were doing. If somebody did something wrong or if a piece of equipment didn't work properly or some piece of equipment failed, if it was significant enough, we wrote it up and publicized it on the reactors. And this was called the reactor incident report. Reactor incident report for the Nuclear Regulatory Commission is something that shuts the reactors down, that's very serious. These were typical things to let people know that this piece of equipment has failed and so forth. And if it was a radiation thing, another group wrote that up. Then we had in-house committees when something happens we'll convene and see what happened, let's see what we can do. Sometimes we never knew what happened. We got a straight thing that said: shut the reactor down. It was shut down automatically. Why? We don't know. We looked at everything, couldn't fix it, started back up, never no problem. But there was a lot of—there wasn't much of that, but it happened.

Now when Westinghouse took over, they got a different story from DOE and all of those things that we wrote up, those reactor incident reports, they were looking at them to see what was done. And they called on me to help them up there, had a week's worth, Ebasco came in to help them. And said, got a week's worth for you to do. So I got out there and looked at those, yeah what you want? Tell us what you want. Find out, help us. I knew what all that was. Before the day was out I'd finished that week's work. And the reason I did that, Ebasco called one of our Reactor Tech people, said, I'd like to talk to you about this. Guy said, What's your name? I put you on my list for next Tuesday. I got out there and I called up the guy, I said, I know who does this, called him said, Joe, I got a problem. Can you help me? Come on over. It happens two times out there, week's work. Total was one day's work for two weeks. Anyway, we did that so we had these incident reports and they were very good. Now some of them— I don't know if you knew about—knew how the reactors operated, but we had these rods we'd pull up, and how many rods?

MS: Wasn't there like a—one of the problems was like a source rod that came up and melted or something?

WD: Oh yeah. That was one, yeah. But the fuel rods went in, they were stationary, but the control rods and the safety rods would come out. And every now and then one of these— They were electronically controlled with relays and so forth. Every now and then one of these rods would run out or go in, whatever it was. (unintelligible) write it up. We didn't know what happened, but— Each rod had a relay system and a panel and there were 61 times 7 rods in there. Some of them were for tritium production and so forth. Anyway, you might have to write one of these up. You'd replace a unit and put a new one in and so forth. And these were written up— We'd write the report. We knew what it was. We needed something else, we'd redesign the whole thing, we'd recommend, that's all you could do. You couldn't shut the reactors down because the customer wanted plutonium and tritium, and in some cases radioactive material for medical purposes and what-not.

MS: Yeah, for the space program, I think, they made some like heat sources, I think, and was that plutonium-238 or—

WD: It might have been. I can't remember.

MS: One guy that I talked to was talking about the differences between like the reactor cycles and then the subcycles. And I'm not sure— Would you mind sort of explaining what the difference was between those or—

WD: Okay, the cycle replaced all of the fuel and whatever rods needed replacing. We got into the program when Seaborg was chairman of the Atomic Energy Commission and he wanted us to do some scientific work. And evidently, there wasn't that much need or requirement for plutonium and so forth. And of course he was one of the guys who discovered californium.

MS: Plutonium.

WD: Californium.

MS: Oh okay.

WD: This was something that— Don't ask me why. I think it was something that was going up in the shoots. But anyway, so what we did was design a reactor component. It wasn't a plutonium facility then. We had something, enriched uranium and aluminum, and it had a core with a lithium rod for tritium production. When that burned out, we'd shut the reactor down, keep the fuel in, pull the tritium-producing rod out and put another one in. That was one of the "short reactors." I think that's what you're talking about.

MS: In the reactors at Savannah River Site, what were the main products that were made? I know they had plutonium and tritium. What were the other sort of like miscellaneous things that were produced there?

WD: I never was involved with that. Californium was one— You talk about going to see Harvey Allen? Ask Harvey. And Gerry Merz, you've seen Gerry?

MS: Right.

WD: You've seen him already?

MS: Yeah.

WD: Okay.

MS: They gave me a list of what they remember. It's just one of the standard things I ask. But they were saying that of course they had plutonium and tritium mostly, but they also made plutonium-238 as a heat source, some cobalt-60, although some weren't affiliated with that at all and then— And then of course the transplutonium materials they were working on for—I guess for a number of years, like in the late sixties, did a lot of that work.

WD: That was californium, I think.

MS: Right. And why did they want to make californium? Was it just to see if they could do it?

WD: It was a source for something, and I'm not sure what it was right now. I just—

MS: I know it was a— They called it a neutron source, but I don't know that they ever found a really viable economic use for it.

WD: I think we put some of it in the source rod—source of neutrons to start the reactor up. I think that some of that went in there, but we had other stuff which we put some polonium or something in there initially. (laughter) I've been gone over twenty years, you know.

MS: Right. I heard that when they brought materials to the reactor, they would usually bring it by truck, and then after the stuff got irradiated, it would leave by train. Was that just because of the weight of it or the weight of the cask around the irradiated material?

WD: Yeah that's it. The plutonium produced initially had slugs and what they called a quatrefoil. And those came in on pallets and they were loaded in an area for that. Then when we went to the enriched uranium, it was extruded facility that uranium was put in. Then they made a long tube, it was extruded and went into the reactor and those came in metal boxes and what-not with—not police—whatever people are, security people that would come along with it. And when it left— Initially the ones with the aluminum in it and so forth, went to Idaho, to the facility out there by railroad. And DOE had people—AEC in those days—had people in a caboose adjacent to it, went up there, and then they brought stuff to Oak Ridge. Oak Ridge would take it after a while and regenerate it and get rid of some of this bad stuff, the isotopes, and would send it back to us. And those were all done in—because a lot of—some radioactive— Anything that came out of the reactor was radioactive.

MS: Right, yeah, that's true, got to go somewhere.

WD: And they had the big cask on the railroad to go to Separations area here on the site.

MS: How many people worked in a typical reactor area? Let's say C, K—

WD: I'll be facetious and say maybe half of them. (laughter) You've heard that.

MS: No, I hadn't heard that.

WD: Well no, the reactor shuts down and people have to work. And maintenance people, the technicians and what-not, worked their tails off getting things done. And then when the reactor was back online, for example the machines to change fuel and what-not, those things were being worked on, but not in a panic. And so they worked on that and you'd see people going to the coffee, get a cup of coffee in the morning and spend an hour there or what-not, say why in the world are they doing that? Well they don't have much to do, but they have to be there.

MS: Yeah, in case there's a problem.

WD: Now the group that ran the machines to take things out of the reactor and put them in, they went from one area to the next, the same as NRC groups, because they have some reactors that are serviced to the reload—reloading of one and then they go to the next one and the next one because they're all pretty much the same. They do that.

MS: Oh okay. So for stuff like that, they would have like a crew that would go from one reactor area to the other?

WD: Yeah. And they had the maintenance people too that would borrow— They'd borrow from one area to the next and so forth.

MS: I heard that if they needed extra material, for example, they would—they felt free to go to R Area since R was closed down as early as 1964, and they could cannibalize stuff off of that, if they needed it.

WD: Yeah they did that. I guess I'm just about— It wasn't very much of it done. There wasn't much there on it that could be lifted out. But we had equipment there that was— We had auxiliary pumps and so forth. Yeah, they pulled a lot of stuff out.

MS: Right, yeah. How did higher power levels affect the operation of the reactors? I know, for example, they pulled—a lot of the original heat exchangers got pulled out and put twelve in instead of the original six in a lot of the reactors and things like that.

WD: Well they put only six in with initial construction because they didn't have enough heavy water. And when they got to C Area, they had twelve heat exchangers in, then they started replacing—adding the others in. The design was to put the twelve in all of the areas. I don't know whether I answered your question or not.

MS: I was wondering if there were any other aspects of running the reactors that had to change as they increased the power in the reactors. Did they have to have more people on staff just in case there were problems or—

WD: No. We started up the reactors at a very low power level. Let's talk about megawatts—200 megawatts or something. And it was a shakedown thing. And you'd operate there for the first load and the next load came along and you said, Well we did okay at 300 megawatts, we're going up to 600 megawatts now. And we got up to 2000, I think. I'm not sure. But we were worried about the radioactivity leaks from the in-core while it's in the reactor. We would monitor everywhere. It was a very sophisticated system, move things up slowly.

MS: How did reactor safety change during that period, or for that matter, over the whole life of the operation of the reactors?

WD: That's a tough one.

MS: I know there was like more and more of an emphasis on safety as the years went on. It almost seemed like as the reactors were beginning to be shut down, there was more of an interest in safety. Maybe it was just because they had more time to deal with it.

WD: We made calculations—the laboratory, SRL, made calculations saying that this was not—we shouldn't be doing that—we should not be operating at that high a level. And we had a manager in Wilmington who believed in that very strongly. And instead of operating at, what I say? I'm going just pick a number out there, 2000 megawatts, we were down to about 1500. And then the customer was yelling for more plutonium, so I chaired a committee to see what we could do to bring it back up. And we did that and management up there was happy with what we came up with. We brought it up to—started out with 2000, had to go down to 1500. These are just numbers again. We got up to about 1850 or something like that, said that's far enough. There was no danger, as far as I know. I don't know why they accepted— One of the top managers up in Wilmington felt very strongly that we shouldn't be operating this high up. You want a name, I'll tell you who it was—guy's name was Jess Schroetch. He believed in that and he had the wherewithal to make us do that. That was the only reason I know we did that. Now— I just—I can't believe anything else. If we came up with something, we immediately put it on the list of things to do to make it safe. Our procedures— We had 2500 procedures to operate the reactor, another five hundred or so to operate the electrical equipment and other pieces of equipment there.

MS: Who wrote those procedures?

WD: Well, they started out in R-reactor. There was a lot of room and the Reactor Technology group was there, and they were assigned the job to write the procedures. So an engineer or physicist or chemist, or what have you, would go look at the equipment and this is what it was going into the reactor, what the fuel looks like and so forth and write a procedure, and get somebody who knew something about the machine that was going to load the reactor, had procedures for that. So we looked at that and then they'd go back out and check them out with the procedure. And most of that started in R-reactor because the people were there, had nothing much to do except write procedures. But they were running the equipment, they were learning how things run—operated. I got there later than that.

MS: How did security in the reactor areas change over time? Let's say— I know that in the early eighties Wackenhut came in, for example, and—whereas before it was pretty much just like Du Pont security officers might be right at the entrance to the reactor areas, but they didn't wander around in the reactors themselves.

WD: That's pretty much what it was.

MS: And then later on Wackenhut, would have guards in different positions and they were more concerned about— I heard in the early days they were more concerned about spying, in the later days they were more concerned about terrorists.

WD: Yeah, but what was going on here about the same time was going on with the Nuclear Regulatory Commission. I did some work, operator licensing for the Nuclear Regulator Commission. And I remember going to Prairie Island, which is in Minnesota, with one of the guys from Washington. They weren't in Washington, they were in one of the suburbs. But anyway, the guy says, Can you imagine the security that's here now? When I first came here, you'd walk in, and walk into the control room, say here I am. Okay, Westinghouse comes in, Wackenhut comes in and they changed that. That was for the—something more of a— I can't answer. I'll say it's—it's more— I can't remember why did they changed, something happened.

MS: Yeah I guess it was like when they took over the embassy like in Tehran, it—that event that sort of torpedoed Jimmy Carter's presidency and then Reagan took over. After that period then, they got more concerned about terrorism. It was just a few years later that Wackenhut comes in.

WD: I was gone when Wackenhut came in. And when Westinghouse came in, I'd already left.

MS: Were there any extra safety measures that were implemented, like within the reactor itself? I heard about that gadolinium—gadolinium nitrate, is that it?

WD: I think so.

MS: They would inject into the reactor in case it got out of control. When did that come in, or do you remember?

WD: Pretty early in the game. We had control rods that should move, had safety rods which should move to shut the reactors down. And if they didn't work, it was the third safety. And they would inject gadolinium nitrate from the bottom, as I recall. And we did test one I think, to see what happened.

MS: Okay.

WD: That's a long time ago.

MS: Were you ever involved in any of the neutrino work that they did, especially like in P-reactor?

WD: Not R and P. R was—people from Brookhaven were doing neutrino work there. The ones in P-reactor, started out Case Western Reserve—no, it started out with Los Alamos and people worked there. Reines went to Case, headed up the physics department there and then moved to California at Irvine. I was the go-between between what they wanted and what the plant could do. And we bent over backwards. We built equipment for them for free to do the experiments. It was a safety feature and we found out that it worked.

MS: Why did they want to use R- and P-reactor instead of the other ones?

WD: You could get closer to the reactor core to put the instrumentation. The design was different. And there was room. Those reactors had a lot of wasted room. They built the building and decided what they were going to put in it and it fit in with the extra room, so the later reactors L, K, C didn't have extra room.

MS: And how long did that neutrino work go on for?

WD: Until the reactors shutdown.

MS: I know that initial neutrino stuff was in the fifties, but I think it went on all the way throughout. Was that something that happened every year or—

WD: Continuous.

MS: Oh really?

WD: Yeah, there were instrumentation there. In P-reactor they had people come in, graduate students, assign them there to do experiments and take data and so forth. A lot of that data was taken on film, Kodak film. And I was there when something went wrong. For example, we got a young physicist graduate student and I told him that you have to follow the rules in here.

And he had access to come in at any time—

END TAPE 1 OF 2, SIDE A
BEGIN TAPE 1 OF 2, SIDE B

WD: —shift supervisor know that he's in the area and that he's gone. So if something happens, they'll get you out of that safely. Oh that's ridiculous. So to get him to do that, I had to call Fred Reines—I don't know where he was at this point but anyway—and told him— This is just one of the instance. Anyway, he said, he says, It's got to be done. I said, Yeah it's got to be done. We had an incident out there where we had a chloride—chlorine leak in P-reactor and it got into the reactor area and it was shut down already, but it started leaking, and people got a little bit of overdose of chlorine. Nothing real serious, but they took me to the hospital, and they cleared the place out. A couple of people in the control room could handle it all at this point with plastic suits and oxygen. That happened there, it was a good example of why people needed to follow— In other cases, they wanted to do something with—put a tank or some chemical in there—hydride, sodium hydride or something. I says, Is that safe? That was my job, is it safe? Prove that it's safe, put it in there. And there were pros and cons. This hydride was what they used in the rockets at that time, rocket propulsion I think. Anyway, hydrogen's a bad thing, let's face it. Anyway, so—and they showed it was safe and so we went on with it. But they'd bring people in who'd want this. I remember this particular hydride one, we got the fire department chief on site, said, What you going do if you get a fire here? Said, Well we'll handle it, so forth. That was my job, in addition to my other work.

MS: What exactly—just out of curiosity, since they were doing all this neutrino work for so long, what did they find? Aside from the physical evidence that neutrinos exist but all the other work they did over the decades, what were they trying to discover with neutrinos? Or do you know? They may have just kept that to themselves. (laugh)

WD: I'll be facetious and tell you what I think. Fred Reines got what he wanted. He got a Nobel Prize. But he told me— He'd come in— When he'd be in town he'd come in my office, P-reactor, when I was there and shoot the bull with me. Say, I just got back in South Africa, said, we put a facility down in—a mine, what was it? I think diamond mine. It was about 13,000 feet deep or something, and had to air condition it down there—not for the people but for the equipment. It was so hot down there the equipment wouldn't operate. That was an example. And the guy from Brookhaven, I can't think of his name now, he was the first one to do this at the site. No he wasn't the first one. First one to do it in this facility at R. And he wanted to know when Reines was coming and Reines wanted to know when he was onsite so they could talk, talk neutrino. And Reines was doing work all over the country, in lead mines and one up in the Dakotas and that sort of thing. I don't know what they got out of it. But it was basic research. And of course, Seaborg was all for it. In fact, he came later of course. That's the head of the Atomic Energy Commission.

MS: Glenn Seaborg was really interested in doing the transplutonium program. He was the one that pushed that. Anyway, was that just something that he wanted to do pretty much just for the hell of it?

WD: Yeah, I think so. That's the way he got californium, I'm convinced. We made a small core for the reactor and operated at 1500 megawatts or something, just that small core. And it would burn up the fuel, two weeks or something like that. Had to replace it and so forth, continue doing it. I'd forgotten most of that. (laugh)

MS: Yeah it just seemed like they were making this stuff and then worrying about the utility of it after the fact. It was kind of like, Let's just make it. And I think he really believed that there was going to be all these great uses for this material, but just didn't pan out.

WD: Well a lot of things you know, that the Atomic Energy Commission did. At Brookhaven, for example, they were irradiating cancer patients with the reactors there. And we had a guy at the plant, he was a pretty high up manager—assistant department superintendent for the reactors, I guess, Ivan Smith. He had gone into a convulsion one time and they opened up this skull and said it was hopeless or something when they saw it.

(interruption)

WD: Where were we? Anyway, one of our Wilmington managers called people at Brookhaven, What was the result of people being irradiated? None of them survived. So Ivan wasn't going to be sent up there. And he overcame it locally and spent four or five years. His demeanor, whatever you want to call it, was different from before versus after—different person.

MS: Yeah that stuff's pretty tough. I know that they thought that californium, if they made these little needles out of it, they would be able to insert it locally into a cancerous area and it would—it might have some effect on that. I never— I never heard that it had any particular beneficial effect. It's kind of pretty much like they just thought they'd try it out and see if it would work.

WD: That was neutrons, I think, wasn't it?

MS: Right.

WD: They were using cobalt and other things, still are.

MS: Right, yeah. Which reactors were most popular for which materials, or was there a break down like that? Were there reactors that were slightly better suited for one material over another?

WD: The only thing you can say there was once you converted to this, if you want to keep it—if they wanted more, you would stay with that one reactor. But none of them were—there's none better than the other.

MS: Were you involved in the HWCTR program? That Heavy Water Components Test Reactor? I know we talked about the transplutonium program. I didn't know if you knew any more details about that, that you wanted to talk about.

WD: I was not too much involved with that.

MS: Yeah I heard there was one story about— And I assume it was during the californium program where they had some researchers from University of California that were out there at one of the reactors and they—this is what somebody told me. It may have been Mr. Merz, but he didn't want to put it on tape. But he said that one—the story he heard was that they called one of the HP people to come out and give them a check through so he could leave or something, and they didn't show up on time. He called Glenn Seaborg directly and complained about it, because they knew him from the

University of California days. That rattled chains all the way down the— (laughter) HP showed up shortly thereafter.

WD: I'm surprised at that because there was an around-the-clock HP representative in the areas. Surprised.

MS: Well it may have been after that.

WD: Yeah. No, that was from the very beginning.

MS: It was? How did they work that out? How did HP interact—how did they function in the reactor areas? Did they have an office in the reactor?

WD: Office in the reactor building. They had a supervisor with two or three technicians at least. If they were going into a contaminated area, they were required to follow the rules. The rules state that you will get permission—written permission from the reactor supervision and from the reactor technology supervision, if that was necessary before they could go into an area.

MS: What other services were available in the reactor areas? I know they had little— I heard they had a little cafeteria. I heard that they didn't probably cook the food there; they probably just brought it in.

WD: They brought it in, yes. The cooking of the food, they made their own tea, I think, and coffee and that sort of thing, but hard stuff, we brought in.

MS: What other little service areas were there to keep people in the reactor areas happy?

WD: I can't think of any.

MS: Why did they have Powerhouses at each of the reactor areas? Was that just to make sure that they had power no matter what?

WD: Dual purpose. They wanted emergency electricity and they needed steam. We did work—steam heating. We had steam in the purification area for heavy water, and that was in all of the areas. There was no— Let's see, C Area— I don't think they had any auxiliary electrical system, but I'm not sure. The other areas had it. See, we had the big powerhouse in the 400 Area, heavy water area. And that was just a duplicate, I think, to give us some extra power in case SCE&G lost the power lines from tornadoes or something. And at the same time, they needed that for the towers where they were separating heavy water from light water. And they needed the steam there and lots of it. So the steam—excess steam from the electrical system would be hot enough to get there. And then later on they put a steam line all the way to the 200 areas, processing area. And the other big one—there was another big one somewhere. I think it was 200 Area.

MS: Yeah I'm sure they probably had it in the 200 area too, Separations—they would probably have to use a lot of that.

WD: They needed the steam more than the electricity, I think.

MS: Right. It always seemed strange to me because they had all those steam lines. When you go out there now, they still have steam lines that are venting periodically. That's always your initial reaction is like, Why do they have so many steam lines here? And they go so far. But somebody told me that's really not that uneconomical. It seems to me like it'd be like a total waste to have steam lines going miles and miles and miles away. But they say, Well, it's not that unusual. Once you get the lines hot, they'll stay there.

WD: There were no external steam lines R, P, L and K. And I think C area also had a small steam generator.

MS: So those were like internal steam lines?

WD: Yeah, all internal.

MS: So they just had their own steam lines. They didn't go anywhere else? When did the first computers come in, in the reactor areas?

WD: (laugh) I really can't answer that. If I was going to guess, it was when I was in K-reactor, whenever that was. Let's see— Probably in the late seventies, that's a guess. A guy named Chris Gimmy could tell you.

MS: Yeah, I got his name from somebody else, but—

WD: Chris was the honcho there. They used it first off for a monitoring system. And we put the safety circuits on it and automated it so that they raised the power on the reactor from this level to that level.

MS: Talking about the reactors themselves, how did the Savannah River Site reactors stack up to other reactors in other areas, like Hanford or even later reactors at some of the Argonne institutions and— I know you can't compare production reactors to power reactors, but did Savannah River reactors do as well as they thought they were going to do or—

WD: I think we produced more plutonium and certainly more tritium because they were designed to make more tritium than Hanford. Hanford had about six reactors I think. And then they've got the big N-reactor out there, which was a—all those were graphite reactors, they weren't heavy water or light water. Idaho had a reactor design— Reactor prototypes were being made there. SL-1 was the one that—in Idaho. You remember that one at all? This was a military reactor designed for Antarctica, I think, and a couple people were killed. And they think that somebody was playing jokes on the other and moved a rod or something manually and somebody goosed him in the rear end and he came up there and the guy pulled the rod out. The rod went up in the superstructure of the building. And I think the guy who pulled the rod out, that rod went right through him.
And there were a lot of these things. A guy in Argentina designed a reactor, thought he knew everything about it and he didn't. He pulled it supercritical. ZPR-1 at Argonne National Laboratory was pulled supercritical. In Idaho, there were lots of reactors. Argonne National Lab had one there. It was a liquid metal reactor. And they did a test on taking the reactor and unload, let me call it a uranium rod, sent it underground to this building, and regenerated it and put it back. And Hanford had FFTF, Fast Flux Test Facility. It was the same type of thing, but it was a higher power and whatnot. But this is just a few of them. Brookhaven National Laboratory had a heavy water reactor. Every now and then this tritium would go bad bad so they'd send it back and get some clean heavy water. I've been to most of these facilities; I know something about them. Oak Ridge had some too of

course.

MS: How long did it take to prepare for a particular reactor cycle? Or again, did that depend on what you made?

WD: Well, yeah it depends on what— Initial years it took longer for two reasons—We had a low power level, so we wanted to cook it—

MS: Cooked longer, I guess.

WD: It took longer there. And also taught the people how to handle making the load. And of course, when it came out the reactor, it was the same thing, we had to handle that. The slugs we had originally, when they took them out of the reactor, they had a high iodine level, I think. We sent them to this Separations facility and one of them—one of those slugs got out of line, they released iodine, which is not good. Relatively low half-life. So you'd leave it in the basin for a while. But if a slug got off, what'd you do with the slug? We had a number of incident reports I mentioned earlier that somebody would have dropped a slug and put it in the wrong place.

MS: How long did it take to train reactor operators?

WD: One-on-one, supervisor would— There were lots of supervisors and they were all learning. The supervisor was learning—looking at the procedures, looking at hands. And the guys came in and— We had lots of equipment that had read-outs on them and we required the people to—the operators to go in and record what the read-out is saying. A large part was to make sure that they were doing something, recording it, if something abnormal showed up you could look at it. If you just watch the gage, you wouldn't know it. So we did a lot of that. Now, training of a reactor operator for our facility was not very difficult except the early days when we were learning, everybody was learning. Not like a commercial reactor where they go to school for— I did some operator licensing, I was thinking— To train them for a reactor operator, I think it was a couple of years. A year later, they could take an exam for senior reactor operator.

MS: How much material actually came out of these reactors? Are we talking about something the size of this house or—I mean just in general size, just to get a feel for what actually, over all the years, came out of all these reactors.

WD: You talking about plutonium, for example?

MS: Let's talk about plutonium, because that'd be easier to quantify. I mean tritium's sort of like a gas thing.

WD: Those numbers are available. I read about them all the time, how much plutonium we have available we're trying to get rid of and so forth. But the other stuff, we'd put a tube down, rods ran through it, and some of those tubes would split after a while from vibration because there were seven rods in there and you had a web in there to separate them all and they'd get a little vibration. So those would come out, and they'd go to the burial ground. Aluminum does not have a long half-life, very long—a little bit but it doesn't get very hot. Initially out of the reactor it's hot. So all of that. I don't know. Your question— There's tons of it just buried, of the (unintelligible) components.

MS: Right, the stuff that you couldn't use but it still got irradiated has to be dealt with. What about, just for the record, and if you wouldn't mind, just kind of going through the basic processes that went on in the reactor, I mean from the assembly room to the reactor and the disassembly. I kind of know that stuff already and I'm sure you do, but I thought it might be good to get it on tape.

WD: Yeah, I'm trying to see where to start.

MS: You don't have to worry about the 300 Area. We can assume that the tube's are already made.

WD: Well, receive the material from the 200 Area, 300 Area, excuse me. And we'd look at them and found sometimes that things weren't acceptable, we'd have to send them back—not often, but we did that, and put them in the reactor and irradiated them and pulled them out. Went into the basin to cool things. Separate the things that you can. There's not much to talk about there.

MS: Right. Now with special products, like the transplutonium stuff, was that handled in some different way? Was it simply just put into a box car just like the other stuff and just went to a different location?

WD: Yeah.

MS: And was dealt with? So really as far as the reactors themselves go, all you really have to do is just make sure that they fuel the target elements and all the other vertical elements that go in there are good and intact. You radiate them for however long you need and then they just go out. And make sure that the heavy water doesn't leak too much and doesn't have— What about leaks in the reactors? I know that was sort of a problem later on.

WD: Leak how?

MS: Let's see, well I heard that R-reactor, that's one of the reasons it was closed down was that it had some leaks in it.

WD: And C Area had leaks.

MS: And C area had leaks under the knuckle, I think, knuckle joint. It had some leaks, but they couldn't quite figure out how to deal with or—

WD: Well they had two sets of leaks in C. They patched the first one. And then it started leaking again. And that was— They were trying to do something there when they probably said, Shut it down, which was a wise thing to do. There was that kind of leak. There was a leak of something—plutonium rod what-not, the uranium rod would leak and it would get—contaminate the water cooling the reactor. We found out some of the things that were causing that and corrected them and they stopped leaking. But you can't— It's difficult to design one that's not going to leak.

MS: Well that's true. You're going to have water, it's going to be difficult. Whether it's heavy water, light water, it's still going to want to leak. But it sounds like, overall, that the heavy water reactors did pretty well compared to, let's say, a graphite reactor. Was heavy water— Were the heavy water reactors inherently safer than the graphite reactors, or do you even know that?

WD: I don't know that. We had three safety devices and there were only two for N reactor at Hanford, I think. The regular safety rod system and they had a system where they dropped some pellets in. Boride, I think. And we had that—the 300 Area reactor– boride.

MS: Right yeah. How did reactor technology change over time? Or did it?

WD: That's a tough one. We got smarter. We trained people harder and when they were younger in their job. I don't think there was much change; that's my personal opinion.

MS: How many people overall were in Reactor Technology?

WD: Cumulative or at one time?

MS: At any given time.

WD: At any given time?

MS: I mean we're talking about hundreds? We're not talking about thousands?

WD: No, we're talking about a hundred, maybe.

MS: A hundred?

WD: One hundred.

MS: How many would be at each reactor area at any given time? Just a handful or—

WD: Seven. The supervisor and two other supervisors, each of the other supervisors and two people under them.

MS: Were there separate offices for Reactor Technology people—

WD: Yes—

MS: —within each reactor area? You had a designated area that you went to?

WD: Now later on, we only had one supervisor in the area and probably about three peons, let me call them.

MS: What building did Reactor Technology people—where were their offices in the reactor areas?

WD: In C Area, I mentioned 8300-C earlier. Remember where we started out with the groups, we had three chief supervisors and each supervisor had subsidiary supervisors. And they had people. And that was the vast majority of the people. Now when things went— People were going out to the areas to check things out all the time.

MS: So in other words, the main Reactor Technology area was in C?

WD: In C, yes.

MS: Okay. And then when you went to another reactor, let's say you went to L-reactor, were there a series of offices there for Reactor Technology people?

WD: Yes.

MS: Would that have been in the reactor building itself?

WD: In the reactor building, yes.

MS: For the C area though—administrative?

WD: It was initially 8300, later became 706. They changed the number, but they didn't change the building. And then we gave up the building— Oh goodness when was that? About 1980. Built another building. Built it with a simulator in it, to simulate the reactor.

MS: I've heard about the simulator.

WD: Then we moved in that building, along with some other people. Maintenance, chief supervisors, mechanics, and so forth.

MS: Right, yeah. How many operators would there have been, let's say in any individual reactor area?

WD: Goodness, there were about ten operators on a shift, three or four supervisors. One overall supervisor, senior supervisor, shift supervisor in charge of the control room, another one for the rest of the building. And then depending on what was going on, you might have another one. And somebody in training, supervisor in training.

MS: What happened to that simulator?

WD: I left there. I left it there. (laugh)

MS: I know it's gone now, but I don't know what happened to it.

WD: I have no idea.

MS: Yeah it would have been nice if we could have gotten our hands on it. Well, thanks again. That pretty much covers all the questions I've got to ask right now. If there's anything else you want to add, we got plenty of tape left, if you want to add anything that you might have thought of that I have not covered.

WD: In some of our shutdowns we did internal reactor tank inspections. We had designed periscopes to look in. Had to work underwater because that was—most of our shielding. We had surprises. I remember one reactor, they inspected the tank wall and the cracks were all on it. What it was, oxide had formed on it. When you dried it up, in an area, it would crack. We thought the damn tank was going to fall apart. But that's necessary to do that sort of thing.

MS: Yeah, I had heard that the 304 stainless steel turned out to be not as good as some of the later products, but at the time that's the best—

WD: I don't know. The design people used what they could get. Most of the stainless steel in the '51, '52, '53 '54 eras, the vast majority what was used made in the country.

MS: Yeah they had— There was a type of stainless steel called 304 and apparently it was used a lot in the tanks and some of the piping and it turned out to be not as good as— It was subject to more corrosion than they thought it was going to be. But they said at the time in the fifties, that was the best you had.

WD: Yeah. I think it survived pretty much.

MS: Yeah it worked well enough to produce the product, so that was the main thing.

WD: See what else? We had training programs, it was for reactor operators up through the senior supervisor level. That was formal, graded and so forth. And I worked on that. Had people that would go around and give them written and oral exams. Sort of based on what the NRC was requiring from commercial reactor personnel. We gave talks to the service groups—electrical groups, electronic groups, maintenance groups, the power groups that were interested. They weren't interested in the reactor, they were interested in the Powerhouse and the steam generation. But the other groups—health physics—would go to these lectures. I gave a lot of them. And some of the guys would come up and say, Woody why in the world didn't y'all tell us some of this in the past? We didn't understand that and now we understand what's going on. Well, you know, they didn't want people to understand too much in the early days.

MS: Well that's probably true.

WD: But I talked mostly about equipment, why it was built this way and so forth. But they enjoyed those lectures.

MS: What kind of equipment would you have explained?

WD: Design of the reactor. So, we had something at the bottom of the reactor, what do they call— Anyway, you could pull them out, and why they were designed this way. If something went wrong, you could replace it. You could put a suction cup down, keep it from leaking and pull the bottom out and put another one in.

MS: Yeah, I heard about that.

WD: These things evolved. You got a leak what you going do? Until somebody can design, we said, We'll do this, make it work. I can't—off the top of my head.

MS: Talking about heavy water and stuff like that, how often did you have to— I know there was some kind of a facility at each of the reactor areas to help keep the heavy water concentration—

WD: That's why we needed steam.

MS: Oh that's what the steam was for?

WD: That's why the steam was needed, most of the steam.

MS: But on occasion when you needed to refill the heavy water, how often did you have to go and get it from D area, when that was in operation?

WD: Well the columns for purifying the heavy water would end up as something that's about 90 percent heavy water and 10 percent H_2O. And we'd take that and send those back to the 400 Area where they'd put them through another still bring it back up. And that's the only time we ever replaced any water, not in any large amount at any time, 55-gallon drums had a lot of it in it.

MS: So that pretty much tried to be a self-contained deal where you could just deal with the heavy water that you had right there on the spot. How does— I should know this but I don't, but how does steam actually do that, using the steam to keep the heavy water purity up?

WD: Well, there were at least two columns in the reactor areas and they had the steam heating the water, and don't ask me how it separated the H_2O from the D_2O. (laugh) But it was a— There were plates where it would boil up. And the H_2O, I think, would boil up higher, faster than the D_2O. And that would go, recycling it all along until you got up—until the H_2O level was too high and they'd draw off some of those. And maybe they drew them off—I wasn't familiar with that that much but they'd draw off as it went along.

MS: Where were these two columns located? Where was that in relation to—just outside the main reactor building, or was it—

WD: Do you have a picture of the in here?

MS: I believe we do—

WD: You must have. It's not on the cover?

MS: Should be. I'd hate to have to go back to the index to find it, but I probably would.

WD: Heat exchanger. Reactor tanks. It's further back than that I think.

MS: Here let me turn this thing off until we—

(tape pause)

MS: I'll just repeat this for the tape, that apparently the two columns in the reactor areas were adjacent to the 105 buildings but not in them. Then there were filters associated with them—

WD: Yeah, the same area where they had some filters, deionizers and so forth.

MS: Okay. And let's see— I wonder, were those things ever taken out? Were they there as long as the reactors were running?

WD: They were.

MS: Okay. Were there any other issues or comments that you wanted to make or—

WD: Well something we didn't touch on was the ventilation system. We had filters, the ventilation system as it went up to the stack it was sucked out up there. And I think that you could have a water seal with some of these, you wanted to isolate one of them. I think that's what they would do, they would isolate them by putting the water in the tank. So the exhaust went up the stack. And there were a lot of leaks into the building where air could go in, and we closed up a lot of those but you could never close them all up.

MS: One thing I was just thinking about was in the early days, I guess if they had water that was too hot or maybe possibly a little bit irradiated or something like that, it would go down the stream, wasn't that correct or—by the time it got to the Savannah River it would be pretty much okay.

WD: The disassembly area, where material came out the reactor went in there, it was about 2000 gallons per minute that went through that—flushing that area, went to an exhaust canal to the river. And we didn't recognize what the—any stuff that came off the assemblies, any heavy water. Let's say there was an oxide forming in the reactor and you ended up with some radioactivity. And it went into the basin and some of it went off. And there was a lot of radiation where those things went into the river. And most of it was owned by the Augusta Chronicle people and it was—they didn't care. Of course, they fell out with the reactor people—with the SRL people—the SRP people, SRP I think. But he didn't care about it, it wasn't bad. And once again, it's one of those deals where you can't detect something, there it is. And that's true throughout the DOE—

END TAPE 1 OF 2, SIDE B
BEGIN TAPE 2 OF 2, SIDE A

MS: This is tape #2 of the Woody Daspit interview, and it's 13 September 2006. And we were talking about releases from the reactor area into—towards the river.

WD: We had a big problem right after the source rod melted. And some of the activity got into a sediment basin, earthen basin. And I forgot how much was in there. It wasn't an awful lot, but it was some. And the basins were there, we dug them just in case we had to dump some water. We had—trying to think. We had some pumps, external pumps. We could pump water into that facility. We had problems with it. The effluent from those pumps—one area I know, maybe more than that– were terra cotta, big old things and they cracked on top. You wouldn't think they would crack on top, not from an external force. But evidently there were overburdened with soil, there was enough to put continuous pressure on them and they cracked. And we found out we had to replace those. No radioactivity involved, but it was there in case you had to dump it out there. So we learned along the way– we had a facility that had tanks of helium. We put helium in the reactor and air, because it was inert, the gas system. We had the problem with the Asian clams.

MS: Yeah I heard something about that. When was that?

WD: In all of the reactors. When was it?

MS: Um-hm.

WD: Probably I think seventies. All of a sudden we had—one of the legs of the cooling system, heat exchangers, changed. We didn't have a proper pressure drop across. It was too high a pressure drop. We opened it up and there was oyster shells, we thought– they were clams. So we had to— And in the heat exchangers, we had to clean the heat exchangers out, because they kept growing. And we had this 50-million gallon basin. You're familiar with it at the facility. Water came in from the river and would go through the heat exchangers and back to the river. And we could recycle water. The pumps could recycle some of that water, which we did, for certain reasons. But the clams got in there and we had to clean out that basin because that's where the motherhood was, so to speak. And these were problems. We didn't know we had them.

MS: That kind of makes sense. When they pumped the water to the reactors from the rivers, was that— The force for the pumping, was that all at the river?

WD: Um-hm.

MS: They would just push the water—

WD: Except we had a—we built a lake on-site.

MS: Oh yeah, Par Lake?

WD: Yeah, Par Pond. And it was used mostly—it grew alligators, don't let me go on. (laughter) Some of the water came from there and went to the river, and some of it went back.

MS: It was just an extra additional source of water if they needed it?

WD: Right. Well we used it. It was there because we couldn't get enough from the river to get to higher power levels.

MS: Even in the early days when the water got hot, that meant that you couldn't run the reactors as high.

WD: That's right, it did change. It changed.

MS: Yeah, I heard about that. I heard that they— And when they started up L-reactor, they had to build L Lake.

WD: L Lake, yes, to recycle it there. It was total recycle out there. And I think they built a cooling tower for K. I don't think they ever used it.

MS: Never used it, yeah that's true.

WD: Required to have it. By the time they got it built (laugh), they shut the reactors down.

MS: Right, yeah that's true. What do you know about L-reactor startup? Were you involved in that at all or—

WD: Walt Joseph was there for starting it up. He sucked a lot of good people over there, but he certainly needed to do it, of course.

MS: When thinking about when they built that reactor tower at K, why didn't they just go to L-reactor and restart that rather than deal with K-reactor at all, if they were going to restart a reactor?

WD: I don't think they shut K down. When they shut it down, that was it.

MS: Yeah I know, but when they were thinking about starting— They all got closed down about 1988 and then they were thinking about starting K-reactor up in the early nineties, Westinghouse was. Why did they select K and then build a cooling tower for that, when they could have gone to L and just do it there? Or was there some reason that—

WD: Environmentally it could be better using the cooling tower than the lake.

MS: So it was for environmental reasons?

WD: That's what I would think. Of course, I'm not an expert on that, but that's what I would think. You're contaminating the soil. Here, you're blowing air out.

MS: And cooling it that way and so it's— Okay, yeah, that kind of makes sense. Are there any other points you want to—or issues that maybe I haven't thought of to ask that you want to bring up?

WD: No.

MS: Well if you want then, we'll go ahead and conclude this, but if you don't mind, I might give you a call later or if I come up with some more information. We're just starting out these, the interviews with people, and we want to interview a wide range of people that worked in the reactors.

WD: I get the same pay if you call me on the phone.

MS: Okay good, good. (laughter) But if you don't mind, I might give you a holler back if I have any additional questions and so on. But thanks again for the interview, and I'll go ahead and turn this off.

WD: All right.

END OF INTERVIEW

Oral History Interview – Peter Gray

Peter Gray is from New York. He was still at university when the Savannah River Plant was first announced on Thanksgiving weekend of 1950. By the time of his graduation, in June of 1952, he already had a job lined up with the Du Pont Company at Savannah River. Gray then worked at Savannah River from 1952 through 1997. By the time he retired, Du Pont had surrendered its long-term arrangement at the Plant, leaving Westinghouse in charge at Savannah River.

Gray was on shift when the very first fuel assemblies were put into R reactor. At that time, and throughout most of his career, he was part of the Reactor Technology section, which was responsible for overseeing all of the Reactor operations. Later he served as a liaison officer to the Canadian nuclear program, and is still an expert on the various forms of commercial nuclear energy, both in this country and abroad. Gray is now retired and currently lives in Aiken, South Carolina.

Interviewee: Peter Gray

Interviewer: Mark Swanson, Historian with New South Associates

Dates of Interview: September 15, 1999 (Session 1) and September 17, 1999 (Session 2)

SESSION 1 (September 15, 1999)

P. Gray: We could do it later, whatever—whenever you get to a question that seems appropriate.

M. Swanson: Okay, we'll go ahead and start now. This is an interview with Peter Gray conducted by Mark Swanson, historian with New South Associates, being conducted on the 15th of September, 1999 at Mr. Gray's house. This interview is being conducted as part of the Savannah River Site history project, which is documenting the 50-year history of the Savannah River Site and its impact on the surrounding area and the people who have lived in that area. Mr. Gray is being interviewed because of his long tenure at SRP. And if you don't mind, we'll ask the following preliminary information. What's your age and date of birth?

PG: Age is seventy.*

MS: Okay. And your relationship to Savannah River Site?

PG: I was employed by Du Pont, then by Westinghouse and then by U.S. Energy in a period starting August 11, 1952 through the middle of March 1997, I believe, yes, '97 correct.

MS: Okay. What did you do before the plant came to the area?

PG: The plant was announced for the area on Saturday of the Thanksgiving weekend of 1950. At that point, I was still in university doing my studies. I graduated university in June of 1952 with a job with the Du Pont company to work at Savannah River already in hand. I had the job in March, I graduated in June.

*Personal information has been removed from the transcription

MS: Okay. Let's see—Why was the work at the plant considered attractive to those from outside the Southeast?

PG: It was not necessarily that it was considered attractive to me because I was from outside the Southeast, because of the Southeast. It was that we were in the middle of the Korean War at the time and I felt my benefits to the country with an engineering degree could be better doing defense work at the Savannah River Site than becoming a foot soldier.

MS: Once you got here to the Aiken/August area, where were you directed or encouraged to live or were you?

PG: I was a bachelor when I arrived and housing was so short that bachelors were more or less left to fend for themselves. I wound up with a furnished room in a very large colonial house in North Augusta owned by a dentist.

MS: And how would you characterize local opinion about your arrival and then local attitudes towards the employees that came in from other areas?

PG: I think the feeling was that the area, especially Aiken, or including Augusta, was a quiet, sleepy, southern area that had been very badly dislocated and discombobulated by the arrival of the Savannah River Site. There were many, including—I forget his name now—a very prominent minister who wrote in a rather vitriolic fashion about the outsiders who'd come in to build Savannah River, and really wished that we had gone somewhere else and left the sleepy South Carolina countryside alone. I did find one specific instance when I settled in Aiken after a year of living in North Augusta, that because of my particular school I, oddly enough, was accepted. The people in Aiken would accept you if you were from Harvard, Yale or Princeton. But if you had come from equally fine schools like MIT, Cornell, University of Illinois and many others, you were not accepted, most peculiar circumstances.

MS: Okay. Let's see— Were you a DuPont employee before—prior to working here?

PG: No, I had my job with DuPont specifically for atomic energy work associated with Savannah River at the time I hired in, which was in March of my senior year.

MS: Had you had any previous experience working in an industrial plant?

PG: No.

MS: How did you view the area when you first moved into it?

PG: Well I thought it was rather nice. It had a lake nearby, Clark Hill. I'd brought my sailboat with me. I found it quite hot, but then I was used to heat of summers because in those days nobody had air conditioning anyhow. It was a pretty nice area to move to.

MS: Were you familiar with the construction period?

PG: Oh yes.

MS: Okay. If you don't mind, I'll ask some of those construction questions.

PG: Go ahead.

MS: When you first moved here, you were living in—

PG: North Augusta.

MS: North Augusta, right. Did you live there during the entire period that the plant was being built?

PG: No. I lived in North Augusta (cough)—excuse me—from September of 1953 until December of 1954. One could say perhaps that most of the construction was done at that point, because the startup of the plant was December of '53. That is the time that the first reactor started. The last reactor started in March of '55. The 200 areas to separate the product were a little bit behind that schedule. I don't recall what their schedule was. So if you're driving towards any question or answer from me about noticing differences in construction because I lived in North Augusta or lived in Aiken, I can't shed any light on that.

MS: Okay. What about— What were living conditions like in general during the construction era?

PG: Well—

MS: (unintelligible) people that would come in.

PG: As a young bachelor, it didn't bother me. I had a job to do. I remember one of my assignments I worked six and seven days a week, and when I got transferred a couple months later to another assignment, my boss said, Well you've got all this extra time coming to you. At your new assignment, you can take one day off a week. My new assignment was six and seven days a week, and so it went for quite a few years, so bachelors were kind of footloose and fancy free and really didn't care too much. I had a job to do, I was truly interested in the job and continued on with it.

MS: Right. Were there lots of trailer parks and (unintelligible) around?

PG: Oh yes, yeah.

MS: And did people live in cars and tents?

PG: I've been told that. I haven't seen that. I've seen photographs and stories of that.

MS: Were most of the construction employees transient or were most of them residents of the surrounding area?

PG: I have no specific knowledge of that. I have a feeling that with 38,000 construction employees at the peak, and I don't know what the date was that they hit that, most of them had to be transients. There just wasn't that sort of pooled labor locally available.

MS: Right. What were food supplies like? Were there ever any shortages?

PG: I'm not aware of any.

MS: Okay. What about traffic?

PG: Well I had a very old 1947 Studebaker with an '82 horsepower engine in it, and the traffic going out on the four-lane to work each day went at seventy miles an hour. It was a helluva hard job for my car to keep up with the rest of the traffic. It was pretty ghastly.

MS: Yeah. What about carpooling and things like that? Was that pushed pretty strongly?

PG: Very definitely. And it very definitely helped. And it was only in the last few years that I worked there that carpools were not used. I was used to carpools right from the very beginning, but people who subsequently got transferred to Savannah River learned about carpools, much to their surprise, and found it was great to have to be able to drive only one day a week.

MS: Right. You said they don't do that anymore. When did that sort of fall out of favor?

PG: My recollection is it was about the time that Westinghouse came. And I don't know why it was—ten or so years ago. I don't know why it happened. It may have been that different assignments for the people caused them to want to be ready to go home at different hours. It may also have been that affluence struck all the people and you had enough cars in the family so that you could afford to drive and nobody else needed your car and you didn't care about the cost of the gasoline to get to work.

MS: What about utilities, like water supplies, waste and sewage disposal back in the early days? Was that a problem with all the newcomers moving in?

PG: Again, bachelor, I don't know.

MS: Yeah, okay. What about local schools? Was that ever an issue?

PG: Schools had a terrible time, and they went on double sessions. And they had children going in a morning session from somewhere around seven o'clock until noon, and then children going in an afternoon session from 12:30 until five or so. It was the only way that the school facilities could cope. The local facilities that were here before the plant came, all of them must have been heavily taxed. And I remember a story about a person going into a hardware store to buy some things. And the owner and the clerks were sitting around talking. And he wanted to buy a frying pan or something. And they weren't the least bit interested in trying to help him get the frying pan. And he asked about it and they said, We've already made enough money today, said, We're not going to help you.

MS: (laugh)

PG: So I think that's an indicator of what I think the heavy load on the local facilities was like.

MS: Did you— When you moved here, did you become part of the community or did you consider it just a temporary home?

PG: Oh the former, clearly. Everybody at Savannah River could have considered it temporary home because we had a five-year contract with the government. We didn't know whether the contract would be renewed. We didn't know what the outcome of the Korean War would be. We didn't know what the problems with the communist world would be—Russia and the iron curtain and that sort of thing, and we all figured, yeah it might well be temporary, but we sort of liked the work. I found it very fascinating. I was kind of hoping it would continue.

MS: Okay. Were construction workers treated differently by local residents than the incoming operations staff?

PG: There are really three classes of workers you ought to ask about. One is the construction workers who, as I said earlier, were most likely nearly or one hundred percent transient, and they were probably not at all well accepted by anybody, though I wouldn't expect them to be well accepted as transient construction workers in any location by any community. The second one you asked about was the incoming staff. The incoming staff was probably around 1500 people who were college degree professionals and would do the managing and the technical and the scientific tasks. And the third group you should ask about is the hourly paid but permanent workers—that is the operators and maintenance mechanics and instrument mechanics and electricians and welders and truck drivers that would be permanently employed by Du Pont, and that was about 6,500 or 7,000 people. Du Pont made a policy in all of its new locations to hire those, so to speak, hourly paid local workers from the local labor pool so that that really meant pretty good acceptance because they didn't come in and bring their own gang. Du Pont did come in and bring its own technical and managerial gang, but they hired the local people for the permanent work. So— And as I said before, I found that in Aiken, Yale, Harvard and Princeton graduates were accepted and others were not. I think one of the things that caused the local people to find it hard to accept the DuPonters is that they were going to come in and they were going to do things and they were going to go places and they were going to make things happen, and this was going to sort of overturn the idea of a sleepy southern town that was moving at its own slower pace.

MS: Right. Anther question was of course construction occurred when the South was segregated. How did local segregation affect construction?

PG: Again, I don't know about the construction workers. I said there were 38,000 of them. I watched the construction go on. I was involved with the operations and getting going those pieces of the plant where construction had already been finished. Segregation affected the permanent workers also, in that there were segregated facilities built into Savannah River, which I think was just an acknowledgement by DuPont of that kind of social situation in the South in those days. I remember one day in the cafeteria, the permanent operations cafeteria, going through the line, getting my tray of food, finding every table in the front was taken up. So I went in the back and sat down. And I was very firmly told this was not where people of my race sat. We were supposed to sit in the front. I said Well what's wrong with sitting here? Here's a table and a chair and some nice people for me to talk with. I'm going to sit here and eat. No, you will sit in the front and eat.

MS: Who told you that, the other whites or the local—

PG: I don't even remember.

MS: Oh okay. Interesting. Yeah, from a previous interview I heard that they had segregated bathrooms.

PG: They did, yes.

MS: At the beginning anyway.

PG: As a matter of fact, toilet rings come, I guess, from manufacturers either white or black. And whatever came out of the box was installed on the toilet. And there was an area when desegregation came along that involved making sure that any particular major operating facility had all white or all black toilet rings, but no mixture of toilet rings with the implication that it might carry that this toilet should be used by this person and that toilet should be used by that person.

MS: Okay. So actually it was like—it was color coded, so to speak, the toilet rings.

PG: They were not color coded on purpose because of segregation in the early days in the south by race. They just happened to come out of the boxes. Somebody noticed that there were a few white and a few black and they said, This building will have only white toilet rings in every single bathroom or it will have only black toilet rings in every single bathroom. We're just going to get rid of any implication, any slight hint.

MS: When did that occur?

PG: I don't remember. In the middle of the efforts to get rid of the segregation problems.

MS: Was there much crime during the construction era?

PG: Oh I suspect there probably was and I suspect it was the construction workers that— The main roads from Savannah River to Augusta, especially, and to Aiken had a fair number of beer joints and houses of ill repute, call them what you want, they were there.

MS: What did DuPont or the AEC or the other subcontractors do to alleviate any of these problems?

PG: I guess I don't really know the answer to that. I'm sure that DuPont— Because in my experience, they seemed to have a large number of very clever answers to different problems I was aware of for those problems like you've just asked, but I really didn't pay much attention to— They must have found ways to solve them, or at least attempt to work on them. But I wasn't aware of the full spectrum of things because in that day and age I was single, I was dedicated to my job. I really had that only—that one thing, the technical aspects of my job to focus on and that's what I did. (cough) Excuse me.

MS: Did you do any, or were you affiliated with any construction work at SRP?

PG: Only to this extent. I gave you a copy of my work resume. And when you read that, you'll see that associated with Savannah River, coming here was my third assignment. My first assignment was in Chicago at the reactor training school and my second assignment was in Indiana at the heavy water extraction facility. So even though I hired in with DuPont in the middle of 1952, I didn't get to Savannah River until September of 1953. When I arrived here, I was put in Reactor Technology, which meant that I was going to be assigned to R, P, L, K and C. And almost everybody was in R-Area because it had been finished being constructed and they were getting ready to start it up. I was assigned to P-Area. And there was only one small section of the reactor building that was open to operations people. The rest of it was still being constructed by the construction people. I and two other guys worked in the P-Area assembly area where fuel assemblies were being put together. Because there was no press for us to get the fuel ready since the reactor construction was still going on, we could run some tests on the fuel assembly machines and give the benefit of our test work to the R-Area people, which was the first reactor to start up, where they were putting together fuel assemblies and they were trying to get the first group of fuel assemblies that would go into the reactor ready. So I interacted with Construction in that I was in an area with two other permanent operations people while the area was still being constructed by 1500, a couple of thousand construction workers.

MS: Right. Was there anything good or bad that particularly impressed you about the construction effort?

PG: I didn't have any real industrial experience to tell or judge whether the construction work was being well done or not. We did find things that needed redoing. Now I couldn't tell you whose fault it was, whether it was poor design or poor engineering or shoddy work in the field or not. I think basically Savannah River went together pretty darned well. I do remember one story from an earlier DuPont atomic energy effort. They were asked, during World War II, to build the Hanford Plant. And at Hanford, they built three extraction canyons for the product—the T-Plant, the B-Plant and the U-Plant, which would be comparable to the canyons at Savannah River. And my father-in-law was in charge of construction checking at 221-B at Hanford. They were about three weeks behind schedule compared to 221-T. Every single day, he'd get a vehicle and go over to 221-T and he'd ask his cohort over there, What did Construction do wrong today? And his cohort will tell him. And he'd go back and he'd be ready two or three weeks later to make sure that Construction didn't make that same mistake in 221-B. So yeah obviously in construction there are going to be some mistakes that are made.

MS: Talking about Hanford and comparing that with Savannah River Site, did they use the same number scheme on identifying buildings?

PG: Pretty much so. The only thing that Hanford did that was—I can't remember any examples of it—that was a little confusing that was straightened out by the time they got to Savannah River, 100 was the number for the reactors, 200 for Chemical Separations, 300 for Fuel Fabrication and so on down the line. Hanford had— And each of the areas had a letter, like, R, P, L, K, C. Hanford had some duplicate numbers. And when I first went out there to visit on a business trip, I was surprised to find this confusion, because I was unaware of any lettering and numbering scheme at Savannah River where you could find two separate facilities that had the same number and letter.

MS: How did they work that out at Savannah River so they didn't have that?

PG: Damned if I know.

MS: (laugh)

PG: I mean there was a lot of experience to put Savannah River together. It came from not only Du Pont Commercial but Du Pont Hanford.

MS: Right. Did superiors solicit contributions and suggestions from employees?

PG: Yes. I'm going to elaborate on that one a bit right now, because I was very impressed with the Du Pont superiors. You really are asking questions in the construction timeframe.

MS: Right. Sometimes it's kind of nice sometimes if it makes you think of something beyond the construction era that's fine too.

PG: Well that's exactly where I was going. I was truly impressed with the DuPont management right up to the very top. When we first started up Savannah River, we had about 8500 permanent employees running it. We worked at trying to install efficiencies, and we got down to the point where we were running all of Savannah River with, at the minimum 4900 employees. It was at a time when our area had been shut down, so there was naturally some potential for decrease in employees. Near the end, when the contract was turned over in 1989, we were back up, I believe to about 8800 employees, and I think that the increase had came not only because we were getting inefficient once again, but rather because there were enough extraneous or extra requirements that the government had been placing, not only in atomic work but all work—OSHA for example—that we needed extra employees to fulfill all of these extra obligations. But with that sized employee force in DuPont, I knew every one of the plant managers, they knew me by first name. I knew the DuPont general managers and later on the DuPont vice presidents in Wilmington. They knew me by name, by first name. We got along well together, and I can remember them even saying to me, Pete, would you go look up such-and-such and tell me about it? They would not necessarily bypass the people in between me and them, but they knew me and they were friendly enough to ask questions on things that they were interested in. I did not find the same experience with the Westinghouse managers. They were above being approached by us even senior experienced people. And I'd say forty-three years at Savannah River, I had a fair bit of experience. But they weren't interested in me. They were not— If you had a Du Pont name tag, implied, because you'd been at Savannah River before April 1, 1989, Westinghouse wasn't interested in you, and they weren't interested in finding out who you were.

MS: Why do you suppose that was?

PG: Oh I have to figure it was the Westinghouse way of doing business. I never found though.

MS: Let's see, those early days, how many hours a day did you have to work?

PG: We would work— Well we— In my early days, which included the time before I came to Savannah River, we worked— We had an assigned forty-three hours a week, but we worked more than that. That was at the Dana plant in Indiana, where we were extracting heavy water for the buildings. At Savannah River, we may or may not have had that kind of overtime, or extra hours, specifically assigned to us, but we worked many extra hours. I remember the longest day I worked at Savannah River is twenty-five hours. I can't even remember driving home. I didn't hit anybody, but I can't remember seeing the road even. I did have, during my very first assignment at Savanna River, I had a boss tell me to keep track of extra time I worked beyond the scheduled eight hours. He said, If you work nine or ten hours, put down zero. That'd be one or two extra hours. He said, If you work fifteen hours, that is seven extra hours, put down zero. He said, If you work sixteen hours—if you work eight solid, complete, contiguous extra hours, put down one day. If you work seventeen, put down one day. He said, If you work twenty-three put down one day, twenty-four-put down two days. So I kept this list. And after a very short while, I had something like 175 days. Now I don't know what happened to it. I didn't keep track of the two hours here, three hours there, five hours elsewhere. And I figured, 175 days, the company owes me seven months time off. So when I went to my next assignment, I told my new boss about it and he says, Don't write that down. Just keep working. I don't know how many extra hours we worked. We just had a job to get done. Turned out, we were all fired up to get it done and we did it.

MS: Yeah. What kind of quality control measures were taken, especially during the construction era?

PG: I had no training at all in quality control at university. So when I saw the quality control measures that DuPont had installed, I had no yardstick by which to measure them, whether they were good or not good. I have to infer from later years looking at the experience I developed through the years, that the DuPont quality control measures in many different fields were really quite good. But as I say, I had no firsthand knowledge with which to judge those. I do know, for example here's one story—I was on shift while the very first fuel assemblies were being put into the [first] reactor. And I was part of Reactor Tech, which was independent from the Reactor Department. Reactor Department had the responsibility to run the reactors and operate them. Reactor Tech had the responsibility and the free hand to oversee everything that was being done and to blow the whistle whenever they saw anything that they thought was not right. We were not allowed to operate any other equipment, but we could blow the whistle. So in essence, perhaps one of our functions was quality control. And I remember, we were given standards by which to judge each of these fuel assemblies as they were passing by the presentation point on their way into the reactor room to be put in the reactor. And at the end of each shift, we would turn our list in of the fuel assemblies that we thought were not qualified to be in the reactor. The Reactor Department, because they owned the building and ran it said, This goes in. And our boss, at eight o'clock every morning, would check over the list from the four-to-twelve shift and the twelve-to-eight shift. And he would say, What fuel assemblies went in that shouldn't be there? And he would insist that the Reactor Department haul them out and the day people would have another inspection of them. And many of the ones that we rejected remained rejected afterwards. So I think in one respect Reactor Tech could be called a quality control outfit. I might go on and tell you there is a document that a consulting firm from Dunedin, D-u-n-e-d-i-n, Dunedin, Florida, and I think it was GNEC, General Nuclear Engineering Corporation, something like that. Their document was GNEC-77, I believe that number is correct, where they were asked to come in and do an assessment of the startup and the early operation of the Savannah River reactors. And the report was probably a half or five-eights of an inch thick. It was a very thorough report, and it was very laudatory of DuPont and the startup of the reactors and it made specific mention of the fact that the Reactor Tech Group, under A. A. Johnson as an independent organization, was in large measure responsible for the success of the reactors just because we were independently overseeing the Reactor Department. Long-winded answer to your quality control question.

MS: No, actually that worked out really well because I mean that's what we want, stories like that. What were the relations between labor and management? This deals primarily with the construction era, but we can talk about subsequent periods too.

PG: I'm not in a position to comment on the relationship with the construction workers. The Reactor Tech people—and I have to speak in terms of my particular experience. The Reactor Tech people were ridiculed by the hourly paid workers, especially in the assembly area where I was first involved with putting fuel assemblies together and testing them and evaluating their quality to go into the reactor. The operators were the ones who were putting the fuel assemblies together. And I remember the Reactor Tech people who could only observe and take notes and so we would go around with notebooks or clipboards. We were called squirrels by the hourly paid operators. And one guy asked why. Well all you guys are doing is going around gathering nuts. You're writing down comments. And I think they had a point. They wondered what we were doing. They didn't see that we were apparently doing anything productive. I don't think they had the ability to judge, or at least the knowledge to look at the job from our standpoint.

MS: Right. Was it set up that way so that it was sort of like a—like you were talking about earlier, it's almost like a check on what was going on?

PG: Oh yeah and DuPont does this—or at least in those days did. I'm not sure how the company operates now because I've been out of the company for ten years, but DuPont did that at all of their plants. The technology people were separate from the production people. The production people, by definition, owned the facility, and they operated it. But now another brief story—Bill Church was the head of the Reactor Department. He was Paul Daline's boss in the early days, and Bill Church ran the Reactor Department, and A. A. Johnson, we called him A-squared, A-squared ran reactor technology. And Bill Church used to say, Well A-Squared you can't do this and you can't have that and you're blocked from doing the other. And A-Squared said very quietly, Okay Church, there's only one thing you need from me. That is you need a test authorization signed to have permission implication under the DuPont System, because that's how we ran it, to have authorization to start up the reactors. And you need about a dozen signatures on there. And the very first signature you need is the signature from the head of Reactor Technology. If you don't give me these things, you're not going to get my signature. Two tough guys, understood one another very well, negotiate perfectly, maybe didn't like one another, but each one did his job perfectly, did it the right way, and we in Reactor Tech got what we wanted. One of the first things that A-Squared wanted was to have about six or eight of his people inside each of the 105 buildings to be there to watch the daily operations. Bill Church wouldn't give him the room. A-Squared says, Well I won't sign your test authorization. We got the space. (laughter)

MS: Yeah that—that's pretty good. How often, if at all, did you see foremen and engineers using models instead of blueprints?

PG: I didn't see any models in the early 1950s. I don't know when the concept of using models came along. I understand that there were models of the 105 buildings. I don't recall having seen one. My first experience with a model was at HWCTR, which was built and— They started construction on HWCTR in, I think (cough) late 1958 or 1959. It started up in 1961, maybe '62, I can't remember the date accurately now. But I also had a chance, since my last work at Savannah River with the U.S. Energy Corporation, to look at decommissioning of that facility. And we had the model, but the young people I worked with in U.S. Energy had all of the blueprints also, and there were copious numbers of blueprints. I think they complemented one another. But the model certainly could be used to avoid having a guy draw a pipe in right through an area where another pipe went.

MS: Right. Did you work in construction at any time after the initial period?

PG: No. Never was in construction.

MS: So you never had any dealings with them after—

PG: No—

MS: After that initial period. Okay.

PG: Well I really had no dealings with construction during the initial period. I mean, I was in P-Area. I was one of three in P-Area with a couple of thousand construction workers there, but they were there. I had no official business dealings with them.

MS: Right, yeah. Yeah, I'm just sort of going through these construction questions because sometimes—

PG: That's okay—

MS: —might come up with some good stuff. This is kind of a general question. What did you do in your off hours, especially like in the early days, or were you allowed to have any? (laugh)

PG: Well, I and my bachelor friends—and I had a really neat bachelor place to live. I lived in a place that had two lakes, eighty acres, a four-bedroom log cabin, and I had three roommates. We had a swimming pool in the front yard. Our off hours were spent swimming and a bit of drinking, cooking on the outside barbeque, a few flicks. There were two or three flick houses in Augusta. There was one restaurant, the Town Tavern.

MS: What was the name of that again?

PG: Town Tavern.

MS: Town Tavern, okay.
PG: Yeah.

MS: What about— Do you remember the big fire in Aiken? Had that already occurred before you moved?

PG: Yes it did.

MS: Do you know anything about that or—

PG: My wife was here. She came with her family in 1951 and I came in September of '53. My wife had a friend whose father was in either the store or the basement of, I think it was Jones Electric, which was one of the stores that was destroyed in the explosion and the fire. And he survived the accident, but I think— If I remember correctly, there were four people who lost their lives in that fire.

MS: And this next series of questions is for plant employees, both (bell ringing) technical and general operations. Some of this we've already covered, I mean like you've already stated when you first started working at Savannah River Plant. Why did you want to work there at Savannah River Plant, and what were the reasons for not wanting to work there?

PG: Well I stated that I was interested when I finished school summer of '52 of avoiding the draft and the Korean War because I thought I could be of more support to the United States with my engineering degree than as a foot soldier. I guess the reason I didn't want to work there might be that I'd never been South and didn't know what the South was like, but I was open minded to come and find out, and here I am what, '53 to '99, forty-six years later still here.

MS: Right. How much did you know about what Savannah River Plant produced when you first started working here?

PG: Oh I knew from interviews in Wilmington. I first started talking with DuPont in December of '51 and they had an interviewer on campus who was doing five- to ten-minute-long screening applications. And then I went down to Wilmington in February and talked for a full day with various people and I had a—I had a pretty good idea of what they were going to do. Obviously, the plant was quite classified at that time. But I had studied what had happened following the atom bomb at the end of World War II. I had studied nuclear things and I was really interested in the whole subject, and it wasn't hard to guess from what I'd already read basically what was going to happen at Savannah River. How it was going to be done, the details, were not known to me because that was being designed at that point even while I was still in school.

MS: Right. I know we've talked about this already but what was your first job assignment at Savannah River Plant?

PG: Reactor Building, the assembly area evaluating the performance of the equipment to put the fuel assemblies together and find out the difficulties and the tight spots and how they might better be put together and how they might be kept from getting damaged in the assembly process, so that that information could be taken back to 105-R where putting fuel assemblies together for the first reactor charge was going on hammer-and-tongs, just going wide open. And there was no chance to do that kind of evaluation in R-Area, so we did it in P-Area.

MS: Right. I know you gave me the resume a little while ago and there's no point in going through that point by point but rough area, can you roughly—can you tell me roughly what areas you've worked in?

PG: A year in Indiana 1952 to '53 on the technical aspects of extracting heavy water from normal water at the Dana plant, 1953 to 1961 Reactor Technology in all five of the 100 areas, R, P, L, K and C, assembly of fuel assemblies, disassembly of fuel assemblies, charge/discharge machines that put them in the reactor, take them out, (cough) the control and safety rod drive mechanisms, shipments of fuel away from the reactors. Even assignments that involved going to Canada to oversee the shipment of Canadian-spent fuel assemblies from Chalk River to Savannah River. That's a pretty good list from '53 to '61. Sixty-two and the first part of '63, I was sent to Canada to be the U.S. technical representative to assist the Canadians in the start up of their first nuclear plant to make electricity. It was a Nuclear Power Demonstrator and it was the—no, acronym NPD. It was the predecessor for the CANDU plants. The Canadians made electricity (cough) using natural uranium and heavy water because they did not want to be beholding to the United States to get enriched uranium from a place like Oak Ridge or to England for enriched uranium or Russia or France for enriched uranium. So they developed this CANDU system of reactors, and I was the U.S. technical representative for a year-and-a-half during the startup of their first demo plant.

MS: Okay. And then after—

PG: Oh excuse me.

MS: That's right, yeah.

PG: 1953 I came back and I worked at HWCTR from '53 to '55 when it was shut down. Sixty-five— If I said '55, I meant '63 to '65. Sixty-five to '69 I worked in Reactor Technology again, various tasks, technical tasks associated with the operation of the reactors. In 1969 I went to SRL and I was put in charge of running the SRL—the three SRL research reactors—the PDP, the SP and the mid-sized one, I forget the name of it now, oh the RTR, the Resonance Test Reactor. And there were forty of us in the building, twenty Ph.D. physics researchers doing physics research, and anther guy was in charge of them, and twenty of us running the reactors and providing support of those reactors. I had operators that put the tests together and ran the reactors, I had maintenance guys who built the experiments, electricians and instrument guys who did the instruments for these tests and a draftsman and a couple of engineers. And my twenty people ran these three experimental facilities for the physicists who were designing the experiments to be done in those facilities. 1976 through 1978 I went to SRL, its main building 773, and I supervised 175 support people who ran—who did all the support work for running SRL, which was the big main research facility for Savannah River. Nineteen seventy eight to 1980 some support work, and I forget the area. Let me have a look at that for a minute, I can tell you. Oh, responsibility for storage technology licensing and liaison on light water reactor fuels for planning for the implementation at the DOE sites. Light water reactors, which number about 110 and generate 22 percent, roughly, of the United States electricity, nuclear electricity generated by the LWRs, they were running out of fuel storage space because they planned originally to store fuels for only about five years and then the federal government was going to take the fuel off their hands and the federal government did not come through on their promise. They did not have either reprocessing facilities or storage—long-term storage facilities. So the federal government got involved in trying to get storage facilities for light water reactor fuels. And Savannah River had a small group that was asked to assist in the planning for light water reactor fuel handling. Nineteen eighty to 1989, I worked in the Technology Group at Savannah River Lab for the safe disposal of defense high-level waste, the stuff that comes out of the storage tanks in the 200 areas as a result of the chemical reprocessing of the fuel assemblies at Savannah River. Nineteen eighty nine to 1990 I was assigned to DOE headquarters in Washington, D.C. at the Forrestal Building (cough) excuse me, to provide liaison to the New Production Reactor Heavy Water Reactor gang up there. And they were doing work both at Savannah River and in Washington on several kinds of reactors for production of more materials needed for defense purposes. It was a heavy water reactor gang, a light reactor water gang, a high-temperature gas cooled reactor gang, and I went to Washington and helped the heavy water reactor people.

MS: Okay. Sounds like a lot.

PG: Well it was an interesting job, but— (tape pause)

MS: Tape recorder back on now.

PG: While I was in Washington in 1989 and 1990 assigned to the DOE headquarters with the Heavy Water New Production Reactor Group, the transition was made at Savannah River between prime contractors from Du Pont to Westinghouse, so I went to Washington as a Du Pont employee and came home from Washington as a Westinghouse employee. When I came back in the spring of 1990, I worked until the fall of 1992, still on the New Production Reactor effort with the Westinghouse people but here in the main gang doing the Heavy Water New Production Reactor development work. At the end of fiscal '92, in September '92, that task ended and I was given the opportunity of several jobs. The one I selected was in 200-H in high-level waste engineering, which was the Westinghouse name for what would have been called Separations Technology, once again, the technology organization doing the support work on operating and maintaining and managing the tank farms, the waste tanks in H-Area that were receiving the waste from the canyon. Then in June of '95, I retired from Westinghouse at age 66. A year later, I went to work with U.S. Energy Corp for about one year doing D&D work on the heavy water components test reactor, and I left them in March of '97 and have been retired since then. Brief resume.

MS: Thank you. That way at least we have it entered in the record.

PG: Yeah sure.

MS: What pressures were there to your job, or actually in this case jobs, if any, like production quotas or strict adherence to procedure, information limitations?

PG: You've really asked three questions. Production quotas, we had deadlines to get jobs done, and certainly in the early days, they were very stiff and severe. At times I guess it's human nature to think that they're impossible to achieve. I think we achieved them. I remember one report we did. We had an anomaly happen in the reactor areas and a committee was formed to investigate it, and they very quickly decided they were too big and there were good many extraneous people on it and they formed a subcommittee of about six or eight people, and they were technically equipped to do the job, but they couldn't seem to get together to get anything solved. That was on a Friday afternoon. So I went home over the weekend to think about it. One of the people on that subcommittee was one of my roommates at the bachelor's pad where I lived. So he and I spent the weekend solving the thing. And we would swim in the swimming pool and work on the problem. And we came in on Monday morning and we had a pencil draft that we gave to the secretary to write it up. And the problem was solved and we had the answer. We got roundly chastised for naming our group the sub-subcommittee. And we actually put the— The place where we were living had a name. Many places in Aiken have names. Winter Colony homes have names. This place was named Pine Acres, so we named it the Pine Acres Sub-Subcommittee Report. And we were roundly definitely told, Don't put that kind of stuff in official literature. So the front page was redone, but we did have the answer, and we got it under the pressure of getting it done quickly because we worked on it over the weekend. You asked three parts to that question.

MS: Right. The other one was like strict adherence to procedure?

PG: Absolutely. Du Pont would not tolerate one minute anybody violating a procedure. That was contrary to what I saw both in Washington and also especially during my time in Canada at the start up of the NPD reactor. They had procedures—they had some pretty good procedures, but they didn't believe in following them. And it was kind of interesting. You may have heard that one of Du Pont's greatest efforts was on safety, was a company very thoroughly known, clearly known for its excellent safety record. After we got the reactor going, the plant superintendent decided it was time for us to have some safety. So he called down to Toronto three hundred miles south and said, Send the company safety engineer up. And every degreed monthly paid professional went into a full one-day session on safety. And about ten or ten-thirty in the morning, the trainer went over to the blackboard and he wrote some numbers down on the blackboard. He wrote 33, 31, 28, 25, 18, 15, 11, 8. Does anybody know what these numbers are? The room was silent. And I said, Would you write another number down there? He said, Yeah sure. I said, At the bottom of your list, would you write down 0.2. Oh okay. Now does anybody know what these numbers are? Again, the room was silent. And he looked at me and he said, Do you know what the numbers are? And I said, Yeah I think it's the injury frequency rate in terms of injuries per million man-hours worked. He said, You're right. He said, Now does anybody know what the specific numbers are? He pointed to 33, nobody knew. He said, Well 33 is the mining industry, and then 31 was construction and 28 was something else. When he got down to the lower numbers they were people in office jobs and normal operations jobs. Then he got down to 8. He said, I'm very proud of 8. He said, That's the Ontario Hydro. Ontario Hydro was the outfit to whom I'd been assigned to run the—to help them with running the reactor during that year-and-a-half up there. He said, Ontario Hydro has a really good safety record. He said, Now— He turned around and looked at me. He said, Now you asked me to write down 0.2. What's that? He says, No, don't tell me. He said, You don't even work for Ontario Hydro do you? And I said, Nope. He said, Let me guess, I know who you work for. He says, You work for DuPont. He said, All morning long I've listened to you talk and you have a different attitude than everybody else in this room. And I think that's a good reflection of the fact that Du Pont was adamant you follow procedures. You write good procedures, you test them and then you follow them. Strict adherence to procedures. What was your third point?

MS: And the third one was information limitations.

PG: Oh, right at the beginning, very severe information limitations on the basis of the whole project being classified. I think within our organization there was no information limitation, even if you followed the security and the classification rules, because we needed to share information, albeit on a classified basis, to be able to know what was going on in the reactors and to get the job done. Yeah, couldn't talk with people in the town, but could talk at work.

MS: Right. What did you see as your most important responsibility of your jobs?

PG: I always had it, I guess, as a self-imposed responsibility to do the job thoroughly and well and correctly. I don't know, that's sort of a hand-waving, good-feeling answer, because that's the kind of question it is.

MS: Right, exactly. It is kind of like a—

PG: I mean I didn't have the daylights beat out of me by my boss because I was doing a poor job, but then it would never occur to me to do a—I do the best I could. I found limitations. We would have annual performance reviews. They were called blue sheets because, in fact, it was written up on a blue sheet. And I do remember year after year after year on my blue sheets, each year there was a particular thing that was mentioned as a weakness that I ought to work on. And I think it was a growing process because I would be aware of what the guy had said. I'd take it in good faith, I'd work on it. The following year, it was not mentioned. There was something else I could work on. So I think it was a growing and learning process. And I can't say that I developed all my capabilities and my responsibilities on my own.

MS: What do you think about Du Pont's and Westinghouse's management of the plant while you worked there?

PG: Now we're getting down to the nitty gritty. I think Du Pont did a fine job of managing the plant. I have already told you that the Du Pont managers, right up to the top— At first there was a general manager in Wilmington, who was responsible for Atomic Energy, and then there was the vice president. These guys knew you all, they knew you by first name. They would talk with you when they visited the plant. They would respect you. I'm sure they knew what your limitations were. They wouldn't ask you to do something that you are not capable of doing. I'm pretty sure that there were some people who just plain bullshitted the hell of out of those guys also, but you and I knew who they were and we could cope with that. I guess just by hesitating I'm signaling to you my feeling about the difference between the DuPont management and the Westinghouse management.

MS: Okay. Did you win any awards for safety or production, suggestions or other actions or contributions?

PG: Yeah, two kinds of awards. When Du Pont was there— We've already talked about the safety. There were safety awards every time we qualified for a certain number of man-hours injury free across the entire site. And we got some very nice safety awards. They were in the order of ten, fifteen, twenty, twenty-five dollar monetary values, went out to buy them at retail price at a local store. The company had great emphasis on making sure that we could keep the string going. We would get our rewards quite quickly, within a week or two weeks. I mean, the day we get the record, it was announced throughout the plant, fliers were posted on the bulletin boards. Within one day, the prize selection list was out. You could select from thirty or forty different kinds of things. Within about two weeks you had your prize in your hands. I have several of them here in the house that I'm still using. Westinghouse came and they sort of picked that up. They inherited it from Du Pont. They got to the point where you could get a Westinghouse umbrella and that was it. It'd take you three or four months to get the umbrella. Or you could get a Westinghouse flashlight. Now they're not even handing them out. But a reflection of what that meant to the employees— I'll come to the other award in the minute. Please don't let me forget it. A reflection on what that meant to the other—to the employees was this—I can remember hearing a Westinghouse higher up say, Isn't it great, we've got to the point where we've got four million man-hours injury free. And Du Pont would regularly rack up thirty-five or forty million man-hours injury free. And I remember also hearing that the first Westinghouse president down here, Jim Moore, was called on the carpet by the DOE manager down here and asked to explain why his workmen's comp costs in the State of South Carolina, up in Columbia, were going up? And it's— I'm told that the Westinghouse president said to the DOE manager, Well we've got a better record than any of the other Westinghouse atomic sites and we—or nuclear sites for DOE—and we've got a better record than any of the Westinghouse commercial sites. Nonetheless, says the DOE manager, It's worse than it used to be. He wouldn't say it's worse than it was under Du Pont. Nobody would say Du Pont after Westinghouse got here. He just said, It's worse than it used to be. And it was, in fact, it was—the safety record was considerably worse. And the safety engineers that Westinghouse had would not have, from me, the same kind of respect that I gave to the Du Pont safety engineers, because they treated the subject in a much more cavalier fashion. When a Du Pont safety engineer talked to you, you knew he meant what he was talking about. You might not respect him, you might not respect what he was doing or how he was doing it. I don't think they had the very top engineers, but the top engineers were dedicated to the process. The safety engineers were tops in their safety field, perfectly fine there, but I didn't have that kind of respect for the Westinghouse guys that I did for the Du Pont safety engineers. Now the other award.

MS: Yeah.

PG: I won from Westinghouse three hundred dollars and a little certificate that I could get framed for inventing a new device. And there's an interesting story on that one. During the New Production Reactor effort, in January of 1992, I came up with an idea for a new reactor. And it happened because Westinghouse was running K-Reactor in December of 1991. And they had a leak of heavy water in one of the heat exchangers. And heavy water had tritium in it and the tritium went down the Savannah River. And Fort Wentworth and Jasper County were alarmed because their drinking water supplies came from the Savannah River. And the reason the tritium went down the river was because the water samples from K-Reactor that would have checked whether there was a leak or not didn't get to the 400-Area lab to get analyzed in time, so there was— The leak went on for two or three days where it should have been stopped in the space of a few hours. And it was a great rhubarb over this. And the New Production Reactor people immediately changed their concept from a reactor that was heavy water moderated and heavy water cooled, which is what K-Reactor was, to a heavy water moderated and light water cooled reactor. So light water coolant passing through the heat exchangers would not have nearly as much tritium in it. And the implication of a leak in the heat exchanger would be not as severe as this event that occurred at Christmastime in 1991.

Mechanically, the change that the Westinghouse New Production Reactor people came up with on the reactor concept was a nightmare. They showed it to me and they asked me to look at it, and it had a calandria inside a pressure vessel with dissimilar metals, with different coefficients of thermal expansion, and a nightmare to build and a nightmare to maintain, and probably impossible to inspect during operation. (...) And I thought, the Canadians have solved this problem, but they've got a new design out, it's called MAPLE. And I don't remember what MAPLE stands for but I think it was Multiple Actinide Production Lattice Experiment, or something like that. You can look up what MAPLE is and figure out what it stands for, but I started looking myself into what the MAPLE unit consisted of. And damned if it wasn't a really neat concept and it answered almost all the problems of reactor safety. And so I thought, Maybe we could build one of those down here, and it looked like it would be less expensive and pretty easy to run and pretty safe and secure. And so I went to some of my senior reactor physics friends, who I'd worked with in 1969 through '75 at 777-M, SRL. And I said, Relative to the Savannah River reactors, what's the productivity of this unit? If the Savannah River reactors, which are really good, are 1.0, how good is this thing? They said, Oh it's not very good, Pete, it's about 0.25 or 0.3, no good at all so, go back to the drawing board. Go back to square one. And I thought and thought and thought about it and I said to myself, I know what's wrong with this Canadian design. And so I did a major rearrangement of the lattice. And I took the darned thing back to these guys and I said, Okay now what's the productivity of this thing? The old one was 0.25, 0.3. Well this is pretty good. This is about 0.92 or 0.93. So I said to myself, For 7 or 8 percent loss in production, I've got an inexpensive unit that's got inherent safety. And then I went to the engineers, to the reactor safety and accident engineers, and I said, Okay analyze this thing from a safety standpoint, from an operability standpoint. What are the design basis accident potentials? What are the severe accident potentials? So three of them gave me about a three-hour skull session and we went through the whole darned thing. They said, It essentially eliminates all accident potential. I said, Bingo, now I've got it. Seven or 8 percent price in productivity and I've got the answers to what the new heavy water production reactor should look like. And I wrote it up in January and I gave it to my boss.

MS: January of—

PG: '92.

MS: This was about two or three weeks after the Christmas '91 heavy water leak that sent tritium down to the coast, down the Savannah River and caused a great alarm and caused the changing of the NPR effort to put this nightmare together that I just described to you. So I was offering this alternative. Now here's what happened from January of '92 through September of '92. My bosses encouraged me. They authorized me to go forward. They paid my salary. They let me work on this at my desk with my regular income for that period of time. They told me that Washington would be very happy to hear about this because it would be a demonstration that we were covering the waterfront, we didn't have just one unit, and we weren't putting all of our eggs in that one basket. They said, There'd be a big rack up in May in Washington and they'll love to hear these two different ideas we're working on. Meanwhile, back at my desk, I continued to work on and improve this thing. And I kept sending new drafts forward to my boss. He didn't approve them for publication. And I was so wrapped up in it, I didn't realize that he was denying me the opportunity to get my thing documented and published. And I continued to talk with people about ways to make additional minor improvements on the whole concept. And finally about May, two things hit me. One, I realized they were stonewalling me, and two I went to my boss's boss, who was just one step below the Westinghouse vice president, and I said, How did things go in the big rack up? And this was his exact quote to me: He said, Oh we didn't tell Washington about it, because if we had told them about it, they would have had to convene a review committee to analyze it for its merits and we didn't want to put them to that trouble. I was astounded. So I said to myself, These guys are stonewalling me. It's a cover-up of some sort. So I went to another friend of mine, a guy named Jack Correy, who was the head of the Technology Transfer Group, in essence, doing patent write-ups. And I will say one thing in favor of Westinghouse. Westinghouse is a company that's very high on patents. Du Pont, if they were, they sure didn't push it at Savannah River. I never even, for thirty-seven years with Du Pont, thought of doing a patent. But now I thought, Hey if I can get a patent for this thing, then the idea will be out there and will be assigned to Savannah River. And I can, in essence, do an end run around my bosses, who I now realize are stonewalling me. So I went to Jack Correy and I said, Hey here's this thing, what does this look like? He said, I'll get back to you in a couple of days. And he phoned me back and he said, This is great, Pete. I'm going to assign two of my summer interns. These are guys who are going to be law students, or maybe are law students, but they're still in school. And I worked with the two guys for about two weeks and we wrote the whole thing up. It took more work than if you'd just invented a new left-handed monkey wrench, because this was a whole damned reactor concept. It got written up and it got revised until they were happy with it from a legal standpoint and I was happy with it from a technical standpoint, and it got submitted. And the Patent Review Committee, which consisted of about seven or eight really shiny badges, guys with big mental horsepower at Savannah River, reviewed the whole thing and they made a recommendation at the highest level. They said, This is worth the full patent award. And so it was approved. And I went to a banquet at the hotel down by the River in Augusta and—Sheraton or whatever it is, and six or eight guys got their award for the left-handed monkey wrench and ten guys got their award for a new kind of glass (unintelligible), and I got my award for a new reactor. And I got my photograph taken with Joe Buggy, who is now the new Westinghouse president and with Dick Begley, who at that time was the SRL lab director, Savannah River Research Lab director, and I got a three hundred dollar check. And I said, Man this is great. Now we're going to show these guys. And I continued on through the summer and the fall working on it. And on September 30th the New Production Reactor Program was stopped. Nothing had ever been allowed to be published, but the New Production Reactor people couldn't stop the Technology Transfer people, so the work on the patent was going forward anyhow, separately. On October 1st, the first day after the NPR program ended, I was allowed to give a talk, just to SRL. And on about October 14th, they finally published a sort of cut-down version of my write-up on this new reactor. Well, that's the end of the story for the patent award except for one thing, to get a patent, it's a three-step process. Then first thing you write is the invention disclosure. That's where the inventor says in print with people signing every single page, This is what I invented on this date. The second step is for a patent attorney to look and see in the literature if anybody's already invented it, called prior art disclosure, did somebody prior to you come up with this concept? DOE spent—authorized Westinghouse to spend about ten thousand dollars for that prior art search to be done. The patent attorney that they used in Columbia came back with, No, I've looked at fourteen different reactors and this idea is unique, it's different. It's not encroaching on any existing ideas. So then DOE gave that word to Westinghouse and Westinghouse said, Go ahead, go forward with the third step, which is apply for the patent and that's another ten thousand dollars. They went back to the guy in Columbia. He wrote up the patent and I worked with his outfit with several trips to Columbia. And it got written up and it got submitted in October of '94. And in June of '95, I got a call from the DOE patent attorney who said, Patent Office is going to allow the patent. It's been approved. It's just two or three months of clean up of paperwork that they go through on any patent, but the patent will be issued, congratulations. If the patent had been issued, I would have gotten another one hundred dollar award. Now there are two or three things that have happened since then that prevented me from getting the award. One, I retired, and I think only an active employee can get the award. Two, Westinghouse has stopped giving out those awards, and three, this is the most amazing fact, the Department of Commerce, where the Patent and Trademark Office is, classified the thing, but they didn't know really whether it was classified or not, so they asked DOE in Washington. DOE in Washington didn't know, so they asked DOE at Savannah River. Savannah River didn't know so they asked Westinghouse. Westinghouse didn't know but they asked some young lady. Now I haven't heard this said but I've had it implied to me and I sort of suspect it might be true. She, in essence, was tasked with finding out that it was classified, not finding out whether it's classified. And I heard what part of the idea they thought was classified. And it turns out the element—that part of my concept which they think is classified, is almost identical to a part—a similar part in the existing 105 reactors that is not classified. So word went back up the line that this is classified in the following category. It's called unclassified, controlled nuclear information. It's truly not classified, but it's controlled so it can't be released. Now this is a classification the Department of Commerce doesn't recognize, so they classified it secret. And they sent me a certified letter, requires my signature, that I got it, saying, You will find everybody who knows about this and you will tell them not to say anything and forget talking about it. And you will not tell anybody else the details of this concept. And until it becomes unclassified, we will not issue the patent. So that's probably the third reason I'm not going to get my hundred bucks. I don't want the hundred bucks, I want the patent issued and I want the silliness with respect to the classification resolved. But even more silly about the whole darned thing is, I wanted to find— I went— Following my retirement in the summer of '85, I went to several EIS meetings for new production reactor efforts in the Aiken and North Augusta area. And I had prepared one page that I handed over to the court reporter. And I spoke— Are you running out of time there?

MS: Oh no, no, just checking (unintelligible).

PG: Okay. And I spoke at the meeting in the public meeting. And I asked them to tell me several different things—Why isn't this being considered and will you consider it, and here are the merits of it and so on. And I understand when you issue—this is a draft EIS. When you issue your final Environmental Impact Statement it'll have an answer to it. Oh yes sir. And the answers never came out. They told me later— I think what they do is they change the rules on how they handle EISs. But they, in essence, refused to address my efforts. I was also concurrently finding out—trying to find another way to get this out in front of the public. So I wrote a paper for an American Nuclear Society meeting and I submitted it to Westinghouse and Westinghouse approved it, unclassified, it's approved for release. They sent it to DOE Savannah River. They approved it, unclassified, approved for release. It was sent off to the American Nuclear Society in Chicago. They approved it for presentation at their winter meeting in 1995 and for publication in the book they give out, which is called the Transactions. The winter meeting was— It started on October 29, 1995. I received the letter from the Department of Commerce that it was classified and I was not to tell anybody on December 18, 1995. So six weeks after the meeting, I'm told not to tell anybody about it. And the letter from the Department of Commerce says, You must find everybody who knows about it and tell them not to say anything about it and to forget about it and not tell anybody else. Now I don't know how many people were at the meeting, but every person who registered for the meeting, because it was in San Francisco was probably pretty damned popular, twelve hundred or fourteen hundred people all got copies of the Transactions. Here's my published paper in the Transactions. I wrote a letter back to the Department of Commerce. I phoned the DOE patent attorney in Savannah River and said, What do I do about this? Well he really didn't know. So I wrote a letter to the Department of Commerce and I explained it to them. I said, I don't know who these twelve hundred or fourteen hundred people are. I don't know how to get a hold of them. Besides, the thing's not classified. Whoever advised you that it's classified is wrong. It was released by DOE Savannah River and Westinghouse as unclassified. What should I do? And I sent that letter back to them certified, requiring a signature. Never heard from the Department of Commerce. Now I signed for my letter in Aiken when I got it. I suspect some mailroom clerk signs for certified letters. Whether it ever got back to the proper person in the Patent and Trademark Office or not, I don't know, or how they're handling it or why they're not answering me, I don't know. But here we sit with a good idea that will work, it's safe, it'll cost a quarter of what—or less than a quarter of what the accelerator will cost. It can't be classified because its genesis was from the Canadian MAPLE design. I'm perplexed. I don't know what to do about it. I think it's one of the damnedest stories that's ever happened to me.

MS: Yeah, that's amazing.

PG: I know the cost of it because when I was studying the MAPLE concepts, Canada—that's a small country from the number of people and its gross domestic product, that kind of stuff, even though it's big geographically—Canada likes to sell as much as they can abroad because that's money for the country. So they developed four different MAPLE designs, four different sizes, and they went through the process of costing all of them and that's been published in the literature. So I got the cost data on all of these four MAPLE reactors. And I plotted the cost data versus the productivity of these reactors, the power level of these reactors. Then I extrapolated it up to the power level I needed to get the production of tritium that the United States was shooting for, and I came up with six hundred million dollars. And the accelerator, at that point, was $2.5 to $4.5 billion, and the light water reactor that Secretary Richardson has now selected two or three of the TVA units— I think he'll have to buy those from TVA because they're civilian facilities and we're going to be making military materials in them. There's this line between civilian and defense. Don't take plowshares and beat them into swords. Take swords and beat them into plowshares, that's okay. Go in the peaceful direction. But if you try— If you try and make tritium in the Tennessee Valley light water Reactor and President Clinton says to North Korea, Don't make nuclear weapons and if you don't we'll give you two light water reactors that'll make electricity so you can improve the lot of your average North Korean citizen by electrifying the country using these reactors. And then we show him we're making tritium in identical units, identical light water reactors? Richardson ought to be run out of town for proposing to use a light water reactor to make tritium. So I think the way the Department of Energy's going to make new tritium is wrong, and I think I've got the answer but I can't figure out how to get it heard. And I think mine would cost about a third to a quarter of what buying two or three TVA reactors would cost.

MS: Wow.

PG: Well you asked a question about awards.

MS: Well that's certainly—

PG: I got safety prizes from Du Pont, I got an umbrella and a flashlight from Westinghouse, and I got three hundred bucks for my new heavy water production reactor concept.

MS: Right. Well, that's pretty good. (laugh)

PG: That's a long answer to a short question.

MS: Well we like those. (laugh) We've already talked about safety at the plant, and did it a change appreciably over time, the attitude towards safety?

PG: Yeah I think so. And I think it changed in the following way. There was a gradual but definite improvement in safety with Du Pont. We were always striving for better safety statistics, fewer injuries. We were learning from our injuries as to how to avoid having them happen in the future. An example of how safety came to Savannah River in increasing emphasis was automobiles in the fifties didn't have seatbelts. But if you wanted seatbelts in your car, you could go to an auto supply parts house and you could buy them. And I had a 1954 Ford Station Wagon, and about 1956 or '57 I bought seatbelts and put them in my car. I bought five of them, so each person in the carpool could have a seatbelt. At the same time, the employees were suggesting that seatbelts be put in the government cars at Savannah River, that this was consistent with Du Pont safety. Well at first, there was, Oh that would cost too much. Now I don't know whether Du Pont or the Atomic Energy Commission said it would cost too much, but the next step was, Yeah we'll put seatbelts in, but we'll put them in only for the driver because many trips are made with just one person in the car. So then the government car showed up with seatbelts for the drivers. Later on, they showed up with seatbelts for everybody. This was in the days before automobile manufacturers were installing seatbelts as original equipment. But you can see the trend towards improving safety in terms of the equipment that was made available for safety for the employees. We went to— We went to plastic hardhats because our original hardhats were aluminum and aluminum carries with it the electrical shock risk.

MS: Okay. When did that transition?

PG: I can't remember. But those sort of safety improvements were coming all along. And I think I've already alluded to the fact that there was, to me, a very perceptible significant decrease in safety when Westinghouse showed up.

MS: Right, yeah. What was the attitude towards security at the plant and how did that change over time?

PG: My recollection is that security was pretty well believed in and adhered to. And a few people decided that they didn't have to put up with the security that was required for classified documents. They'd leave them, not out in the open on their desk, but rather than putting them in the safe, they'd put them underneath the blotter, things like that, but I think the security attitude was pretty good.

MS: Okay. We probably alluded to this to some degree but, how did the contractors, DuPont and others, encourage safety and security as well as employee adherence to those particular guidelines? We are talking about like the safety meetings—

PG: Well let me give you one quote, one little slogan that DuPont had—Safety is a condition of employment.

MS: Did you do any work at the plant prior to getting a security clearance?

PG: No. Oh I finished school in—June 2nd and they would not take you on until you had your clearance. So went from June 2nd to August 11th before I had a job. I had to cool my heels without an income. In later years, they would take people and give them red badges. They weren't cleared, they'd give them unclassified work to do. But it kind of galls that I had to cool a summer without a paycheck (cough) and then they were hiring people, taking them on and giving them a paycheck and we sort of had to baby-sit these red badge people.

MS: Right. Were there any major incidents in the area while you worked there, that you can recall?

PG: Well, the answer to that question is going to be dependent upon your definition of major. That's a subjective word and you may have a different idea of major than I do. Yes, we had incidents. We had incident reports. We wrote them up. We wrote them up and investigated them. Pardon me, we investigated them and then wrote them up on the basis that the event that it occurred could be a positive learning lesson. And we, because of our idea of seriousness of an event and consequences, though they might be very low in probability, we would maybe say this was a major event. I think alongside of other facilities, you might come away with a general feeling that we did not have a major event, we did not have a major incident. I can't remember what it was, but somewhere— Oh I think I know what it was. It may have been— (bell ringing) It may have been employees who—

(tape pause)

PG: —or should I go back just a few moments to what I was saying?

MS: Repeat a little bit. I think it probably got it but you never know. Okay, I think we're set.

PG: A major example I can remember, and I think it was with respect to the whole body radiation absorb dose, which in the early days had a limit of 5 rem. And Du Pont right at the beginning said, We do not want our people to exceed 3 rems, so they took a number that was only 60 percent of the federal government requirements. And for some period of time, and I can't remember what it is, but essentially the duration of DuPont's time at the plant we had something like one person that exceeded that. There was a value for the other DOE sites of three hundred employees that had exceed that, and there was a value for the commercial light water reactor incident—commercial light water reactor industry where the—something like four thousand people had exceeded that. I can't remember but on a relative scale it shows that—what we would call a major incident, because we wanted to investigate it, we want the employees involved to realize it was serious, really was the way we did business but it might be considered by others minor alongside of some of the other things that had happened.

MS: Right. We talked about this a little bit, but talking about carpools. And the impression I get is that most people did normally ride to work in a carpool.

PG: Many people did.

MS: How were carpools organized? Was it done on an individual basis? Did DuPont have some hand in organizing it or—

PG: Oh I think Du Pont sponsored it. I don't know that they had a formal procedure. I think you just did it on an ad hoc basis. You talked to—or, Oh I know somebody who lives over there. He's on your street and you might want him to join the carpool. He's coming over here to work in this area from another area, that kind of thing.

MS: Okay right. Did people ever pay for their rides?

PG: Some people ran carpools where one guy would drive and the other people would only ride and they would pay for it. I don't know what the implications are on that with respect to taxi, bus, jitney, personal insurance, liability. I never was involved in one.

MS: What about bus transportation?

PG: None. Buses were provided by the Department of Energy at Hanford because the distance was longer and by the Department of Energy at Idaho because the distance was longer. And they may have been provided at places like the nuclear test site in Nevada, I just don't know. I think people asked for buses out here and we were told that it's not far enough of a distance for the Department of Energy or for the Atomic Energy Commission to either pay for it or subsidize it. As a matter of fact, they had buses at Chalk River to take people to work. And for the year that I worked—or year-and-a-half I worked at the NPD, I rode the bus all the time. Chalk River people were really upset because it cost twenty-five cents to ride twelve miles to Chalk River. It cost me a dime to ride (laugh) to the NPD, the same distance.

MS: All right, wow. We've gotten into this and you may not want to deal with this question anymore but, How did plant operations and management change when DuPont left and Westinghouse took over?

PG: We talked about that on the telephone the other day and I told you when you first came in this afternoon that I wanted to discuss a point on that. It turns out we've covered so many areas and so many memories have been brought to the forefront, that I've forgotten for the moment the example I wanted to cite to you. Oh, now I forgot—

MS: One thing you did want to mention— We can get to it later if you don't want to talk about it now, but the story about the one dollar for Du Pont.

PG: Okay yeah, we'll do the dollar story right now. I told you a moment ago that at Hanford— And I think the contract for Savannah River (cough) was essentially the same. No profit. No liability on the part of the company. And it was slightly different in that this time Du Pont said, We'll stick with you for a longer period of time. Hanford they said, We want out right after the war is over. I think Du Pont said— You'd have to talk to somebody considerably higher than me. I think Du Pont said that they would get out when it was no longer a unique technology. President Truman convinced Du Pont that they ought to take on Savannah River because they were the only company qualified in the United States to do it. And on the basis of however that pitch was made, I think Du Pont said, Yeah we'll go along with you. We won't put a time on when we want to get out. But the dollar. The dollar was to make the contract legal, call it a profit if you want. It was not per year. It was at the time the contract ends. Now—

MS: In other words, if they renewed the contract every three years or whatever, they didn't get a dollar then—

PG: No, no.

MS: They just rolled that promise of a dollar in the future.

PG: Right. Now the contract at Hanford with Du Pont and the contract at Savannah River with Du Pont has not ended. And there's a reason for that. There are two financial obligations with respect to Du Pont retirees from both of those sites. One is pension and the other is health insurance. And the pension is taken care of because it was fully funded as we went along. The day that Du Pont stopped operating Savannah River, for example, the money was in a trust fund (cough) from which pensions would be paid, so that there is no ongoing obligation for the government to continue to put money into that pot. It's different, for example, than social security. My social security check next month is funded by somebody else putting money into social security. It wasn't funded by what I put in while I was working. My pension from Du Pont has already been totally funded by money that the federal government put into this trust fund, which is now being administered by, I think, Bankers Trust, to pay Du Pont pensioners. So that part of the contract is satisfied. Du Pont asked, I'm told, to have the federal government fully fund the health insurance also, so that in fact the whole thing could end. The federal government would not do that, did not agree to that. So the federal government is funding Du Pont health insurance on a pay-as-you-go basis right now. It's still being paid for. On March 31, 1989, Du Pont relinquished the contract at Savannah River. Two days earlier, I sat next to the Du Pont vice president at the time, Ernie Rupee, who was in charge of the Atomic Energy Division. And he was the featured speaker and I was the emcee at a big dinner in the Augusta Civic Center for the 25-Year Club. Du Pont gave 25-year employees a banquet once a year, a whoop-'em-up, feel good, here's-the-story on the company, here's a nice dinner and go home with a happy memory of having met with your friends. And it was available for employees and retirees if you had twenty-five years of service. And this was the last 25-Year Club that Du Pont was ever going to have at Savannah River. And one of the things they passed out that night to all the people who were at the banquet was a crisp brand new one dollar bill embedded in a piece of Plexiglas as a paperweight for your desk. And the paperweight says on it, Thanks to you, Du Pont earned its dollar. I asked Ernie Ruby several questions about this. He said, This was funded not by government money, this was funded by Du Pont corporate money. But they passed out a thousand or fifteen hundred one dollar bills in these envelopes. I said, Hey Ernie, as a matter of fact looking at this, When does Du Pont get its dollar? He told me the story I've just told you, that until the last Du Pont retiree and spouse dies, there will be a contract with the government to get the government to reimburse Du Pont for the health insurance, under the Du Pont health insurance plan. So he said, We're probably going to get a Hanford dollar in about forty years from now and we'll probably get a Savannah River dollar in about fifty years from now. The dollar has not exchanged hands yet.

MS: Wow, and it doesn't appear like it's going to for a while.

PG: Yeah right.

MS: That is a good story, thanks. How did the newer environmental legislation change operations, or did it?

PG: Oh it very significantly changed it. I indicated that at one point we'd gotten down to 4900 employees and then near the end with DuPont we'd gotten up to about 8800 employees. A large number of those employees were with respect to new environmental regulations because there were many more requirements that we had to comply with, and that just meant increased numbers of people to meet these obligations.

MS: Right. What about the Operations Recreation Association, the ORA? Were those programs popular?

PG: Oh I think they were very popular. I never participated in any.

MS: Was this back in the fifties when this was (unintelligible)?

PG: I don't remember exactly when I started. Well I know the ORA is still going like gangbusters. Yeah. No, it's got a big site out in Boyd Pond Road, which is between Aiken and the 700 area. They sponsor all sorts of activities that a large number of employees would like to be involved in. Oh it's a very popular affair.

MS: These are just— These next set of questions are kind of general, so is there anything that stands out in your mind as the greatest accomplishment at the plant during its history?

PG: Several things. And my list is not going to be complete. But one of the ones that tickles me is that we would regularly have various oversight committees came down and review the site, and almost invariably their findings were not only good, but they were almost accepted as a yardstick by which they'd measure other sites. And we would regularly come up at the top of the heap or very near the top of the heap in comparison of other AEC and DOE sites. Another thing that ticked me was— This is sort of an old story that goes back to the very beginning. When Congress was thinking about the Savannah River Site, the Atomic Energy Commission put together some general specifications for what they wanted Savannah River to do. And they got a price tag and they gave Congress the price tag. And they asked Du Pont to do the job and they asked Du Pont to come up with a very early rough guess as to what the price tag was going to be. I'm told that the federal government thought it would be $400 million and Du Pont said it would be $1.2 billion. And the federal government was appalled because we said it would be three times what they thought it was going to cost. And so the Congress said— I think at that point, there was a Joint Committee on Atomic Energy, JCAE, and they asked Du Pont to send somebody down to Congress to explain it. Now the story may be just a story. I think it's a lot of fun. I've enjoyed telling it through the years. They asked Du Pont's chief engineer, Slim Reed, long, tall, thin drink water, to go to Washington. And he was seated there in front of the congressional committee. And before he went down, he asked for a few things. He said, May I have a blackboard and a piece of chalk and eraser? They said, Oh yes Mr. Reed, We'll have that for you. So he went down there and they went through all the formal opening steps. And they then said, Now Mr. Reed, you understand—and they presented the problem of $400 million versus $1.2 billion. Could you please explain why Du Pont thinks that it should cost this much? Yes Mr. Chairman, may I go to the blackboard? Yes certainly Mr. Reed. So he gets up and goes over to the blackboard, picks up the chalk and he writes down five production reactors, two chemical separations areas, one heavy water extraction area, one fuel fabrication area, one research laboratory, miscellaneous facilities, administration area, three flagpoles. And he drew a line and he put down $1.2 billion. He says, Now are there any questions? And I'm told the room was silent. They, in essence, were looking at the chief engineer of the Du Pont company and the company had a reputation and he had a reputation and that was it. I subsequently saw books that showed the capitalized value. The initial capitalized value of Savannah River was $1.159 billion dollars. We came in $41 million dollars under estimate. Yeah, I think we did a pretty good job. There are many other indicators of the good job we did—our very low injury frequency rate, the tritium facility has never failed to meet a deadline for delivery of tritium for weapons, and the list goes on and on and on.

MS: Right okay. Let's see, the converse of that question, the previous question was, Does anything stand out as the greatest problem?

PG: Well, again on a relative scale, we discussed a moment ago the definition—the subjective definition of the word major. And I would think that I could call several great problems, at least as I became sensitized to what is major or great and what is normal, what is minor. But I don't know of great problems. I think probably the greatest problem is one that I can tell you about off the record.

MS: Should we shut the machine off? Okay.

(tape pause)

MS: Machine's back on now.

PG: Well I think that another great problem was one that we discussed a moment ago. You talk about the dirty thirty, which is sort of a nickname for the incidents. And we were talking about major incidents. And that was a document written by Gorman Ridgeley and it reviewed the thirty events in operating the reactors that were considered most major incidents. And I know Ridge when he wrote that document and the support it got and the review it got, they were considered very major events. I think, compared to what some other gangs have done in operating reactors, they probably are not as major as some of the other things that have happened in the nuclear industry. So yeah, we would say they're major. It was a great problem in operating reactors (unintelligible).

MS: Okay. Do you feel that the plant operated more effectively during some periods than at other times, and were there periods of less effective operation?

PG: Oh yeah. The early days were more effective.

MS: Okay. Any particular reason why?

PG: Less influence from the outside.

MS: Okay. And can you describe your feelings about your work or the aspect of your work you identified most closely with as far as the plant itself is concerned or the contractor, the government, the mission?

PG: Would you hold that question for a minute and go back and ask it later, because I wasn't listening carefully, and I happen to have a couple of things on my mind while you were discussing that—pardon me, while you were asking that question. I had something else on my mind I wanted to say.

MS: Well anytime— We can interrupt anytime and go off on tangents, that's perfectly fine.

PG: Well I want to go back, and I'm not sure it was the immediate preceding question. I want to go back to a question you asked at some point and say, Another major achievement I think that the plan did was the high flux operation, which was from 19—oh it didn't mention this in my brief resume on the tape but it's probably in the printed resume I gave you. Nineteen sixty five to 1967 we operated the high flux and Curium II operation. And the incentive to do that was Glenn Seaborg, who is the discoverer of plutonium and the head of the Atomic Energy Commission at the time. And he was really interested in kind of doing new far out research things. And so we operated C-Reactor at a neutron flux level about a hundred times as high as normal reactors. Normal reactors operate in the one, two and three times ten to the thirteenth neutrons per second per centimeter squared, or neutrons per centimeter squared per second, I forget the units. We ran C-Reactor at two and three and five times ten to the fifteenth neutrons per centimeter squared per second, really heroic power levels or neutron flux levels. We operated two cycles near the end up to one times ten to the sixteenth. What it provided was a test bed for many of experiments where things were produced that could not otherwise have been produced. And I was in charge of coordinating the research samples. And in the space of two years, we put something in excess of four hundred research samples through that reactor and we—

MS: This was C-Reactor now, right?

PG: C-Reactor. And Curium II was running in K-Reactor. So we ran in C-Reactor and in K-Reactor to do these two operations. And the report of the high flux operations in a book with a document number DP-999. And I said— I can remember sending these research samples back across the country, especially to Argonne National Lab in Chicago and to Berkeley in Livermore in California. I would have samples in the lab in Chicago ten to twelve hours after the reactor had shut down. We were looking for very short-lived high activity radionuclides. And I'd have samples in Berkeley and Livermore in their labs in less than eighteen hours after the reactor was shut down. You know, and I got to talking with people who ran LWRs and they'd say, Well we really achieved a record. We did a shutdown in less than twenty five days, how about you? And I said, Can you conceive of shutting a reactor down from full power, taking all of the fuel out, taking everything else out, putting a whole new load in, putting it all back together, starting it up and getting up to full power in less than eighteen hours? They'd just be totally amazed. That's the kind of thing we did in the high flux operation. And so I think that was another one of Savannah River's great achievements, DP-999. The instigator was obviously Glenn Seaborg.

MS: Right. Did you ever meet Glenn Seaborg?

PG: No I did not. I saw him at the site when he came down during this whole thing. Matter of fact, if I met him, (cough) I may have forgotten it. I met two of his co-workers, a guy named Albert Geoso and Ken Hewlett. And Geogso is listed as a co-discoverer of plutonium and I worked with Geoso many times on different experiments that he conducted during the high-flux campaign at Savannah River. Here comes your coffee.

MS: Okay. Great, great.

END SESSION 1 (September 15, 1999)

BEGIN SESSION 2 (September 17, 1999)

MS: Testing 1, 2, 3. This will be a continuation of our interview from the 15th of September, and it is now the 17th of September at 1 p.m. And we'll sort of pick up the pieces where we left off. (laugh) Why don't we just go ahead with the regular questions (unintelligible).

PG: That sounds fine. Just plunge forward.

MS: Okay. I think the next set of questions that we had to deal with dealt with the laboratory and—

PG: Did we finish off the previous group?

MS: I think we did.

PG: Okay go ahead.

MS: So, what is the purpose, as you see it, of the Savannah River Laboratory? By the way, if any of these questions get too general or if they're not good, just say and we'll pass on it.

PG: Recognizing that Savannah River was originally designed, constructed and operated by Du Pont, the laboratory occupied the same position as many other Du Pont facilities where laboratory work to support the production process was a part of the way Du Pont did the job. One of the major differences is that not many Du Pont commercial plants had laboratories on site, whereas with the dedicated task of doing nuclear business, which was different than the rest of the Du Pont Company business, the Savannah River Lab was built on site to provide support—research support for the production process.

MS: Okay. Was your research usually related to specific problems at the plant or to larger issues in nuclear physics, chemistry or other fields of investigation?

PG: Very definitely at Savannah River the former. The laboratory at Savannah River, unlike laboratories elsewhere and at first the Atomic Energy Commission and later the Energy Research Development Administration, E-R-D-A, or ERDA, and then Department of Energy, DOE, the laboratory at Savannah River was dedicated to merely supporting a Savannah River production process. And there was one lab director who came up short because he tried to expand the mission of the Savannah River lab, which would have put Savannah River lab in competition with other labs like the Argonne National Lab, Berkeley and Livermore and Oak Ridge. And it was made very clear that the mission of the Savannah River Lab was solely to support the production activities at Savannah River. I believe under Westinghouse, that has changed to the point where the lab now—and it's called the— I can't recall, the Savannah River Research Center or something like that—

MS: Savannah River Technology Center.

PG: That's correct, Savannah River Technology Center—it now supports missions outside of the Savannah River Site effort.

MS: In fact, I've been told that the mix of on-site work and off-site work is now about 50/50.

PG: I've heard that number, yes.

MS: Okay. What were the most valuable or rewarding research opportunities made available to you because of your job at the laboratory, or work in the laboratory?

PG: I'm glad you changed that question at the last minute because my responsibilities at the lab were work not research. And it was to me a great opportunity to supervise people in the support effort of the Savannah River Lab. I did not have any direct explicit research activities or assignments.

MS: What did you feel was the most valuable research that you contributed to or were able to be involved in because of your employment at SRP?

PG: One might almost say that a subsequent assignment at SRL, because your question had early in it the emphasis on the word research, my work at SRL—after the original supervisory positions at 777 and then running all the support people—my job was back in that of a professional working on his own without supervising people. And I was involved in several aspects of the disposal of high-level waste. And one of the ones that I was most interested in was the fee that the Nuclear Waste Policy Act of 1982 decreed should be charged to the commercial light water reactor folks to get rid of their spent fuel. The Act also required a fee, a comparable fee for the defense waste. And where many people thought that the portion of defense waste activities ought to pay for about 30 percent of the repository, in fact, based on the curies of fission products or the kilowatt hours of thermal energy generated, the defense waste should have paid for about 3 percent rather than 30 percent. I fought this one violently and vigorously. And where at one point it looked as though the defense portion would be ten or more billion dollars out of a thirty- to forty-billion-dollar effort, we got about half of that. I got four to five billion dollars lopped off of the costs that the defense folks were going to have to pay. I have not since followed up to see what they're actually paying because the defense folks had not paid into the nuclear waste fund from the beginning of the Nuclear Waste Policy Act the way the utilities have been required to pay in.

MS: Okay. Did security issues impact the value of your research or other research conducted at the laboratories? In other words, did security issues ever make it necessary to place limits on the dissemination of this knowledge?

PG: The question does not apply directly to me because I did not do explicit research. At the time I was doing my later work on the disposal of high-level waste, the security issues with respect to those activities were essentially nonstarters. They did not exist, so there was no limitation there. There may have been some limitations that true researchers had on their work. I cannot answer that.

MS: Okay. Did you feel that your ability to contribute to your field was hampered or enhanced because of your work at SRP?

PG: Well having not worked in any field other than on SRP assignments, that's a very hard question to answer. I think it was enhanced because I worked at SRP. Nuclear was a brand new thing when I went through university. And when I started to work, only one school in the country, North Carolina State, had degrees in nuclear engineering. So we all learned it in the early days on the job. I think the opportunities provided at SRP for me to grow in that field were definitely there.

MS: If it's possible to generalize, were you encouraged or discouraged from taking part in conferences, publishing findings, or otherwise making research findings known to the larger scientific community?

PG: At the very outset, I suspect we may have been slightly discouraged, in that a lot of our work was classified. The first Geneva Atoms for Peace Conference in 1955 had nobody from Savannah River and they had people from many other U.S. Atomic Energy Commission sites giving papers. The second conference in 1958, I happen to sit next to a good friend of mine who was one of only three allowed to attend the 1958 conference. And I asked Tom what was his feeling about the conference, and the very first thing he said was that people in Geneva were amazed because they knew of Savannah River and they said, Where are the people from Savannah River? Later on, we were definitely encouraged to write papers and present our information. But of course, the major restriction was classification and so many papers which should have been published and recognition which should have been given to employees and researchers was not available.

MS: Are there any research efforts that you are particularly glad to have been involved with?

PG: I enjoyed doing the work at HWCTR, which was the responsibility of the Savannah River Laboratory. The work at 777, which is where the three SRL research reactors were located because we did a lot of very interesting pioneer research, albeit, I was only in a support position there. And I enjoyed trying to fight the battle to save the federal government money, the taxpayers money, on the nuclear waste fees that had to be paid as a result of the Nuclear Waste Policy Act of 1982.

MS: Are there any research avenues that you wished the laboratory had been able to pursue but didn't?

PG: If I accept the premise that the Savannah River Lab was there only to support the Savannah River Site, the answer to that question has to be no, I think it was perfectly fine. They did what they had to do. They did it well. It was probably a good thing that they didn't try and compete with Argonne and Oak Ridge and Livermore and Berkeley because we had people designated to support the production effort. We didn't have high-powered theoretical thinkers who just sat in corners or cubicles, thought up exotic things, outer spacey type things, so I think it was fine. As a matter of fact, even with the limited work that by charter the Savannah River Lab was assigned to do, we did some very definite pioneering things that other labs and other countries took note of because of our prominence in our particular areas.

MS: Okay. The next series of questions deals with sort of like upper level management questions and they start out with, Why was Du Pont chosen instead of GE or some other potential contractor operator (unintelligible)?

PG: Du Pont was chosen in the summer of 1950, about the time that the Korean War started. I think Du Pont was chosen around June 16th, the Korean War started in June, I think, 25, both in 1950. I think the press of getting a second laboratory, Livermore, and a second production facility, Savannah River, was such that Truman and his people and the Atomic Energy Commission were looking for a quick response to get these second facilities going. The first obviously before Livermore was Los Alamos and the first before Savannah River was Hanford. And because Hanford was a—pardon me, because DuPont was an integrated company—integrated in terms of having its own design division, its own construction division, its own operating people, it could much more quickly come online than any of these other outfits that would go to ABC Jones for design, XYZ Smith for construction and LMNO Green for operations. So I think that's why DuPont was selected. Perhaps also because of its World War II record at Hanford.

MS: Okay right. The next question sounds really kind of obvious, but there might be something more to it than just what's on the surface. The question is, Why did DuPont accept the project? Of course the standard answer is because the president asked them to do it, but if you wouldn't mind sort of like if you could kind of imagine what the pros and cons might have been at like one of the board meetings of the top managers at DuPont when they were first approached for this. What might they have said, We should or should not get involved in this, if any of this stuff ever came out?

PG: I suspect— I have never read anything. But I suspect that probably what went on at the very top level was a feeling of an obligation put on the company, perhaps by President Truman, similar to the obligation put on the company during World War II. At the time DuPont was asked to do the Hanford Plant, they were terribly pressed with a very large number of their facilities doing conventional munitions for World War II. And I think, as a good corporate citizen within the country, they felt an obligation. I have to believe that the same sort of conditions prevailed in 1950 when we were asked to do Savannah River. We recognized, of course, the obligations that the company, in turn, requested of the federal government with respect to immunity because it was an unknown field, no profit because it was a field that they didn't regularly conduct business in.

MS: How did the organization and management of SRP differ from practices that the contractor operated as commercial operation?

PG: I'm not really aware of any significant differences. We were cloistered (cough) excuse me, or segregated from the rest of the DuPont company because of the classified nature of the work. As I mentioned a moment ago, the laboratory was located at Savannah River rather than at some of the DuPont company's central laboratory facilities for commercial work. But I don't know of any other part to that answer.

MS: Right. What benefits were there to operating the site for the government and what problems were there?

PG: I think the benefits, first of all, would be the quick design construction and startup. Secondly, the very aggressive nature with which the DuPont company people at Savannah River went about improving productivity. For example, the ultimate production in the large reactors was on the order of seven times the amount for which they were originally designed. I think the drawbacks were ultimately near the end of the contract very major ones and the all-invasive approach of the federal government to try and tell

Du Pont how to run Savannah River. I think the working relationship we had with the government at the beginning, tough guys on both sides, very capable, good negotiators, strong willed, strong minded forceful people, we— Each side recognized the force of the other side and we got along well together.

MS: Did this contract with the government offer certain advantages to the contractor operator, (unintelligible) Du Pont, that was not available in its commercial ventures?

PG: I don't think so. One could say, and I've heard both sides of this argument made through the years. One could say that the Savannah River operation meant that an employee on the commercial side of Du Pont could be taken off the commercial payroll and put on Savannah River and his pay and benefits would then become the responsibility of the federal government. At first that looks like, Hey this is a sink, where we can take the nonproductive commercial people and dump them. On the other hand, I think the opposite side of that coin is that Du Pont, in order to make a good start at Savannah River, took many of its valuable people from commercial operations, put them into Savannah River operations to give the government its best results at Savannah River with a concomitant penalty to commercial Du Pont.

MS: What were the most important organizational structure changes that have taken place at SRP?

PG: I think the organization, during my thirty-seven years with DuPont, remained fairly steady and unchanged, though we did have to add a fair number of organizations in the more recent years to comply with the various extra government regulations. OSHA and things like that, EPA, they seemed to bring in more people. I told you the other day we had gone from a low of 4900 operating people to about 8800 at the time of the contract change. We were still running essentially the same number of facilities and the people who were designated to run them were still the same. The operators, or the production gang, ran—Works Technical provided the day-to-day support. SRL provided longer-ranged research technical efforts and scientific efforts. And then Electrical, Instrument, Transportation, Maintenance, so on. They all had conventional functions. I don't think it changed much. I do have to admit that I don't really quite understand all the various organizations that Westinghouse installed during its time when it first was there and when I started during the first six or six-and-a-half years with Westinghouse on site.

MS: Have there been any basic changes or trends in management philosophy during the (unintelligible)?

PG: I don't recall any with respect to Du Pont. I can only call to mind a very significant change, at least from the standpoint of how it impacted me and what I saw between the Du Pont company on one hand at the Westinghouse company on the other hand. And I'll tell you a little story, and this is from a guy who was sort of at the bottom of the heap, albeit a college grad in engineering, but a person normally at the bottom of the heap. I was, during my ninth year of working for Du Pont, assigned to Canada. And one day in the summer of 1962, I was down in the boiler room doing a test and I heard the PA system call me to report to the station superintendent's office. I came upstairs in my work clothes and went in, and here was the Savannah River DOE, no excuse me, AEC manager, Bob Blair, the top guy for Savannah River, and Rom Squires, who was the top Du Pont guy, he was a general manger at that point, later they were named vice presidents, and Hood Worthington, who was the top technical director for the Atomic Energy Division of Du Pont, all sitting in a room with one of the very top Canadian guys, Dr. Bennett Lewis, Ben Lewis. He was the head of research for Atomic Energy of Canada Limited. And the three Savannah River people had come north to see Ben Lewis at Ben Lewis' request, and they were there visiting both the Chalk River Site and the NPD, or New Production—pardon me, Nuclear Power Demonstrator reactor where I was working. And when I walked in, they interrupted the conversation that was going on and Hood Worthington said that he wanted to let the other people there know that the Du Pont company did a nice thing for all of its employees. They recognized service anniversaries and that today was my tenth anniversary with the Du Pont Company. I'd totally forgotten that it was. And these three guys had come to Canada, because Ben Lewis had asked them to come, but they had scheduled it so they could be at my workplace on my tenth anniversary date. I was just overwhelmed. It as such a nice touch that top guys from Wilmington and taking the top guy from Savannah River Atomic Energy

Commission, would visit and give me my ten-year service award pin at my place of work in Canada three hundred miles north of Toronto. On the other hand, in opposition to that, when the New Production Reactor effort ended in September of 1992 and Westinghouse had the contract at that point, I was offered four different assignments elsewhere at Savannah River. Three of them came from supervisors who had come to Savannah River with Westinghouse. One of them came from a supervisor who had been working for Du Pont earlier and then transferred over to Westinghouse. The Du Pont— The ex-Du Pont guy asked me to come over and talk with him and I spent a morning with him and several of his other people and was totally interested in the job they were talking about. The other three people merely talked to me over the phone and didn't sound at all interested. So I take it that the Du Pont management, from upper management all the way down, were truly more interested in what I think is one of the most vital resources, people, and I don't see that Westinghouse was that interested in people.

MS: Okay. That may sort of dovetail in with the next question which is, What about— How about basic changes or trends in management in the various areas during the history of the plant?

PG: Well I think what I just told you is probably a good example. The example (unintelligible) for the situation to answer that question you've just asked.

MS: The next series of questions is about heavy water. Why was heavy water chosen over graphite and natural water for SRP production reactors?

PG: Heavy water has an ability, in a nuclear reactor, to go critical if natural uranium is used. Natural uranium occurs with about seven tenths of 1 percent U-235, which is the fissile atom, and all the rest is U-238, which is at thermal energies, non-fissile with neutrons. You cannot make a light water reactor and natural uranium go critical. There was not very much enriched uranium available because in 1950 it was being produced at Oak Ridge, and I cannot remember when Paducah, Kentucky, and Portsmouth, Ohio, came on line. They also were uranium-enriching facilities, but enriched uranium was, at that point, dedicated to weapons so that the plant had to be made to run with natural uranium. The only two moderators available for natural uranium were graphite, which was what was done at Hanford, and heavy water. Heavy water from an engineering standpoint, had many advantages over graphite. Graphite was used at Hanford because heavy water was essentially non-available during World War II. Savannah River people had to engage in a fairly heroic effort to get heavy water to stock the reactors at Savannah River. Matter of fact, the reactor started up with only six of the twelve heat exchangers installed in each reactor, just to sort of keep pace with the rate at which heavy water was being extracted in the Dana plant and in the 400 area at Savannah River. Heavy water occurs at about one part in 6500 in nature, so you can extract it, but because it's hydrogen, there's no chemical process. You have to rely on very subtle physical differences. Heavy water boils at a different temperature than light water does, and there are several other processes that we use to extract heavy water from normal water. I think— To encapsulate the answer in one simple summary phrase, heavy water was used because it was a more efficient moderator for a reactor, for a production reactor especially, than any other material.

MS: Okay. How long did you work with heavy water?

PG: One year at the Dana Plant during the initial operation of the extraction units at the Data Plant, and then six-and-a-half years at the 777-M building, which is where the three SRL research reactors were located. My work there was one of managing an inventory of heavy water for the process development pile, which was essentially the same as a production reactor. It's just that rather than running at hundreds and thousands of megawatts, we ran at about 50 watts. We ran at an extremely low power level, but we did physics research for the production reactors there. And we had to take care of the heavy water because of its very high value. In other words, it was a job of making sure that we minimized our losses.

MS: Right. How did production at the Dana plant affect D-Area production at SRP?

PG: We were a few months ahead of D-Area production, 400-D and that's at SRP. We were a few months ahead of the D-Area folks because we had started up the Dana plant before. And we, in essence, piloted all of the things that those guys were going to have to learn, including errors and things that went out. One of the major difficulties was that the heavy water at the Dana plant was extracted in three different phases. It went from natural abundance to between 5 and 15 percent in a process that was a dual temperature hydrogen sulfide exchange process, high temperatures and H2S gas. H2S gas is very, very noxious in terms of industrial hazards for the employees. Five parts per million will knock you out and a little bit more than that will kill you. So it was a difficult thing to operate with. But worse than that, H2S was very corrosive on the iron pipes and the valves and the pumps and the heat exchangers and so we had a large amount of corrosion experience developed that we could translate to the people in the 400-D area.

MS: And I guess the next question kind of dovetails with that, was, Was Dana's design different from SRP's D-Area design?

PG: In one nature respect, many of the areas in D-Area where they, I believe, anticipated they might want to run the facility for a long period of time, were manufactured with stainless steel, which was considerably more resistant to corrosive attack by H2S. The Dana plant was made all out of carbon steel and we would chew it up regularly. We had— I remember one phone call we made to D-Area saying that valve number such-and-such was going to go out. And they said, Well how long have you been running? Said, about thirty-five days. You watch for it, it'll go out anywhere from thirty-two to thirty-eight days. And the D-Area people said, No, no you're wrong. It's not going to go out that fast. It was a valve that had a body of cast steel, one-and-an-eighth inches thick and we had ours going out just in about thirty-five days. The D-Area people phoned back thirty-five days after they started up said, Yeah you were right, it went out. So with just carbon steel, we had a different plant there, because Dana was designed only to supply the initial load of heavy water. The 400-Area—400-D Area was designed to keep up with loses and extra needs of heavy water after Savannah River was initially stocked and was started up.

MS: Okay. It sounds like we've sort of— You may want to add something to this next question but, was there anything learned from Dana that changed the design of SRP's heavy water production facility? You already mentioned the steel.

PG: I don't think that changed the design of— At the time that Savannah River was built, there was a tremendous call on the resources of the United States for stainless steel. It was planned to go into the 100-Area reactors, into large portions of the 200-Area canyon, separation process, and it was essentially nothing left for the 400-Area or for the Dana plant. And because the Dana plant was designed to be sacrificial and run for just a few years, started in '52 and closed in '57, it got the bottom of the heap. The 400-Area got some stainless steel. But I think they were planning to put stainless steel in the sensitive points of the 400-Area right from the beginning. Other of your interviewees may know the answer to that better than I.

MS: Okay. All right, yeah. There was an article in the Savannah River Plant news dated January 21, 1982 that noted that D-Area was considered the, and I quote, "free world's major source of heavy water". Is that how you thought about D-Area?

PG: I don't think so. I think what that does is sell short the Canadians. There's an interesting history of heavy water, and I'm not going to be completely accurate on it because I'm a little foggy. But very early in the game, heavy water was made in Norway because there was very inexpensive hydroelectric power. And one of the three processes for getting heavy water that the Dana plant used was the electrolysis process. You just build an electrolytic cell, run a current through the water and deuterium would come off preferentially to hydrogen, or the other way around, at one of the electrodes, and so you could collect it. And Hitler, with his World War II effort for an atom bomb, made a raid on the Norwegian Heavy Water facilities and some people spirited the heavy water out of Norway—I don't remember the details, but I've read several books on it—just before the Germans got there and I think it went over to England. It may have gone through France first and then to England. Concurrently, there was a little bit of heavy water production being done at Trail, British Columbia by the Canadians. Once again, a terribly inexpensive hydroelectric power was available to do that. And as a result of the Canadians' heavy water experience, I think that's one of the reasons, and I mentioned just a moment ago, a reactor can be made to go critical with natural uranium and heavy water, but not with light water. That was another driving factor on why the Canadians developed the CANDU reactor, the deuterium natural uranium configuration. So there was heavy water around, but it was sort of just a curiosity. It was— I think Harold Urey discovered it in 1932. It was a curiosity until people began to realize that a nuclear reactor could be made to operate with heavy water. Then there was a big push partially during World War II. One of the reactors developed at Argonne National Lab, CP-3, Chicago Pile No. 3, was a heavy water reactor. It was a small one and was built for research purposes. But I think that's where the early pioneering heavy water reactor work was done. And as a matter of fact, many of the aspects of the hundred area reactors were designed at the Chicago Argonne National Lab, much to the disgust of other labs, who wanted the task but it was given to Chicago because of its early heavy water and heavy water reactor work. I don't know much more about the production of heavy water in the very early days, but I will tell you this, the Canadians had a very large heavy water plant at Port Hawkesbury, and they had another very large one at Glace Bay. Because we had more success with heavy water production, or heavy water extraction I should say, at Dana and at Savannah River, we sent people to the Canadian extraction plants to try and help them get going— People like Bob Garvin, who may be on the interview list, could give you much more details because he worked in the 400-Area and he was one of the people sent to Canada. He went— I think he went to Canada twice to help them with their heavy water manufacturing efforts, or heavy water extraction efforts. Later on, the Bruce Plant on Lake Huron in the western part—southwestern part of the Province of Ontario, got into heavy water extraction work, and I think the Canadians now are far and away the bigger extractors of heavy water than Savannah River. I didn't see that article in 1982 in the SRP News, or if I did I forgot about it. But I think in all fairness to Canadians, Yeah we did some very definite pioneering things at Dana and 400-D, but we are not the only folks.

MS: Yeah. Okay. Talking about that article, the same source stated that 37 percent of the employees working in D-Area in 1982 when the facility was closed, had been there since the startup. Did that seem the case to you?

PG: I never was assigned to D-Area, but it certainly doesn't surprise me because I've met many people at Savannah River who had careers unlike mine. They worked in one area for many years. For example, I have several friends who worked in 300-M area on fuel manufacturing. (dogs barking)

They worked in 300-M Area and fuel manufacturing from before reactor startup, that would have to be 1953 until M-Area shut down or until these guys retired. And I know people who worked in 100 areas for their entire working career. I may have been a bad penny and just flipped from here to there because they didn't want me or maybe, I'd like to hope, I was called to these other assignments. But it's not inconsistent to see 37 percent of the people working in the 400-Area from the very beginning.

MS: Okay, right. As far as equipment goes in the GS area, the GS towers and the flare tower were probably the most identifiable SRP feature to the general public. How would you describe the assembly of these pieces and was there any specifically designed equipment that you were aware of?

PG: Well there were massive units. I saw similar units to them at the Dana Plant in Indiana when I first started to work for the company. I think they were identifiable to the public because the Atlantic Coast Line used to run trains on their tracks, which ran through the center of Savannah River Site, sort of the center, near the river. But you could see the 400-Area towers from the trains as you went through, and a reporter for one of the Augusta papers got on the train and rode through just so he could get a photograph of the towers. I think in general, construction and erecting terms, yeah, it's a big job but not a really big job when you consider some of the jobs done to put bridges up. And I use bridges only as an example. I mean, then kind of towers that the 400-D Area had were same kind of things that you see at, for example, oil refineries all over the world. So it's flare towers likewise. Oil rigs, my gosh the oil rigs that sit on the ocean bottom, heroic efforts compared to 400-D.

MS: Okay. Were you able to participate (telephone ringing) in scientific exchanges about your work?

PG: Yeah I was. You want to wait while I answer the phone?

MS: eah, I'm going to shut this off, yeah.

(tape pause)

MS: That last question was, Were you able to participate in scientific exchanges about your work?

PG: In the later days, yeah, or latter days, when there was less classification associated with the work. And we would go to technical and scientific society meetings, make paper presentations, and I actually wound up serving on several national committees in various areas. I think one of the greatest opportunities I had with respect to exchanges was when I made that trip for a year-and-a-half, the assignment to Canada, the nuclear power demonstrator reactor, because the people running that reactor were folks who generated electricity and didn't know much about nuclear. They understood generating electricity from a hydro standpoint and a burning coal standpoint. And I may have told you the other day that my boss, who was one step below control room operator, turned out in the long run, partially because of my tutelage, to be the vice president Ontario Hydro in charge of all their nuclear units. But I basically described to him the extreme intricacies of running a nuclear facility, showed him the kind of money reports I was writing to Washington, D.C., to Wilmington, Delaware and to Savannah River on the—on my experience at the NPD, and showed him the kind of details he'd have to do in running the Ontario Hydro nuclear plants. I had many other good exchanges at technical society meetings, American Nuclear Society and so on.

MS: Talking about the D-Area here, were you there at either the startup or the shutdown?

PG: No. I was at the Dana plant during the startup of it, and I was at the Dana plant for a year so I missed the startup of D-Area, I missed the shutdown of D-Area, but I was never even assigned to D-Area.

MS: Right, yeah. What was it like when they started up Dana, just out of curiosity?

PG: Pretty hectic. We were working much longer hours and we were having difficulties, but I think there were always the normal startup difficulties. And of course everybody had to learn how to cope with H2S as an extremely severe industrial risk from a personnel standpoint.

MS: That may be a good lead-in for the next question was, What made working in D-Area unique?

PG: Well, it smelled like the devil. Anybody who's— If you haven't been to D-Area but you have been to Yellowstone National Park and you've smelled the geysers, they are filled with H2S, which is the smell of rotting eggs, very strong, very obnoxious. Matter of fact, one of the interesting things—In those days, young people may not remember this but the United States coinage before 1964 was silver. And you could take your silver coins in your pocket to work and they would turn black because of the H2S corrosion—silver belt buckles, silver watches. You brought cheap junk stuff to wear to work.

MS: It wouldn't take much then?

PG: No, oh no, no. And as I say, the ability to smell H2S is real and it exists from less than one part per million up to about five parts per million. At that point the olfactory senses are blocked and you are unaware of the fact that you're smelling or breathing H2S above five parts per million, and it only takes ten or fifteen to do you in. So if you've smelled rotten eggs or you've been to Yellowstone or you've been to 400-D and you remember smelling H2S, it's probably because it was well less than one part per million, but it would still turn your silver coins black.

MS: Wow. Were there any special safety and security concerns working in D-Area?

PG: Yeah and these would be applicable both to Dana and to D-Area. You never went anywhere without having a Scott Air-Pak with you, self-contained breathing apparatus.

MS: Scott Air-Pak?

PG: Scott Air-Pak, yeah. S-c-o-t-t and A-i-r hyphen either P-a-c or P-a-c-k, I can't remember which. But they were self-contained oxygen-filled breathing devices. You carried one on your shoulder. It had a mask that would fit over your mouth and your nose. It had a fifteen-minute supply of air. You were not allowed to go into anywhere in the early extraction stages, the GS extraction stages, without having a Scott Air-Pak and without having a buddy, definite safety rules.

MS: What were the daily tasks that faced you in D-Area?

PG: One of our most difficult problems was because the extraction units ran on the order of 200 pounds per square inch, you wanted to hang onto every drop of heavy water, even though it was at a low enrichment, and there were many pumps to circulate the water from the hot towers to the cold towers and back again. And every one of these pumps had a seal so that the shaft where it came out to the electric motor did not lose too much of the processed water. The seals were not conventional packing. They were mechanical seals, which if put together right, would not leak a single drop. And we tried to study, though I certainly never learned any of the real secrets about it. We tried to study what to do to make mechanical seals last well and not leak. And I worked on that and several other tasks during the first year there. I'm not sure that I made any progress on it. (laugh)

MS: Right. You talked about you had a buddy usually when you worked in D-Area. Did y'all work in teams or with partners?

PG: Well because we were technical people and we didn't have big teams doing big tasks, it was just sort of a partner. It was just a buddy system, not a large group of people.

MS: How was work, whether it's maintenance or repair—how was that kind of work handled on the towers? I guess we're asking like how was it organized? Was there a regular routine for maintenance?

PG: There may have been a regular routine for maintenance, but because the Dana—now I'm talking Dana Plant, not 400-D—because the Dana Plant was put together with all carbon steel things kept breaking right and left. When I say breaking, I mean the hydrogen sulfide would cause a failure somewhere, it would be eaten away by that noxious gas and maintenance basically was one of keeping ahead of the (laugh) corrosive attack on the carbon steel. I can remember at one point— All of our valves were about an inch-and-an-eighth thick in the body and I can remember at one point we were just taking valves out and putting new valves in as quick as could be. And the maintenance shop on the floor had valve bodies as far as the eye could see and we were taking valve bodies that had been eaten out, laying up weld rod—where welders would just weld, weld, weld to get the weld rod built up and build up the thickness of the body. They'd put the bodies in the truck and they'd take them to Indianapolis where they'd be heat treated. And they'd be brought back and we'd machine them and reassemble a valve and throw it back in for another short while before it got eaten up again. Another fact, there was one thing I tried to do. They had double-seated plug valves and without blackboard unless you know what I'm talking about, it's kind of hard to describe. But the gas went through from between the two plugs and it was a throttling valve to control the flow. The gas went through from the upstream side of the value between the two plugs and it exited out in the top and the bottom so that when it exited, it was at high velocity and it would not only be the H2S corroding the carbon steel, but it would be the velocity eroding the carbon steel. And so these valves would— These were some of the valves that would go out in thirty-five days I was telling you about a moment ago. I suggested that they turn the valve around so that the gas came in from the outside of the two plugs and met in the center of the valve and the energy of the streams could dissipate by having each stream impact on the other stream, and the energy would dissipate just on the gas itself and there would be less erosion and the valves would last longer. Now I was just a young kid straight out of college and I had an old maintenance mechanic say to me, You can't do that you dumb kid. Look at the arrow on the valve body. It says you can only send the gas this way. You can't send the gas the other way. And I kept telling this story for years and years and years. And after about forty years, I finally ran into a guy who gave me the answer. The reason you can't turn the valve around is because experience has shown if you run the gas in the direction I was proposing, the valve would chatter and it would not control well. But it certainly was an effort on my part to make sure that valves would stay in the line longer, stay in service longer and we could up the production of the Dana plant. I tried but nobody could tell me why it wouldn't work. I was amazed that it took forty years to find out what the answer was.

MS: Either at the Dana Plant or at D-Area, what was considered the job with the most responsibility?

PG: Oh I suspect in the overall structure of the Du Pont company, the greatest responsibility was the production departments because they had to get the product out. I would like to think, since I was never in production at all, was in Works Technical, that is, providing the day-to-day technical support, that we were equally important in making sure that from a technical standpoint the process was run safely and correctly and efficiently. I don't know the answer to that. Plant manager maybe. (laugh)

MS: Right, that'll work. (laugh) Okay the other parts of that question were like, which had the most status or the most— What jobs were considered the most dangerous?

PG: Oh, I would like, in a sort of self-serving way, to say the one that had the greatest status was the technicals because we'd like to think that the production guys couldn't run it without our technical assistance. That's probably a bunch of horse hockey because they probably could have run it. We'd like to think not as well. The most dangerous probably were the maintenance guys, who had to open these units up, hoping that all of the H2S had been purged from the unit and that it would be safe to break a flange or take a valve out or open up a pump. And you don't— You wonder what kind of hazard they might really have faced. Certainly if it was handled properly, the hazard would be low, but always lurking in the back of your mind is, Have they got this thing cleaned out before I break into it?

MS: Right. Do you remember for yourself or for any others any close calls, speaking of the D-Area or Dana (unintelligible)?

PG: I remember hearing at the Dana plant about this one event. H2S is heavier than air, so H2S collects in low pockets, and because of rainstorms, there are always ditches to take runoff water around a facility. It happens just like gutters on a street, only in some (cough) excuse me, in some cases, ditches might be a bit bigger. I remember being told when I first got to the Dana Plant that there were large numbers of bridges over these little ditches, and the employees were not to walk through the ditches, they were to go to the nearest bridge and walk over the bridge, and it was because the H2S would collect in the low spots. And I guess I heard that one or two guys walked, not across bridges but through the low spots, got an extra strong whiff of H2S and passed out. Don't remember any severe incidents or deaths.

MS: Okay. Either at Dana or at Area-D, did both men and women work in this area, or were some jobs reserved for men, some—(telephone ringing) I'll pause (unintelligible).

(tape pause)

MS: Before we got interrupted, I think that the last question that was asked, was, Did both men and women work in this area, in this case being either Dana or D-Area, whichever you want to talk about, and were some jobs reserved for men and some jobs reserved for women?

PG: I think there was discrimination in the early days with respect to sex on jobs. People in those days were categorized and maybe even stereotyped as to what kinds of assignments they'd get. Yeah, I remember the GS or hydrogen sulfide extraction area was populated entirely with males. In the early fifties, the jobs for females were— The jobs for females were secretaries, receptionists, telephone operators, nurses in the medical unit, lab technicians in the laboratories, and that was about the limit of it.

MS: Right, okay. Was there much or any socializing among area workers? In other words, did D-Area workers socialize with other area workers or did they stick to themselves?

PG: Well I'll answer that question not for D-Area, because I didn't work there, but for the Dana plant, and of course it was just the Dana plant in the middle of Indiana, but they had a very active socializing effort, both in terms of bowling leagues and bridge and things like that, company sponsored dances and so on. I think, to sort of key on what you're trying to drive at in that question, I could answer with respect to my early days at Savannah River.

I think the reactor people socialized together. I'm not aware of socializing with 400-D people or with 300-M people or 200-Area people. You have to remember, each of the lettered areas—R, P, L, K, C, for example. F and H, D, M, A, they were all so large that you could find a large group, coterie of friends, for socializing without ever going outside your area. Now there was enough mixing between the reactor areas because—just of job transfers, I worked in all five of them—so that you knew all the people in the reactor areas, all five of them. So there was socializing between areas there.

MS: Did employees sometimes prepare food together or take turns cooking for others on their shift?

PG: Yes.

MS: There was only one heavy water production area on site. How was working in the heavy water area viewed by workers—other workers– say, for example, those in the reactor areas?

PG: I think the 400-D heavy water area was viewed as less desirable. Probably one of the major reasons was the hydrogen sulfide smell. I know that when I hired in with DuPont, I interviewed in Wilmington during my senior year at school with respect to reactor work, and I was very interested in reactor work. And I was assigned to do reactor-type tasks very early in the game. They put me almost immediately in the Dana plant and I spent a year there smelling H2S and thinking how awful it was. Everybody who left the Dana plant and went to Savannah River before I went was transferred to 400-D. And I said to myself, I don't know what the South is like, but I can tell you this, I'm young, I'm single, I've got plenty of free time and ways to be free. If they put me in the 400-D area when I get to Savannah River, I'll go down and give it a try, but if they put me in 400-D, I'm history. And when I walked into the 700-Area and got my assignment in Reactor Technology, I said to myself, Whoopee, I'm then first one who didn't go into D-Area. And I was very happy that I didn't. I went into the kind of work I wanted to be in.

MS: Okay. What was your most memorable experience as—well it says here

D-Area worker, but I supposed what was your most memorable experience in D-Area?

PG: Well I think we mean Dana plant because it's comparable and I think my most (laugh) memorable experience was getting out of there. I think another sort of memorable experience—this may surprise you—I had an officemate whose name was Bob Aiken. He did not go from the Dana plant to Savannah River. He went into commercial Du Pont. And at the very end of the Du Pont contract, Bob Aiken was an executive vice president of Du Pont, and one of the several responsibilities he had was the Savannah River contract. He had previously been a vice president in charge of all international affairs. So where I stayed near the bottom, he rose to the top. He came to Savannah River a few months before the contract ended, and it was kind of funny. I had been asked to go to a party in the 773 Savannah River Lab building that I found was populated with a whole bunch of very bigwigs wearing suit and I was just there in my short-sleeved shirt. And I wondered why I was there. And in walks Bob Aiken. And he walks into the room, he looks over the whole crowd, he walks over to me and says, Hello Pete, how are you? But that was because we were carpool mates and officemates at the Dana Plant thirty-four, thirty-five, thirty-six years earlier. And I think it really rather shocked the bigwigs who were waiting to see this new vice president, that he was an old friend of mine. (laugh)

MS: Who did you consider the key individuals in D-Area at the time that you were (unintelligible)?

PG: Well I think many people. I tend in my early days, and even to this day, to think key individuals are the ones who are able to get the job done, and that cuts across all organization lines—the ones in production, in maintenance, in technical, all over the place.

MS: Who were the designers for SRP's heavy water facilities? Was there any one individual that contributed to its success?

PG: I don't know by name or face any of the designers of the Dana plant. Matter of fact, the job of designing Savannah River was so big that even though the Atomic Energy Commission gave it to the DuPont Company and the DuPont company's Design Division, there were many tasks that were farmed out to various other design outfits, and I can't even call the name now of any of the companies that might have done major design work for Dana or for D-Area.

MS: Okay. Why didn't heavy water play into the development of the American power reactor as it did in Canada, and did any people within the reactor community see heavy water moderated reactors as a technological dead end?

PG: With respect to that question, I'd really sort of like to answer the first part, but I'd have some comments about the second part, the technological dead end. I think the answer to the first part is that—(telephone ringing) Excuse me.

MS: Sure, I'll turn it off.

(tape pause)

MS: (unintelligible) (dog barking) (cough) previous question was, Why didn't heavy water play in the development of the American power reactor as it did in Canada?

PG: Okay. I think there's a quite clear reason, the—or maybe two factors, two major factors. Light water reactors were first developed for use in submarines. The Nautilus was the first use of a light water power reactor to generate electricity so that a submarine truly could be non-air breathing and stay submerged. And so that sort of set the stage for light water reactors. The heavy water reactor also probably was not accepted because one of the capital costs of building a reactor unit is to pay for the heavy water. Heavy water was at a price of around a hundred dollars a pound, so that maybe a heavy water reactor carries a 10 to 15 percent capital cost penalty, higher than an LWR, light water reactor. And the only way you can overcome that kind of financial negative aspect is to find some other efficiency. I'm wondering if, in fact, light water reactors probably aren't less expensive than they ought to be, because I don't know how much utilities pay to buy enriched uranium. It costs a helluva lot of money to enrich uranium at Oak Ridge or Paducah or Portsmouth. (cough) And maybe the government, in the early days in the interest of subsidizing a nuclear electric power industry, gave a loss leader price on the enriched uranium with which to start up these reactors. So that I think that's probably why the United States did not go to heavy water natural uranium power producing or electrical generating reactors. Canada, on the other hand, did not want to be bound to any country that could make available enriched uranium because they didn't want to have their supply of enriched uranium cut off. They could make heavy water. They could buy natural uranium. Matter of fact, they could probably mine natural uranium right in Canada. And so it's to me pretty obvious as to why the two types were developed in the two countries as they did. Now I think the second part of the question was with respect to was the heavy water power reactor a technological dead end. I think certainly the Canadians proved that it wasn't because more than 50 percent of the nuclear electricity in the Province of Ontario, which has 50 percent of the Candia population, 50 percent of the electricity comes from nuclear power in the Province of Ontario. I think Ben Lewis, who's a vice president of AECL, and all the people who worked with him developing the CANDU, the heavy water, natural uranium power reactor, and then the Ontario Hydro people, including my boss, Elgin Horton, who came to be vice president for Ontario Hydro, those people deserve a great deal of credit for pulling off the success of the CANDU reactors.

MS: Okay. The next series of questions deal with fuel and target production. Could you describe the role of that area and the role that it played in the production or operation of the plant?

PG: In one simple word, vital. Without fuel and targets, we wouldn't have run. They did a very competent job of making the fuel and target— And not only did they make the fuel and the targets, they also made the control rods. And, let me go a little bit further and say that the variety of fuel assemblies and target assemblies used at Savannah River in their reactors, far exceeds anything done in the commercial nuclear game. For example, nuclear reactors that are used by utilities to make electricity maybe in their lifetime will have one or two or three kinds of fuel assemblies and control assemblies. We have had, at Savannah River, developed by SRL and Reactor Technology—manufactured by the 300-M fuel and target fab area and burned in the reactors—we've had on the order of eighty-five different fuel and target assemblies, not three or four. And we've had great numbers of different products that we've produced, and we've operated the Savannah River reactors in a very versatile, large number of different ways to make these different products.

MS: You sort of partially answered that, but what are some of the most important production problems that had to be overcome while you worked in fuel and targets area?

PG: Again, just as with 400-D area, I did not work in 300-M. I had friends up there. I would go consult with them on various fuel and target questions and problems, but I think you'd have to ask that question of a 300-M person.

MS: Okay. Again, I'll ask this question. If it's not good to answer it, then we'll skip over it, but how did operations in the fuel and target fabrication change over time, and what were some of the most important developments? You talked about the different marks for example, eighty-some that they—that were designed over the life of the Savannah River.

MS: The ability of the 300-M Area people to build these different assemblies increased phenomenally because Savannah River started up with Mark-1 slugs, which were just solid natural uranium metal, about one inch in diameter and about eight inches long, clad and about eighty thousandths thickness of aluminum on the outside. These were essentially the same kind of slugs as were developed and used in the Hanford reactors during World War II. And the Savannah River reactors were built in such a way that they could take a greater variety of fuel assemblies than the Hanford reactors could, but we didn't have that technology to build those assemblies to begin with. So we started up with Mark-1, which is as I say looked pretty much like World War II Hanford slugs. We then went to tubular fuel assemblies, Mark-5, Mark-5B and all the rest of the tubular assemblies, and they were phenomenal developments, including the high flux assemblies, and I think they were Mark-18 but I can't remember. They were tubular assemblies where the cladding was twenty thousandths of an inch thick on the outside and on the inside, and the core was a uranium-aluminum mixture that was also twenty thousandths of an inch thick. Think about it—sixty thousandths of an inch, which is the same as the thickness of twenty sheets of paper built into a fuel assembly. And the fuel assemblies in the high flux campaign ran each fuel assembly just two concentric tubular fuels with a core about four feet long. They ran at something like four to six megawatts apiece. Heroic work. And the 300 area did a lot of good work developing and manufacturing those and many other fuel assemblies. (cough) Excuse me.

MS: What procedures—

END PART A

BEGIN PART B

MS: We've just finished with the—some of the questions dealing with fuel and target areas, and we are now going into the reactors. I know we've discussed this already, but I'll ask the question again. If you feel like it's adequate already we'll leave it, but why was heavy water chosen over graphite or natural water for the SRP production reactors?

PG: No, I think we really hit that one in depth.

MS: I think we (unintelligible).

PG: I don't remember where on your list it was.

MS: Yeah, but I think we—
PG: You'll be able to find it.

MS: Right, right. Were you present when any of the reactors went critical?

PG: This is a very interesting question because the startup date for the Savannah River Site is given as December 28, 1953. Obviously, there were—

MS: For R-Reactor?

PG: For R-Reactor, yeah. But they call that the startup of the plant because it was the first production. We had made fuel assemblies before then. We had made heavy water before then. We'd started up the SRL research reactors before then. But this was listed as the startup of the plant. I was in Connecticut that night visiting my parents for Christmas holidays. I came home on the 29th and I went in to work on the four-to-twelve shift on the 30th of December. And between the 28th and the 30th after initial criticality, the reactor was shut down to make a few adjustments, and it was started up again on the 30th, at initial critical. And I sort of like to consider— I'm going to tell you another story. I'm sorry I'm long-winded on this whole thing.

MS: No problem.

PG: I sort of like to consider the fact that I'm the first person who saw production at Savannah River. And here's the story. On the four-to-twelve shift, we had the reactor critical, but it was at zero power, and so essentially no production. And Ken French, who later on was the plant superintendent, that night was the R-Area superintendent and he was in the control room. And he said, All right boys everything looks fine. We're going to put some power in this reactor and we're really going to run it. We're going to make some product tonight. But he said, First we're going to go to dinner. We're going to get everything calmed down and we're going to have a chance to have our dinner and let everybody settle down, no more nerves, and then we'll put power in the reactor after we come back from dinner. And after we came back from dinner, I had an instrument mechanic who hooked up an old Wheatstone bridge to one of the thermocouples right in the center of the reactor. And I measured what the temperature was with the Wheatstone bridge, looked it up in the table. And then I knew that we were headed to put in something around 50 megawatts, which at that point was a classified number. But I looked up what 50 megawatts would mean in terms of a temperature rise. It would be about a 2 degree centigrade increase in that thermocouple temperature. So I figured what I would do rather than try and chase that temperature by readjusting the bridge, I would adjust the bridge ahead of time. That meant that the Null needle went way off to the side and I had it set up with the extra millivolts for the extra 2 degrees centigrade increase. And then as they started to put power into the reactor, they pulled the control rods and there was a slight increase on the nuclear instruments and so on. I could see my needle beginning to move towards the center in Null position. And so I kept French and the other Reactor Department people informed as to where the needle was, and I think as a result of my looking at the needle on my Wheatstone bridge, I was the first one to see production. Two degrees centigrade on the normal instruments that they would use to run the reactor regularly was such a small increment, they couldn't see it, the noise on the instrument, which was set up to measure 50 degrees centigrade increase would be so small. The noise, pardon me, would overwhelm such a small increase as 2 degrees, they wouldn't see it. So I saw the first measurement of production. And I like to say that the startup was not December 28, 1953, but two days later, December 30, 1953. And I remember one other remark from that evening when we'd leveled out at 50 megawatts. The NRX reactor in Canada had been operating for awhile at 20 megawatts. And it had an accident in December of 1952, one year earlier, where they accidentally took the reactor critical when it was supposed to be in the shutdown phase. And the instruments (unintelligible) and they extrapolated from the chart to say that the reactor had probably been up to about 90 to 120 megawatts, when it destroyed itself and shut itself down. And French walked around the room after everything had been settled down at 50 megawatts and he said, Well boys, this was the highest that we know of any heavy water reactor in the world running at such-and-such a power level. And then he hesitated for a moment. He said, Under control. We must remember the NRX.

MS: (laugh) What about subsequent runs as the reactors—other reactors were brought to criticality? Do you remember anything about those periods?

PG: Well I was assigned soon after R started up to L-Area. I had started out in P-Area. (cough) I think we discussed the work that I did in P-Area when there were only three operations people there. Basically, construction was still building it. So I went to P-Area, then to R-Area, then to L-Area, and I was there during its startup and initial critical. And then I went to K-Area and was there during its startup, and then I went to C-Area and was there during its startup. And then I left C-Area, in terms of the group inside the 105 building, and went to work in the Studies group over in the 706-C10 building. So I was sort of at the heart of the reactor work right from 1953 until 1962 when I got my transfer to Canada.

MS: Okay. Right. What was the atmosphere like when the reactors were shut down for the last time?

PG: That was when Westinghouse was there, because even though the site likes to advertise that the last operation of the reactors was 1988, Westinghouse ran K-14 after it got there, which was a low power short run, and then they ran K-15, which was a long production run at the normal power level and the normal duration, making tritium, and it ran through sometime in 1982. I think there was some sort of sadness associated with the fact that we were really sort of coming to the end of an era. But I was certainly never given the clearance to know, nor did I have the need to know, what the amount of tritium was that we had produced compared to the amount of tritium that was needed for nuclear weapons. That's a decision made at another level, not mine.

MS: In dealing with the reactors, what aspect of your job did you most look forward to doing and what aspect did you like the least?

PG: I guess in general terms, the thing I liked the most was just making forward progress on whatever assignment I had. I remember that my first assignment was for assembly/disassembly, charge/discharge machines, and the control system. And everybody and his brother was interested in assembly area work because we were putting fuel assemblies to go together in the reactor. Nobody was interested in disassembly work because there would be quite a few months before the first irradiated fuel assemblies came out. So nobody was paying any attention to that. There was a whole gang of half a dozen people who were interested in the charge/discharge machines, and they were very sophisticated machines that ran beautifully and the guys were paying attention to that. Nobody had paid any attention to the actuator system and system that ran the control rods and the safety rods in and out of the reactor. And so I started studying that during my free time. I was on shift work quite frequently with oversight responsibilities, but pretty easy to discharge. It was required to be there but I didn't have a lot of work to do, so I started studying the control rod system. And I became the expert in it and I gave training lectures to all the other people on how the control rod system worked and how the safety rod system worked. And I, for many years, was one of the gurus that they would come to when there were problems with the control system. But I guess just in general terms, getting any assignment, whatever the assignment might be, getting it done properly and well.

MS: Right. How was versatility incorporated into the design of the reactors?

PG: In any way you could think about it. I was amazed when I got there to realize how versatile the reactors were in terms of the number of different fuel assemblies that they could handle and the versatility I found in the way the control system operated. One of the things they found in the control system at the beginning was all the control rods, which were in clusters, were given the same assignment in the reactor. These clusters were peppered throughout the reactor core, and because all of the rods—say all of the A-rods—were pulled out and across from them the C-rods were still in, that would mean that in each little cell surrounding one cluster of control rods, there was a tilt in neutron flux, so that the fuel assemblies on the side of the A-rod were running at a higher power level than the ones on the side of the D-rod. And this tilt then magnified itself across the entire reactor. Well because flexibility had been designed into the control system, we could change the functions of the rods. And so on one side we had the A-rod coming out first and then one-sixth of the reactor farther on we had the B-rod, another one-sixth pie-shaped segment we had the C-rod coming out first, and on—directly opposite where the A-rod was in that sector, we had the B-rods coming out first. We leveled the reactor out by that. And it was the flexibility built into the control rod system that allowed us to do that. That's just one example of many degrees of flexibility that we had in the Savannah River reactor systems.

MS: Okay. What could have been done to have made them better or more versatile? I supposed the implication there being in subsequent use, was there something that—some drawback that sort of appeared glaring later on?

PG: I'm not sure there's any glaring drawback that I see, but I did tell you a moment ago that we had a limited amount of heavy water to start up the reactor, so where we had twelve heat exchangers built for each reactor, we only had enough heavy water to start up with six. So we started up with six. Later on when more water became available, we put in all twelve heat exchangers. We put in the extra six in each reactor. And we ran them with the heat exchangers in series so that meant a fair restriction on the flow. And we had some fairly high pressure pumps, the Byron Jackson, or BJ pumps, and that meant that the flow through the fuel assemblies was limited to some degree. We then subsequently took out the BJ pumps and we put in— Pardon me. Yeah we took out the BJ pumps and we put in Bingham pumps, which were high flow, low head pumps. We changed the pipes around so the heat exchangers were put in parallel. There was less resistance to flow. We had lower pressures in the plenum and we had higher flow, lower pressure fuel assemblies, which increased the production in the reactors. I had mentioned earlier that the reactors were ultimately run at something like about seven times their designed power level. We were always striving for ways to make the reactors do more and do it better.

MS: Okay. Did the goal of versatility have a cost in terms or reducing other potential production goals or missions?

PG: No, I don't think so. As a matter of fact, it helped because you could put into any one of the five reactors whatever fuel and target assemblies you needed based on what the mix was of the desired product.

MS: Okay. Were there any production programs that you were particularly interested in working with?

PG: Well one of my most exciting assignments was the high flux in the Curium II program, which basically, as I told you the other day, was at the instigation of Glenn Seaborg, the head of the Atomic Energy Commission and the discoverer of plutonium. He really wanted to see a reactor run at a very high flux level, and we were producing curium and transuranic elements well beyond plutonium. We got up to the point where we were making californium-252. Now to get from U-238 to californium, it takes ten neutrons, one after another. And because of this program, we got up to the point where we were making californium-252, which has its own unique properties and was foreseen as a possible great boon for medical science purposes. And we also used the high flux campaign for irradiating all sorts of materials. I was in charge of coordinating all the research samples that went through. In a space of two years, I worked with other labs around the country and in other countries to irradiate something in excess of four hundred samples.

MS: Okay. What were the most important changes to the reactors themselves?

PG: One was—

MS: Like heat exchangers—

PG: One was going from six heat exchangers to twelve and then going to parallel heat exchangers and the low head Bingham pumps. Another was the perception that these reactors were not contained the way light water reactors had steel-domed containment vessels over them. The energy stored in a light water reactor was considerably higher than the energy in these reactors, when you consider those reactors were operating in the two thousand pounds per square inch and 550 to 600 degrees temperature and ours was essentially below 100 degrees temperature and was at atmospheric pressure, or at most about five pounds per square inch above atmospheric pressure. There was less energy to be dissipated in the event of an accident. Nonetheless, they worked towards putting confinement. They didn't use the word containment, but they put confinement in the reactor buildings. They sealed up all the gaps in the buildings. The buildings themselves were too big to build a containment dome over. But they built this confinement system that sealed the reactor room, had negative air pressure so that during normal operation any radioactivity in the air in that room would be sent out through the filter compartments and up the stack rather than migrate into occupied areas of the buildings. And it was sort of our answer to the question of how about containment for the reactors. There probably are other things, but I can't think of any at the moment.

MS: Okay. Were there any major operational differences among the five reactors?

PG: Yes. Two parts to that answer. One, it depended on what kind of reactor charge was in the reactor. I mean, you might have a charge making plutonium in one reactor and a charge making tritium in another reactor. That was one way of describing differences between the reactors. A plutonium charge—If you wanted Pu-239 of weapons grade, you would run it for a very short period of time and then change all the fuel assemblies out because to go longer would add Pu-240, which was not wanted in weapons, but you—almost pure Pu-239 was the desired product for weapons. Whereas in the tritium reactor, you would run for a longer period of time because you just kept going until you had enough tritium gas in the tritium target so that you would exceed the safe limits of containing that tritium in the target until such time as it was collected in the tritium extraction units in the 200 area. The other major differences that C-Reactor had a bigger tank than the other four reactors, and so its flux shape out—in the outer rings of fuel assemblies was much higher relative to the center of the reactor than for the R, P, L, K reactors. Those reactors, because the reactor wall, the side walls—the cylindrical side wall, was so close to the core, needed protection against—after long years of operation—needed protection against neutron embrittlement, and so those reactors were operated with a blanket assembly. There were eighty-four blanket assemblies in the outer ring to absorb neutrons and (cough) the next ring in was left vacant, so that was sort of a heavy water reflector. And both of those steps were taken to reduce the influence of neutrons on the walls of the reactor vessel. That was not necessary in C-Area.

MS: Right, yeah. Did any of the reactors develop a reputation for being better at producing certain products?

PG: Well you might say that C-Area did because with flatter flux and higher power level, relatively speaking in the outer rings, it could achieve the highest power levels. But other than that, I don't think so. R-Reactor we shut down in 1964 when Lyndon Johnson, as president, made an agreement with the Russians to cut back a bit on production of materials for nuclear weapons. So maybe the agreement was just a cut back on the total number of nuclear weapons, but R was a good reactor up until that time. C-Area was subsequently shut down because it developed a leak in the reactor tank. Westinghouse came in long before the contract turned over from Du Pont to Westinghouse to attempt to repair that leak with remote welding equipment, working through various approaches and openings in the side of the reactor, recognizing the high radiation level. They were unsuccessful at making that repair. I can't think of anything else for the moment that would distinguish one reactor from another.

MS: Okay. How did reactor operators and other personnel feel about the reactor where they worked as being a pilot reactor? I heard that any time a new product was tried, sometimes one of the reactors would be designated a pilot reactor in order to test it before the others got a hold of it.

PG: Oh that's true and even piloting on another scale, a few assemblies like the first seven clusters in the center of the reactor, septafoils 1 through 7 would have, each one of them, six new assemblies around them. So you would have forty-two new assemblies in the core of the reactor as a pilot run with a new mark assembly before even a full reactor charge was made. And, yeah there was plenty of excitement on the part of the gang assigned to one particular reactor that their reactor was piloting this. I think one of the other excitements was P-Reactor operated from startup until shutdown without a single lost-time injury. They went, what thirty-odd years without a single lost-time injury. They were very proud of that record.

MS: Did one reactor tend to be designated as the pilot reactor more often than the others or was that task pretty much shared?

PG: The latter, to my memory.

MS: How did security concerns affect the operation of the reactors, or did they?

PG: Well I don't think they did very much. I mean obviously security was a factor. To my knowledge, security requirements were pretty well obeyed. I suspect we felt annoyances that some of the security requirements with respect to trying to get the job done, transmission in our case in Reactor Technology it was information we dealt with, transmission of information was impeded by security requirements, but we found ways effectively to get the job done cooperatively with security rather than in confrontation with them.

MS: What about when Wackenhut took over? Were there any significant security changes in the reactor areas?

PG: Not that I'm aware of. I think the only thing I recall when Wackenhut took over was that there was a change by the DOE with respect to the kind of response the DOE wanted a security guard to use under certain confrontation situations with people like terrorists. And I think what they, in essence, were doing was asking the DuPont guards to lay their lives on the line and the plant manager said, We're not going to have any of that crap. No DuPont employee is going to have to lay his life on the line. That's not consistent with the DuPont safety philosophy. You go find yourself somebody else to run the security organization, and that's why Wackenhut came in.

MS: Okay. Was there any appreciable rivalry between reactor personnel, for example, between C-Reactor people and R-Reactor people?

PG: Oh I suspect there may have been to some degree. I would guess that management would probably pretty well put the kibosh on that because any rivalry would tend to foster competition and fostering competition might produce rash actions whereas you run a reactor in a rather carefully calculated, planned, controlled manner.

MS: That pretty much agrees with what other people have said. I think Doug Leader may have mentioned that as far as he was concerned that— And (unintelligible) mentioned this as well that Du Pont did not foster that kind of (unintelligible)—

PG: Absolutely not—

MS: —because it was counter to their (unintelligible).

PG: Right. Well it was counter to the safe way. I mean, if nothing else, and I've already given you during this interview Wednesday and today several examples of how safety came first in the Du Pont organization and if nothing else, we were going to run these reactors safely.

MS: Right. What about— How did reactor cycles change over time? We talked about like we mentioned high flux, some other stuff. Seems like they got faster.

PG: Well, if you can increase the power level, which means you have increased the neutron flux, then you can produce your product at its specification in a shorter period of time. I'm not sure how many numbers from the very early days remain classified, but I can tell you that if the power level of the reactors went up to a point seven times what the designed power level is, then compared to the design power level in the early days, a cycle near the end would take one-seventh as much time, using the same kind of mark number. In fact, that's not a good analogy because the original Mark-1s were not designed to take the kind of power levels we achieved at the end. We had to change the design of the power—of the individual fuel and target assemblies to get those higher power levels. But yeah, you could produce the product faster if you had a higher power level. That's just straight forward.

MS: Okay. How did power ascension affect operations?

PG: Power ascension was a goal because of the demand for product in the early days, and we had a very aggressive program to look at any and all aspects of the reactor that might limit power ascension. And the fact that we did increase power to seven times the design power level sort of indicates we were pretty successful in looking at that. It also, to me, indicates that there were many conservatisms designed into the reactors to begin with, and I guess our big increases in power ascension caused our big increases in productivity and product delivered to the AEC and the DOE.

MS: What was the impact on safety procedures, power ascension (unintelligible)?

PG: None. Safety came before power ascension. I mean, we were going to have power ascension if we could do it, but it was not going to be done at the price of safety.

MS: Okay. Did safety procedures get tighter as a result of doing the power ascension, in order to compensate?

PG: No, I think that safety got—tighter may not be the right word, but safety got more involved as we all learned more about reactor technology, reactor operations design of fuel assemblies and other factors of things that might threaten the reactors, the product, the fuel assemblies, the people, the environment, the countryside, and so we would have to acknowledge and factor into our work increasing safety concerns. But they never were ones that we would consider overriding for the sake of getting on with production. We would have to get on with production consistent with new safety requirements.

MS: Okay. The next series of questions deals with separations. Should we get into those?

PG: Yeah, go ahead. I never worked— Well yeah, I'm sorry. I worked in the H-Area tank farm for the last three years I was there with Westinghouse, but yeah I can go ahead and take a stab at them.

MS: We'll throw them out and see what you can do.

PG: Give it a stab.

MS: Okay. As far as Separations are concerned, what were your daily or weekly job responsibilities? Were they routine or were they varied?

PG: With respect to the time before I was signed to H-Area, I had very little contact with the Separations people. The only major area of contact was with respect to the shipping casks that carried finished fuel and target assemblies from the 100 areas to the 200 areas and I would meet with Separations and Separations Technology people over the handling of the fuel assemblies, getting them out of the casks and into the first processing step in the 200 area (cough) excuse me, in the 200 area separations processes. After that, my assignments were sot of technical on-the-spot research, not day-to-day overseeing of activities in the tank farms because many of the tanks in the tank farms were quite close to being filled with waste from the separations processes, and there was a desire to get the tanks emptied. I remember one of the areas I worked on was getting samples out of the tanks so that we could analyze what was in the waste and know that we could add water to slurry it up and pump it out safely without having an accidental criticality. It turns out the tank that I worked on the most did not have the quantities of fissile material so—that they thought might be there, so the question of adding water and slurring it up and pumping it out was not as severe as they once thought. I really enjoyed the task of getting the samples out of the tank because many people had come along with very complicated, sophisticated pieces of equipment in a concept stage to take samples and I had an electrical engineering roommate who always used to say with respect to mechanical engineering, Never work too many moving parts. And I'd look at these designs and I'd say to myself, Never work too many moving parts. All the pieces would trip over one another and get complicated. I designed and had installed and used an extremely simple thing to take samples out of the tank and send them off to the lab for analysis. In essence, I took just a straight-sided drinking glass, but a smaller device, upside down, put it on the end of a handle. We put it down into the salt in the tank and pound on it with a hammer a few times until the sample cup, open at the bottom, was filled with an impacted bunch of radioactive waste salt, lift it up out of the tank and directly into a shielded cask, close the bottom of the cask, disconnect the handle, close that hole and send it off to the laboratories. And we got some samples using this technique that allowed us to know what was in the tank. Unfortunately, with the results which showed it was okay to go ahead and handle the tank, I found out three or four years after I left H-Area that they still hadn't put water in and slurried up the tank. I don't understand the process of why they're managing the waste in the tanks the way they are, but that's not for me to comment on.

MS: Okay. Were there any production programs that you were particularly interested in?

PG: No, because I was not there.

MS: Okay. What were the most important changes to or process developments in the Separations areas that you were familiar with?

PG: Not familiar with any. I'm sure that they have the same sort of goals and achievements from Separations Department and the separations technology standpoint in the 200 areas that we had in the 100 areas.

MS: Right. Was there any rivalry or competition between the F- and the H-Area operators?

PG: Can't comment. Don't know.

MS: What about between the wet chemistry and the tritium operators?

PG: Ditto, don't know.

MS: Okay. It seems that the general public tends to hear more about reactor operations than separations in the nuclear industry in general. Has separations been slighted or does it benefit from the public attention being directed more towards the reactors?

PG: I think the attention towards the reactors come from the fact that there are on the order of 110 commercial light water reactors making electricity in the United States and almost anything those guys do is subject of news articles. And maybe because the reactors were the production units at Savannah River, they got attention in the local news. I think the reactors ran pretty well. We talked the other day about the dirty thirty and we may talk more about that today. Those were thirty incidents with respect to the Reactor areas. There may be a comparable list with respect to the Separations area. I don't know. I've never heard of it. But I think the Separations area has had a bit of publicity in the local newspapers. I think that probably 100 areas and 200 areas both included, there's not much really significant to talk about in terms of negative information, though I personally think the newspaper tends to grab anything (dog barks) and make it just as big an item as they can.

MS: Right. What about— Did Separations employees tend to feel that the Reactors and Separations were equally important or did they feel jokingly or seriously that Reactor or Separations operations were—one or the other was more important for one reason or another?

PG: I don't know.

MS: Okay. The next series of questions deal with waste.

PG: Yep.

MS: (unintelligible) okay. (dog barks) What kind of responsibilities did you have in relation to the waste tank area?

PG: Well my last three years at Savannah River were in the high level waste engineering group, which would have been called in the old days Separations Technology, because in the old days Du Pont called technical groups technology and also because the waste tanks were part of the Separations Department. I do not know when the waste tanks were split off from the

Separations operations so I guess it was Separations Technology and high-level waste technology, which became high-level waste engineering. I had responsibility with respect to trying to manage the waste in the tanks, get the waste out of the tanks, get analytical results of what was in the waste in the tanks.

MS: Okay. Can you describe what your average day was like?

PG: Oh I guess there's not much to say. There was plenty of work to be done in the office. I tended, in my daily activities throughout my working career, to go out in the field, to meet with people, to talk directly with them rather than closet myself in the office and issue written slips of paper. They talk about the way to get a job done is to issue five copies of it to the most important people and then you say, Now issue eighty copies to everybody so everybody will know about it. The real answer is to issue one copy and hand carry it to the guy you want to have do the job and present it to him and tell him what's on the piece of paper. So I would go out in the field and meet with people and I found myself fairly effective doing that kind of thing.

MS: How did the storage and treatment of waste change during the time that you were familiar with the Waste Division. We've already gone into that a little bit.

PG: Well in the three years I was there, not much at all. Oh I will tell you one other—going back one or two questions—one other responsibility I had. I told you on Wednesday, I think, that we had—

MS: This is waste stuff, right?

PG: This is waste, absolutely. We had fifty-one waste tanks at Savannah River. Hanford had 179. Our fifty-one tanks have a capacity of about, I think it's around 36 million gallons and yet through the years we've generated on the order of 130 million gallons of waste. Now you say, Where's the other roughly 100 million gallons? It's in the tanks, in that the waste has been concentrated. We had, in H-Area tank farm and F-Area tank farm, evaporators which would boil up the waste and would take the vapor, which was just water, and run it through a cleaning and purification process so that in fact nonradioactive vapor was generated and was condensed and released to the environment and much more concentrated liquid waste was left behind. So rather than having tanks for 130 million gallons, we have tanks for only 36 million gallons, and those evaporators have been very efficient in terms of reducing the number of tanks we needed. I had a job with respect to those evaporators that said, Analyze the evaporator vessel itself, because in the four operating evaporators we had used something like seven or eight or maybe nine evaporator vessels through the years. And I did a very thorough study on how long each evaporator had lasted, what kind of materials were put through it, and why it failed, and how long it took to get it out and to get a new one put in. And I did it basically because we had only one spare evaporator vessel at Savannah River, and I was trying to make a case to have a second spare evaporator vessel built, one for H-Area and one for F-Area, thinking that the areas could probably get by with just one evaporator rather than two in each of the two areas, but that the evaporator vessels that were in service at that point were pretty old. And up to the time I made the study, all evaporator vessels were taken out after they had failed. They just waited for a catastrophic failure and then they had to clean the thing up and on the spur of the moment take the evaporator vessel out and put a new one in, in the face of released greater activity inside the evaporator vessel hot cell. And I made the daring proposal, based on my report, that it was time now to take the evaporator vessel out of H-Area. H-Area was more important at that point than F-Area—to take the existing evaporator vessel out, which was running well, but according to my study, really was near the end of life and to do it in a planned, controlled fashion when they could decide to change our operations just enough so that shutting it down and removing it and putting a new one in would fit into their operations rather than having a knee-jerk reaction to, Hey we got a catastrophe on our hands. What do we do now? And it was a daring proposal because almost nobody thought it would fly. But I did have one boss who thought it was a good idea, and he pushed me to do it and I did it and it got accepted. And then the change was made.

MS: This next question we kind of hit at already, but I'll throw it out anyway in case you wanted to elaborate or anything. Can you describe what happened to high-level waste after it was sent to a tank?

PG: Yeah, it would sit in the tank, and at Hanford the tanks would cool and concentrate by boiling, just natural boiling, and the vapors would come off the tank. Hanford essentially had no cooling coils in any of their tanks. At Savannah River, we put cooling coils in our tanks to keep it cool so we did not have boiling of the waste. So the waste would get into the tanks and they would cool and be cooled by the cooling water in the coils until such time as the higher quantities of short-lived, really the major heat-generating products had decayed way and you wouldn't have to cool the tanks anymore. Some precipitation of the activity went on. About 90 to 95 percent of the radioactivity, when you add (cough) a base to the waste— The waste comes out of the process stream in the canyon as an acid and the acid would chew up a carbon steel tank. The tanks in the tank farms are not stainless steel. We didn't have, in the 1950s when we were building Savannah River, enough stainless steel to build stainless steel waste tanks, so carbon steel and to offset the carbon steel, you add great quantities of hydroxide to make a base. It goes from a pH of less than 5 to a pH of around 10 or 10.5. And most of the radioactivity was contained in insoluble nuclides, or compounds, and it would precipitate and that was where 90 to 95 percent of the waste went. In terms of the total radioactive inventory in the tanks at Savannah River, probably as I say 90 to 95 percent of the activity is in something well less than 5 percent of the total volume in the tanks. So that would drop out and settle to the bottom of the tanks. The rest would be the (unintelligible) strontium salts, which would not precipitate in the face of—in the presence of the hydroxide. And those materials would be taken off of the tops of the tanks, run through the evaporators and concentrated and still wouldn't precipitate but there was so little water left that essentially you've got a large amount of salt cake. The first stuff that I said that was insoluble and would precipitate is called sludge, the large volume of stuff is salt cake, and then there's a little bit of liquid on top of that in some cases.

MS: Okay. Did your job change I should say did the job at the waste tanks change when attention began to be paid by the general public about environmental concerns? How did that sort of impact operations at the waste tanks?

PG: Oh I think that the general public needed to be informed. I think that the word needed to be put out on how the wastes were being handled and what the various defense mechanisms were against releases of radioactivity and why the public ought not to be concerned. And so there had to be information prepared, developed and disseminated on these questions.

MS: Okay. The next batch of questions is about health protection. And can you describe in general the health protection measures taken at SRP to provide safe working conditions? In other words, this would be like a broad program to insure a safe work environment.

PG: I guess in a word, big. Certainly I gave you a number the other day, something like either three hundred or seven hundred people exposed over the federal limit of whole body dose in one year in the—either the rest of the DOE nuclear complex or in the commercial whitewater reactor field. And the other number was either seven thousand or three thousand people exposed. The number at Savannah River was one person in excess of this limit. I'm not sure I'm accurate on that one, but there would be an excellent person for you to contact, a guy named Bill Reinig, R-e-i-n-i-g, who's now the vice chairman of CNTA, Citizens for Nuclear Technology Awareness. It's an advocacy group in Columbia, South Carolina that is interested in promoting Savannah River. Reinig was the head of the health protection organization at Savannah River for many years. He lives in North Augusta, and he can certainly give you a very full, thorough story on the health protection. The other person who also lives in North Augusta can give you a very good story on it is Walter Marter, M-a-r-t-e-r. Well I told you one thing the other day that DuPont started off with 60 percent of the federal limit. We were limited to a whole body dose of 3 rem per year, whereas all the other sites had doses of 5 rem per year as their upper limit.

MS: What were the most important measures taken to insure worker health and safety?

PG: Training, before you even went in to do the job—thorough discussion and training. I started to work for Du Pont and the very first thing that happened was I had two eight-hour days of safety indoctrination before I did anything else. I checked in, I told them I was there, I gave them my papers, I spent an hour in the medical department getting a preliminary physical and then two eight-hour days of training on safety.

MS: How have safety measures changed over time at SRP, SRS?

PG: I think as we learned more about safety hazards and risks and possible occurrences, they have been factored into the safety training at SRS. But the other thing I've noticed is that safety sure got a back seat when Westinghouse showed up. I talked with several Westinghouse safety engineers about ideas I had for safety after Westinghouse got the contract during my last few years there, and they seemed to be treated in the most cavalier fashion compared to how seriously I found safety was taken with Du Pont.

MS: What powers have health protection workers had, or do they have, to locate, stop and change unsafe conditions?

PG: Absolute. They can blow the whistle on you anytime.

MS: How have management or organizational practices or changes affected the ability to insure employee health and safety? In other words, has management changes had an impact on safety?

PG: Again, it may be because it's in the past. I don't recall any significant change other—just an endorsement of new factors by Du Pont. But again, I have to tell you the difference between Du Pont and Westinghouse is the difference between day and night.

MS: The last batch of questions here deals with specific products that were produced that were not military. The first one is, Other than military products, what were the most important non-military items produced at SRS, SRP?

PG: I guess as time went along, not only because the security aspects were relaxed, probably rightly so, we were involved with more technical and scientific exchanges. And one thing that came out of that, in terms of a product, was not the standard product that would be produced in the fuel and target assembly in a reactor nearly as much as information. We had a great deal of information that was available and made in more and more copious quantities available to the rest of the nuclear game in terms of all sorts of technical aspects of nuclear work.

MS: Okay. What about out of the other, let's say, out of the other nuclear products that were made that were nonmilitary in nature—I'm thinking about cobalt-60 or californium, things like that—what would you characterize as the most important—significant of those?

PG: Well, we were in competition with Canada making cobalt-60. We had bigger reactors so we could make more of it. I'm not sure I recall exactly where the cobalt-60 went for use. A lot of cobalt irradiators would require large quantifies of cobalt-60 but not very high specific activity. We could make it, Canada could make it. I don't know that we felt as though we had any compelling reason to make a lot of cobalt-60. We had the capability of making many radiopharmaceuticals at Savannah River. We didn't. I suspect the reason we didn't was because it was not a military mission and also because it would have been in competition with Canada. You know, we tend to treat other counties in the world as though we are the great big daddy of them all and so we don't want to do anything to just clobber the daylights out of somebody else making a product, and Canada made in the NRX reactor and NRU reactor many different radiopharmaceuticals. The United States is now dependent upon Canada for these—well has been for years—dependent upon these radiopharmaceuticals coming from Canada. Canada gets a nice hunk of change for selling them to us, but we could have done it at Savannah River. Again, another product that we didn't make and probably wouldn't have been important if we had made it and might have helped our balance of payments, but hell it seems we give money away in the world anyhow as it is. Californium-252 had a great deal of promise for various medical things, but I think in the medical field there are many other ways that advances have been made. Also, the beauty of californium-252 was it was a very intense irradiator with a very localized small field. And you could take a very small californium-252 pellet and implant it either permanently or temporarily and dose the hell out of a tumor in one part of the body without giving the body significant radiation. I remember the time we were making it, it seemed to have a great deal of promise. I haven't heard much of it—about it in the period of time since then. I will tell you one thing that I did that I had a lot of fun doing, when I started to work on the high-flux campaign making samp—coordinating samples from labs and running these more than four hundred samples through the reactor in two years, I looked at a curve of neutron flux versus specific activity for cobalt-60 and I realized that the flux levels we were running, we could make some very high specific activity cobalt-60. Normal activities were ten or twenty or thirty curies per gram, and Canada was very happy about the fact that they were making some stuff at sixty or eighty or maybe even up as high as 100 curies per gram. And I looked at this curve and I said, If I get a couple of small cobalt wafers and I put them in a little aluminum slug and put them in the reactor and leave them there for a year, we can get 700 curie per gram cobalt-60, and that intrigued me. So I got a slug made and I got permission to do it. I had two wafers, each one a bit smaller than a dime. They were side by side in the slug and I put it in the reactor and it stayed there for a year. When it came out of the reactor, they did assay work on it and they found out it was at 705 curies per gram, far and away the highest specific activity Cobalt-60 ever made, and no reactor was ever going to run at that neutron flux level again, so there was no opportunity to make that. I sent the sample off to SRL. That came out in 1966 or '67, I forget which. As a matter of fact, there's a photograph of it and me looking at it with a telescope while it was under about twelve feet of water in the disassembly basin and it advertised in the— This was in the AEC annual report and advertised, World Hottest Cobalt-60. The thing that really intrigued me about it was that the cobalt was going to decay to nickel, and cobalt has a five-year half-life. So I figured in about five half-lives, twenty-five years, half of this material, which had been one hundred percent cobalt, would now be a cobalt-nickel alloy. It was made differently than any other alloy had ever been made. It was made, not by melting two dissimilar metals together, but it was made in essence in situ. And I would love to have found out where those two pieces of cobalt went and what was done with them in terms of research since then. But I went on to other assignments at Savannah River and I lost track of them in a space of a few months after they came out of the reactor. To this day I'd still like to know what happened to them.

MS: Yeah. That's pretty cool. That pretty much concludes the set questions that we want to ask on the interview, but there are some other additional questions that I'd like to ask—

PG: Please go right ahead.

MS: —based on items that we brought up the other day. We already talked about the story about one dollar that Du Pont was going to get for the contract—

PG: Yep—

MS: —which, by the way, I've told a few other people since you told me that and they didn't know that.

PG: Well you see I got it on March 29—

MS: In fact, I talked to somebody who thought that Du Pont got a dollar every year for—which I think is sort of like a common misconception.

PG: I think it is, yeah. I've met many people through the years who thought it was a dollar every year. But I got it from a vice president two days before the contract was relinquished. Ernie Rupee told me.

MS: Well I've never seen it in print that (unintelligible) it was like— Except one time, but it was a much—a (unintelligible) secondary source that said it was like a dollar a year or something like that. But it was a source that you would not think would be authoritative. But usually when I see it in print, they say a dollar. I think that a lot of people just assume it was every year.

PG: I think that's right.

MS: I do want to ask about— I've got a star here to ask about the Heavy Water Component Test Reactor, HWCTR.

PG: Oh yeah.

MS: And (unintelligible) a good time to get into—

PG: Now let's— Yeah, let's get into HWCTR, or Hector, which is the pronunciation everybody used.

MS: How did they come up with that?

PG: There are no vowels in that word, and I remember one very stiff and proper senior manager in SRL in research who said the proper way to pronounce that is HWCTR. He was trying to use five consonant and no vowels, HW-CTR. Well it came up as follows. There was an interest in the country.

You asked a question about why did the United States go light water reactor rather than heavy water, natural uranium. And the answer really is it started with the nuclear navy. There was an interest in the country, after the first few light water reactors started, to find advanced types of reactors to make electricity for civilian purposes. And I think part of that came from the fact that large numbers of companies wanted to get into the nuclear game. They saw there might be a buck in it for them. And so they advanced all sorts of ideas. And there were quite a few different reactors on the scene. And the government decided they would support financially in the Atomic Energy Commission a program to look at developing advanced power reactors. And one of them that they thought of, especially because of Canada's work, was a heavy water reactor. Now they asked Savannah River to do the heavy water reactor. And the reason why HWCTR came the way it did in its form—and this is the reason for the name of the reactor too, I'll get there in a minute—is that DuPont said a couple of basic things. Heavy water has a high price tag and it's not going to be a desirable reactor unless we can beat it in some other way. And they thought the best way to beat it was to make low-cost fuel assemblies. If you had to pay a high price for heavy water, at least you didn't have to spend as much money for fuel assemblies as the light water reactor folks were spending for theirs. So— But they said, We don't know what these assemblies are going to look like and we don't know how well they'll last. So the fuel assemblies were going to be tested in a reactor so that's where TR came from. And C came from it because these were components they were going to test in the reactor, and then of course HW because these were heavy water components that were going to be tested in the reactor. So that's where the name came from. A couple of the other things that they thought they ought to test were, Would you be able to hang on to the heavy water and not have any high loses because if you did, there would be a price penalty against losing this very valuable water. So we were testing components other than fuel assemblies to see if they would work well. And one of the approaches was to buy off-the-shelf components, standard components, rather than spend more money to make what would have been called nuclear grade components—valves, pumps, packing (unintelligible) pumps, that kind of thing. And so several of the things for which we thought we definitely needed answers were included in the heavy water components test reactor concept and design. One of the things that was not there, and everybody asked us why isn't it there, we had no generator and no turbine. And the answer was a very simple one. Given steam, which the Heavy Water Components Test Reactor produced—given steam, any damned fool can make a turbine run and produce electricity. So all we did was let the steam down with some pressure reducing valves and a gigantic muffler that was about eight or ten feet in diameter and 24 feet long. And when the Heavy Water Components Test reactor was running, all you could see was this great plume of steam rising through the woods. Made spectacular photographs, but it also made for a less expensive program. The HWCTR was built for, I'm told, around $7.5 million. There are some people who say it was eleven million dollars. Nonetheless, it gave us the chance to prove out those components we thought were necessary to be proved for a heavy water power reactor. Turns out, we did run fuel assemblies up to 20,000 thermal megawatt days, at which point these massive, inexpensive-to-build fuel assemblies would have been economically productive. So that goal was achieved. Unfortunately, we had more heavy water losses, or heavy water retention capabilities, with the commercially available components, was not as good as we wanted. But HWCTR died along with all the other advanced reactor concepts because the commercial light water reactor industry, those guys designing and building them, were so successful that the advanced reactors didn't stand a prayer against them.

MS: Was that already— Was that trend already in evidence before HWCTR went (unintelligible)?

PG: Oh yeah. Yeah. Yeah.

MS: So it was an attempt just to see—

PG: Well we hoped we could overcome it.

MS: Right.

PG: I remember one of the incidents that happened, and this is why we could get the good performance out of the fuel assemblies. One of the incidents that happened was an evaluation of all of these reactors at a big meeting that AEC conducted in Washington, D.C. and Admiral Hyman Rickover, who was obviously Mr. Nuclear Navy and a great supporter of light water reactors, was in attendance at the meeting. I did not go but I prepared for one of the Du Pont guys who went, some information about the heat transfer capabilities out of our fuel assemblies. And because of our ability in the older reactors at Savannah River to measure flux very carefully, we knew we could measure where the flux was, how much, we could shape it to get exactly what we want, we could control the amount of heat coming out of any surface area, any square inch or square centimeter, whatever you want, surface area in the fuel assembly to make sure that we didn't exceed the capability of the light water coolant or the heavy water coolant to take that heat away from that square centimeter of fuel assembly. And we advertised in the meeting that the reason we had this good performance was because of these high heat fluxes. The heat fluxes were three times what Rickover was running in the nuclear navy reactors. And the guy reported to me in essence, and I think this is an exact quote, Rickover said, Bullshit. Nobody has ever had heat fluxes that high come out of fuel assemblies. That's three times as high as the heat fluxes are in my reactors in the nuclear navy. Well, he was running the heat fluxes on his fuel assemblies at a very low conservative level because he had no flux shaping in the reactor and he didn't know what the flux was. So in essence, if he didn't know what the neutron flux was, he didn't know what the heat flux was in a square centimeter of fuel surface, and he had to run at a conservative value. And unfortunately, the Du Pont guys in the meeting, when Rickover came out with this terrible statement, the Du Pont guys didn't attempt to refute him. They were so intimidated by his bad language and his loud voice and his bold statement, that they sort of tucked their tail between their legs and shrank from view. I'm not sure that a refutation of what Rickover said would have meant any more success for heavy water power reactor in making electricity in the United States or not. I suspect not. I think the game was probably over by that point.

MS: When did HWCTR go on line or go critical or—

PG: March of 1962. I was in Canada then at the NPD, the Nuclear Power Demonstrator, and HWCTR and NPD both went critical within about three weeks of one another. I forget which one was first. But see now the Canadians and the NPD had an entirely different mechanism there. They wanted to sell reactors to other countries around the world. So where HWCTR was only testing certain components, the NPD was a full-fledged right-from-the-word-go nuclear reactor to make electricity. We generated electricity at the NPD, and this was to show people from the Third World that, Hey, you can buy heavy water, you can buy uranium, you can buy stainless steel, you can buy zirconium, you can buy a turbine, you can put a reactor together and make electricity in your Third World Country, and they wanted the visitors to be able to see electricity coming out of the back end of this reactor. So that's why the two reactors were different. But it was between HWCTR and the NPD that the two countries had a bilateral program, and that's why I went to Canada.

MS: Okay. When did HWCTR get shut down for the last time?

PG: December 1st of 1964. I wrote the morning report and I said that HWCTR operated until midnight, at which time it was shut down and preparations were made for final—started for final closure, a very dry, dull thing. And then because we who worked there were all hoping that the reactor would be restarted and we were still looking for some mission for the reactor. Those copies of the morning report that went to the local folks, I'd written the night before. We all knew it was going to shut down. I'd written the night before a little poem about HWCTR's restarting. And I gave it to the secretary and she typed it on the morning report. But I said, Evelyn, don't send that to Wilmington because they don't like frivolity. Wilmington heard about it and I got my fanny chewed out for not letting them see a copy of the poem. (laughter)

MS: Times changed I guess.

PG: Oh yeah.

MS: I don't guess you have a copy of that, do you?

PG: I do. Oh, I've got all sorts of Savannah River memorial—memorabilia upstairs.

MS: Oh really?

PG: Oh yeah.

MS: We'll have to talk about that later. (laugh)

PG: As a matter of fact, the HWCTR morning reports went out on green paper, and Evelyn took a black magic marker that was about three-eighths or half-an-inch wide and she drew a black border around all of the morning reports that morning because it was, in essence, the end of HWCTR.

MS: Yeah. I know that— I've heard this. I can't remember now if you've told me or not, but isn't there some story that you had about the closing of HW-CTR and the different ways of dismantling it?

PG: Oh yeah, yeah. HWCTR was shut down in December of 1964. There were a couple of minor efforts made, just in terms of paperwork studies, for what will we do with it? We don't want to just let it sit there. What's a better way to permanently D&D, decommission and— I forget what D&D stands for right now, decommission and something. But in any case—

MS: Disassemble?

PG: Well except disassemble carries with it the concept of you know what you're going to do. You might leave it right where it is without disassembling it. Could you decommission it where it is without disassembling it, see? So I'll have to just scratch my head as to what D&D stands for. In any case, there were two or maybe three studies made through the years. They were just paperwork studies. The paperwork was put in the record files. And then in—what was it, '95 or '96, I think the DOE made a more significant effort to think about D&D for HWCTR. I should back up one minute and tell you that HWCTR was funded out of a different pocket than any of the other activities at Savannah River, because it was truly a civilian activity. Could we use this reactor to answer the unknown questions that would lead to a heavy water civilian reactor to make electricity? So the funding came from a different source. It came from, in essence, a civilian source. And the funding for what I'm about to tell you also came from a different source than any other—any of the Savannah River activities. Okay in probably late '95 or early '96, a small outfit at the Savannah River research campus called U.S. Energy, was given the task of studying ways to D&D HWCTR. And in— Gosh, they must have started in '95. Because in the spring of '96, several of the people who had worked at HWCTR were given a telephone call from U.S. Energy. They were going to have a reunion, come out to the research campus, and then we were going to go out to HWCTR and look at it and we were going to have a barbeque luncheon or a sandwich luncheon, and we want to talk about how to do the D&D of HWCTR. And fourteen people answered the call and went out there. And we had a grand day. And we didn't get paid anything for the day, but we had fun seeing one another and touring through the building and talking about how to do the D&D job. And we just thought it was a feel-good alumni day. But it turns out that U.S. Energy was looking over the fourteen of us to see who of the fourteen might be hired as a consultant to help them doing their D&D planning, because they were all nice, capable young folk but none of them had worked there. And they really only knew about HWCTR from reading reports and looking at blueprints and going into the building lo these many years after (unintelligible) shut down in '64, do this in '96, thirty-two years later. And out of the fourteen who were there that day, they phoned me and said, This is what's really up. We selected you, would you like to work for us? And I had already retired from Westinghouse and I was approaching sixty-seven years of age and I said, Hey, that sounds like a great deal of fun. I'll do it, yeah, part time. And they said maybe three or four hours a day, two or three days a week. And I went to work for them from March of '96 through March of '97, or maybe April of '96, I forget which. It doesn't matter. And they all came to me and asked bunches of questions. And I found one place where these guys were smarter than AEC. There were fifty-five boxes of records that we had put into vital records storage in Atlanta after HWCTR shut down. And U.S. Energy asked for the boxes of records. And DOE said, Well you tell us which five boxes you want and we'll bring five boxes over. And the guy said, HWCTR is new to us. We don't know which five boxes we want. Bring us all fifty-five boxes. Well we'll send you five just out of the stack and when you finish with them, we'll send them back and we'll give you five more. That way you can learn about it. U.S. Energy insisted absolutely that DOE get off their damned high horse, send all fifty-five boxes over, which DOE ultimately, to their credit, did. Then they started going through the boxes and cataloguing what was in the boxes and there were some pretty good catalogues of what was in the boxes to begin with. And we used those boxes of records and the blueprints pretty copiously. But I found that U.S. Energy was going at it a little bit in the wrong way. They were not relying nearly as much on blueprints as I was. I went to the blueprints far more often, even though I was more familiar with them. They could have learned an awful lot by going to the blueprint. I kept taking guys in there saying, This is what this blueprint means. And I was even, unfortunately, teaching them how to read blueprints in some cases and how to relate this blueprint to that one to that one—the hierarchy of how individual components go together to make an assembly, go together to make a unit, go together to make a whole reactor building. Well we studied the whole thing and finally the report came out. Now before the report came out, my boss in U.S. Energy said—(cough) excuse me—he said, You know more about HWCTR than any of the rest of us do. I think what I'm going to do is give you the job of deciding how we get the reactor vessel out. Now the reactor vessel, when it was manufactured, weighed about sixty tons with everything in it. And I definitely proposed that we don't take anything out of it. It weighed about 100 tons. And the question was, How do you get this 100-ton thing that's about twenty-two or twenty-three feet high and about seven or eight feet in diameter at the most out of the hole in the concrete and laid down on a great big transporter with shielding and carry it over to E-Area, which is the burial grounds, and bury it down in the burial grounds? And they said, Well your section report ought to take about three pages. I think my section report wound up taking eight to twelve pages, because it was a very involved thing that needed careful study. And (cough) we did drill some holes in the concrete and we stuck some instruments in right next to the reactor vessel. We found out the radiation level at the side of the vessel was less than 200 milligram per hour contact, which meant that it wouldn't be too severe a job and we could probably get it out without any shielding and lay it down on the transporter then put some shielding around it. And so I wrote that section report and I was deeply involved in the technical aspects of it, not paying any attention to the cost aspects of it. There was another guy writing that section. And we got the whole report finished and it came out. And then I started reading the whole report as a finished product. And I said, You know, this report is wrong. The recommendation was to disassemble and dismantle it. They were going to take everything out of the building and carry it all over to the 200 area, to E-Area, and bury it in the burial ground. Now this— First of all, what's wrong is it takes up space in E-Area, this valuable space where you might bury other components. Secondly, it's a fairly heroic job to get the reactor out and get it transported over there. And one of the bad aspects is the radiation level that the people would absorb in doing it. So I began to think, Well why don't we entomb it—take everything that's above zero level into pieces. It essentially was not very radioactive, or not radioactive at all. Just take all that stuff and put it down in the basement, and then fill the basement in the areas in between the pieces that are there with concrete. And a building that's 125 feet high, fifty-five or sixty-five feet, I forget which above— I think it was— I think it was sixty-five feet above grade level and then fifty or so feet—fifty-five, or something like that, feet below grade level. So I already got four- or five-foot thick concrete walls. Leave the reactor vessel where it is, put everything else below grade, pour it full of concrete and do the entombment. And one of the reasons this appealed to me was just a rough guess, the radiation dose for the workers doing the work would be only one quarter of what it would be if they were to dismantle and take all the pieces over to the E-Area burial ground. Another reason is that the guy who did the cost estimating said it would cost eight million dollars rather than sixteen million dollars. We'd save half of the cost of dismantling it, save three-quarters of the radiation dose to the workers, and the final result would not be buried in the ground. It would be buried in concrete and the bottom of the concrete structure would be farther away from the water table than the stuff we put in the ground would be in E-Area. The water table was farther below HWCTR in B-Area than the water table was below the burial ground in E-Area. So it all made sense to me. Well by then I was no longer working for U.S. Energy and my only recourse was to appear at public meetings of the Citizens Advisory Board. And I don't think I have to explain what that is. I went to public meetings in the Aiken and Augusta area, and I think probably the reason I got shot down was because I ridiculed the report. The reason I ridiculed the report was because after I had it at home and I studied it here in the house, I found that the cost estimating for entombing was wrong. For example, the ventilation stack was twenty-four inches in diameter, about eighty feet high. It was made of quarter-inch thick carbon steel, so it weighed about 1500 pounds. The cost I estimated to take that stack down was $230,000. And about two weeks before I looked at this, I and another guy had gone into Hitchcock Woods and we'd taken down a hundred foot high pine tree that was twenty-four inches in diameter at the base, and we took it down, just the two of us, in about three hours. And we cut off the bottom sections of it into three eight-foot long logs. Each of the eight-foot long logs would weigh on the order of 1500 pounds. So we carried those logs off to elsewhere in the Hitchcock Woods to make a jump for horses in horse competition—horse jumping, show jumping competition. And I thought, God if we can take a pine tree down that's taller and weighs more in the space of three hours, I'm going to go back and give them a bid to take the ventilation stack down for five to ten thousand dollars, not $230,000. That emboldened me to look at all the other cost aspects of entombment. And I finally wound up with a cost estimate to entomb the thing, not of eight million but about two million dollars. And I made this presentation at a Citizens Advisory Board meeting. The DOE guy who was responsible for administering this civilian money said, Well actually you're wrong. We can't do entombment. We have to do dismantlement. He never explained to me why. And he said, Dismantlement is going to cost, even in a simplified basis, it's going to cost seventeen million dollars and furthermore, the money's already gone because we've given it to somebody else. Well I couldn't get him to tell me who he'd given it to because there was no other source at Savannah River that could use civilian money. So I went away with my tail tucked between my legs, but very upset that they couldn't see the sense of doing this two million dollar job, doing it now and getting the task over and done with. So they could run the flag up the flagpole and say, Hey Savannah River, or Hey world, we have entombed and finally shut down irretrievably and irrevocably and completely another nuclear reactor at Savannah River, you see. They haven't come to grips yet with what to do with the 100 area reactors. Those are big ones. Those are big monsters and they represent their own problems, but I thought, this would be a neat little thing they could do. So what did I read? A year or so later, I read in the SRP News that Schwallie and his people had made a decision to weld the doors closed on HWCTR and leave it for sixty-five years. Sixty-five years from now they're going to—every one of them is going to have to reinvent the wheel and there'll be nobody like me or the other thirteen guys around who could go out there and say from personal firsthand knowledge, This is what you ought to do. So it's going to cost somebody a bundle of money to do it sixty-five years from now. I think it's a wrong decision.

MS: Yeah. One question that I thought of just a little while ago, this is something that I ran across at the Hagley. We were doing some research up there several months ago about a year ago, and Du Pont originally did not express an interest—correct me if I'm wrong with this—did not express an interest in having (unintelligible) with any patent work that would come out of this work when they did the original contract. I think in the sixties, they thought about changing their mind on that and—

PG: I think the first part you say is true, because I had that impression. If they decided to change their mind, I was not aware of that. What you found in the Hagley Museum is probably absolutely accurate.

MS: I don't know if anything ever came of it but I think there were—if I'm correct, I think there were some Du Pont officials who wrote to the Atomic Energy Commission that they maybe were sort of (unintelligible) see if they were—(unintelligible) changing over to—changing the nature of that aspect of the contract to where Du Pont could possibly have some patent activity.

PG: I'm not aware of any patent that Du Pont obtained, either in its name or in the name of AEC, ERDA or DOE while Du Pont had the contract at Savannah River. I know that there was no effort made for employees to try and file for patents. We were just told, Do the job. If you invent something new, good, so be it. But it was a very significant contrast when Westinghouse came in with its mind definitely on patents. And the Technology Transfer Group was set up and employees were encouraged to try and get patents. That was a very significant shift from the Du Pont days.

MS: Oh okay. Right. I think we were talking about the dirty thirty incidents that—at our last session.

PG: Yeah.

MS: And I got a note to myself that we want to talk about it some more.

PG: Sure go ahead. The guy who wrote that report was Gorman Ridgeley. I think Ridge still lives in the Aiken area. I don't know whether he's on your list to talk with or not. I do know that at the time he wrote it up, he, and I believe, several other guys in Reactor Technology did a quite extensive review of individual incident reports, just to use a common yardstick and assess the severity of each of these. And the idea of putting together the dirty thirty was that this would be a learning/teaching/training tool to let other people know how he'd come close to having some difficulty. I think that the nickname Dirty Thirty, though it is an apt description, because there were thirty incidents investigated, I think dirty might carry with it the idea that these were the thirty most severe that they could find. I don't know whether they set out to get thirty explicitly or they set out to find everything above a certain breakpoint, or how they decided it would be thirty. I think dirty thirty is a name that's probably not going to go away, though I think it's a shame because it carries a frivolity, or looseness, or whatever you want that certainly cannot be assigned to the seriousness with which Ridge and the others looked at this. Management would never have delegated the time and the salaries for these guys to make this study if they didn't have a serious purpose on it. I particularly, or specifically, do not remember (cough) what any of the thirty were, but I'm sure a copy of that report is available if you go to the archives.

MS: I've seen— I think he— Correct me if I'm wrong, I think he wrote that in 1985, at least that's the date of the copy that has his name on it.

PG: Okay.

MS: But I don't think it became— Either it wasn't released or it did not become a controversial thing until a couple of years later. I think it may have been as late as '86, '87—

PG: I don't remember.

MS: —maybe '88.

PG: I don't remember.

MS: I think that's when it actually made the New York Times and became—and the name dirty thirty got stuck to it or something. It was about—I think about a year before DuPont got out of SRP. I know that we were talking about some of the Canadian work that you've done, the New—

PG: NPD?

MS: Yeah, the NPD, which is the Nuclear Power Demonstration.

PG: Right, yes.

MS: We talked about that already. I don't know if we want to get into that in any more detail or no—

PG: Well I can give you— I mean, we've got the recorder going, we've got some time to do it. I can give you a few recollections that may already have been on the tape from before. But here's a perfect example. The NPD was actually— The NPD-II, because NPD-I died, and to me it's a credit that the Canadians were gutsy enough to do this. NPD-I was going to be a pressure vessel. And NPD-II turned out to be a pressure tube. And the reason was that— They could have done a pressure vessel for the power level they were talking about, but when you wanted to make bigger reactors

(tape pause)

MS: Okay. This is side 2 of the second tape of Peter Gray Interview on the 17th of September.

PG: It turns out that the Canadians were pretty gutsy in making the decision to go from NPD-I, which is a pressure vessel to NPD-II which is a pressure tube reactor. Light water is a very efficient moderator of neutrons because the hydrogen atom weighs only half as much as the deuterium atom, so it takes only half as many knocks on the neutron to get it down to thermal energy. That means the core of a light water reactor is smaller. Light water reactor that makes— The biggest one in the United States is only about eight or so feet in diameter, but to make that same power in a heavy water reactor, you'd need a reactor that was fifteen to twenty feet in diameter. You can't build a pressure vessel that big. So this one guy, an engineer at Chalk

River, blew the whistle. He said, Hey you can't demonstrate big heavy water power reactors in Canada using the pressure vessel. You ought to blow the whistle on this thing, stop it right away—they'd spent a fair amount of money—and start on a pressure tube. So the Canadians did give up on it. They used the same site. They built a pressure tube, really a calandria reactor with zircaloy pressure tubes inside each of the calandria tubes. And it turns out during my very first visit to Canada, I went to the site where they just had a hole in the ground that NPD-I was going to go into, and a year—a couple of years later I was back there at NPD-II, which was the new reactor, and I was there for a year-and-a-half. It's kind of good to see that at least the Canadians were gutsy enough to realize they'd made a mistake rather than stonewall and go down with a failure on their hands.

MS: Right. One question that I had was we talked about the naval fuels, the naval fuel situation they had in, I guess it was in F-Area?

PG: Yeah, the naval fuels facility was going to be in F-Area, and I think that came very near the end of the Du Pont time. I think I had told you on Wednesday the 15th, that the AEC pretty much left Du Pont alone and allowed them to design things in the way that they thought they ought to be designed. I had heard, but this is only second or third hand, that the naval fuels facility was designed and then it was reengineered and cost cut and slimmed down and shrunk by various DOE edicts, which probably were part and parcel of why the whole darned thing failed because Du Pont was not allowed to put into it at the beginning—was not allowed to put into it in the end run—what they thought at the beginning was necessary to make the thing run. Now whether it was that or whether it was a failure of the basic technological concept of how to do this I don't know. But I think that story is pretty widespread at Savannah River amongst the employees and there must be some truth to it if it's been that widespread. Where there's smoke there's fire.

MS: Right. Right. And then we talked about the— The other day we talked about Barnwell Nuclear Fuel Services Plant.

PG: Yes.

MS: And again in the 1970s and that's— I mean it's adjacent to Savannah River Site, so it would be kind of interesting to go into that a little bit. I think the discussion that we had on it was off tape, I believe.

PG: Probably so and what ought to be said about Barnwell was that everybody in the United States in the early days of civilian nuclear energy was captivated by the idea of getting electricity from the atom, even including people who said the electricity will be so inexpensive, or so cheap, that you won't even meter it, we'll just generate it and deliver it to your house. I think hope springs eternal or there's optimism before there's realism in many, many different processes. The government, through the nuclear navy, was an early sponsor of light water reactors. I don't know the details of how the idea of fabricating fuel assemblies and then reprocessing ones that came out of a reactor was developed, but the idea, I guess, was to isolate the waste, the radioactive fission products, recover the plutonium and uranium, put it back into fuel assemblies, and in essence, get three or four or more times the energy out of a fuel assembly than would be gotten just by irradiating it once and then setting it aside, so that nuclear fuel reprocessing for the civilian light water reactor industry was definitely encouraged. The first plant to do that was built at West Valley, New York as a private venture. The second done was built by General Electric at Morse, Illinois as a private venture, and then Barnwell was the third one. And for various reasons, all of these plants failed. The West Valley Plant at West Valley, New York, did operate for a while, but I think I told you they had shut down to make improvements in the process and the improvements were planned to cost fifteen million dollars, and by the time that the governmental authorities finished ratcheting the private investors upwards on various requirements that ought to be incorporated, the fifteen million dollars had escalated to, I think, on the order of $600 million and the guys at West Valley said, Forget it. We're not going to start it up again. And they let their contract with federal government lapse, and it meant that the federal government wound up taking over West Valley in 1980 (cough), and West Valley is now using the same vitrification process that was developed at Savannah River for vitrifying the Savannah River waste, and the logs—the glass logs which are going to be two feet in diameter and ten feet long that are being made at West Valley, I guess, will come to Savannah River for storage before they go on to the federal government repository, which is planned for Nevada. I think the plans call for the waste to stay at West Valley after they're finished making it for another fifteen or twenty years and maintaining a force there to monitor it. I think that's a dreadful waste of taxpayer money, since taxpayer money is now paying totally for West Valley. The minute they're finished making those glass logs, which are only a few in number, they ought to ship them to Savannah River right away and store them with all the rest of our glass logs, which are being made now at the rate of in excess of 250 a year, and shipped the West Valley logs and our glass logs whenever the repository is available, shut down West Valley in terms of numbers of employees completely fifteen years earlier and save the taxpayer a lot of money.

MS: Right.

PG: But that's only my idea. I don't think I hear the government moving in that direction.

MS: Right, right. What about the— Of course, we talked a little bit about the— at the beginning of the day today about the nuclear waste (unintelligible) in 1982 and the 3 percent versus the (unintelligible) percent, we probably have that one covered. A couple of other topics to bring up—What was the— There was some issue about the disability rate for building 773 maintenance mechanics?

PG: Oh yeah. I had two supervisory positions for a total of about nine years at Savannah River. The rest of the time I worked as an independent professional without anybody reporting to me. For two-and-a-half years, I ran the Laboratory Operations and Services Division of SRL, which is about 20 percent of all the people in SRL or 175. I had a hundred maintenance mechanics working for me in that group of 175. They, by and large, were older than anybody else in the SRL organization. And there was a general sort of rule of thumb perception the older you are the more sick you're going to be, and these guys were out on disability all the time. And I didn't like that charge being made against my guys. And so I asked my secretary to take a little time and look through the disability records of all of these hundred and find out how many days each guy had been gone for the last two-and-a-half years during the time I was there, how many days they'd been gone each year. And I also asked the medical department to give me the general disability rate for SRL and for different classes of people at Savannah River. What I found was the disability rate was on the order of four to four-and-a-half days lost away from work because of disabilities per year per employee. I found in spite of a few of my guys who had really bad records, that the average for my group was on the order of just a little over two days per year. And I can tell you what happened with respect to the two guys that were the worst. They would regularly, through the years, long before I got there, rack up forty, fifty sixty or seventy days of disability. And other people would talk with them and they'd pass it on to me second and third hand. Oh these guys say, I don't feel like coming to work today; I'm just going to stay home. So I talked with my general foreman and I had my general foreman talk with the foreman, the guy first on the line. And I said, We're going to have a contact with these guys. We're going to explain to them what the company's responsibility is with respect to disabilities and what the employee's responsibility is. These guys had the contacts. I know the foreman didn't want to have the contact. I spent a great deal of time with the foreman in both cases as to how to handle it. And when I felt that the foreman was ready to do it— I wasn't pushing him, but when I felt as though he really believed in it and wanted to do it, I said, Okay you're free to have the contact. I will not sit in. I don't want management at the higher levels appearing to threaten these guys. So the contacts were held, and these guys changed their disability performance to between forty and seventy days a year to between about four—to down to about four to five or six days a year. They walked with a sprightly step rather than shuffling, and all of my other guys were more productive because they said, Oh these two guys are no longer getting away with it. Pete got their number. Well, I don't know whether it was Pete got their number or what, but everybody was now pulling their weight, and it was one of the people who said to me that he was really upset with my high disability rate was my immediate supervisor, and I was—I was just revolted by that suggestion on his part. So after my secretary found out these numbers, I went back and I said, Here's the full report. My guys are in better shape than the average guy here. I don't want you making any nasty remarks about my guys again. Because they work for me, they also work for you, and they're your guys too. I don't want to hear any more of this nonsense. One of the other things I will say, at the beginning of my time supervising these 175 people, I had talked to you before about safety meetings and security meetings. There was a third type of meeting at Savannah River called information meeting. Okay, the information meetings really were not adhered to too well by many of the DuPont people. An information meeting was designed to give information to the employees from management, which is a necessary task. It was also designed for management to listen to the employees. And when I got the job, I asked my general foreman— Out of 175 I had five guys who reported directly to me. And I asked them when they'd had their last information meetings. I found it was a year or so ago and I said, Okay we're going to have an information meeting for each of these groups. And I asked the general foreman of the maintenance department to get the big conference room and we're going to sit down. So I sat down with this whole hoard of guys. And before the meeting, the general foreman and the five regular foremen said, What are we going to talk about? I said, We're not going to tell them anything. We're going to let them tell us. And I said, You guys are going to run the meeting and I'll be there if there are any questions that come up. And they all felt uneasy about it and they elected the general foreman to start the meeting. And he felt uneasy about it and he talked for about one or two minutes. And so I said to him, All right, you sit down, I'm going to take over. And I stood up and I said, Guys, I want you to know who I am. My name is Pete Gray and I'm the chief supervisor for this organization and this is what information meetings are supposed to do and I want to have it today. I'm not going tell you anything. I want you to tell me what's on your mind and I'll go to work and see if I can fix it up for you. And so I pointed to the guy over in the far left corner and said, You got a question? No. You? You? You? And I went about five or six guys. And then I had a guy who said, Yeah I got a question and he asked me. And I said, I want to tell you, I'm new to maintenance but I'll answer it the best I can and if I can't answer it to your satisfaction, I'll go find an answer. About that point, I saw number one. He was agitated. I said, Okay now it's your turn. You didn't have one before. We went around the room. We were in there for two-and-a-half hours. And the highest ranked hourly paid maintenance mechanic at Savannah River who'd left the Bell Works in West Virginia to come down here, and he hired in the very first day. And he was always agitating to be union shop steward in case management didn't treat the workers right. And he was always— To get rid of this guy, they were always offering him a promotion to be a foreman and he would—always turned it down. And after this meeting was over, he came up to me and he said, I've been at Savannah River for fifteen or twenty or however many years it was, twenty five years. He said, Best damned meeting I've ever been to. He said, You got my vote. I thought to myself, God if I got Frank's vote I got all these other ninety-nine guys with me also. And it was after that, that my disability rate was down to a little over two days—two days per year per employee. So I had the guys with me. And I always felt— When I first got the assignment, I said How do you get this work done? I said, There's no way I could do the work of 175 people. Only thing I can do is create an environment where they'll want to get the work done. I will have to support them. So I said to all of the people in the lab, If my guys do anything good, you tell them directly. I want them to know that they've done something good. If you got anything wrong with my guys, you come tell me and I'll work behind the scenes and it'll get taken care of. We're not going to have anybody going around chewing ass on my guys right there in front of other people. There are proper ways to take care of my troops. I think they loved me. I hope they did. I believe they did.

MS: Right. Also too I think there was— That may be the thing you were talking about, the information meeting in Building—

PG: Yeah that was it.

MS: 773—

PG: Yeah, the big conference room in 773, yeah.

MS: I've got a note to myself too, to ask about the bilateral agreement between the U.S. and Canada and what you might have known about that.

PG: Oh. I don't know. I think one way to look at it is, somebody might have said, Hey if we don't need this guy, we can farm him out to Canada for a year, year-and-a-half. And it won't—his loss won't hurt us too much. I don't think that's true, but I didn't feel really well equipped to handle that assignment because I didn't know much about the Canadian heavy water power reactor program. But then nobody else did. When I got up there, I found several things. And one of them, as I say, my boss Elgin Horton, was just doing technical work. Now the technical work at a coal burning plant was to find out how many tons of coal they had at the beginning of the month, how many tons came in, how many tons were burned and how many tons came they had at the end of the month. And then that'd be the starting point for the next month's report. They did the same thing with bars of soap, rolls of toilet paper and secretaries. And I said, Elgin, it's not that simple. And I described to him how Reactor Technology operated independent from the Reactor Department at Savannah River and was sort of a check-and-balance on them, and we knew technically all of what was going on. I showed him copies of the monthly reports I was writing back to Savannah River. And I also showed him a copy of a paper— I told you earlier that the Atoms for Peace Conference in Geneva in 1955, Eisenhower sponsored the whole thing. Nobody from Savannah River went because we were focused on this task and it was classified. And then either three or four people went in 1958. One of the guys that went was A. A. Johnson, my boss, the head of Reactor Technology. A. A. turned into A-Squared, so he was just called A-Squared Johnson. A-Squared presented a paper there, and I got a copy of the proceedings from the 1958 conference. And I bought it in Canada and I gave it to Elgin and I said, Read this paper. This is how A-Squared runs Reactor Technology in terms of being independent from the Reactor Department that operates the reactors. You're independent from the guys who run this power reactor turning out the electricity. I said, This is the kind of thing you ought to do because it's been very successful at Savannah River. And he took the book and he read it and took the lesson to heart. And as I say, the last time I saw him in Toronto in 1990, he was the vice president in charge of Ontario Hydro Nuclear. So I think— I think how we ran Savannah River was pretty successful and what I carried to Canada during the year-and-a-half I was at the NPD really sort of helped those guys. There were a few guys who'd had nuclear experience from Chalk River, but there were many guys that—wholly new to this game. I think I told you the other day about the Du Pont safety record versus the Ontario Hydro safety record. Remember I was telling you about the blackboard with the numbers? Is that on tape or not, and do you want it on tape?

MS: Let's put it on this—

PG: It's a reflection—

MS: For some reason I don't think, it is—

PG: I don't' think it's on tape. Okay. We were working hammer-and-tongs to get the NPD going and to get electricity being generated—nuclear electricity being generated and sent out in Canada because this really represented a new phase for Canadian nuclear activities. And we got the reactor up to power, and we made electricity and we got it up to full power. We changed fuel. This is one of the places where the Canadians were ahead of the game because they could run the reactor 100 percent of the time and change fuel. You didn't have to shut down, so this was an offsetting factor that made money for them opposite the high cost of having to pay for the inventory of the heavy water. And we did all of this, and then finally the station superintendent decided, Hey we sort of missed safety. We ought to have a safety session. Unlike Savannah River where we'd had safety meting every month, this was our first safety meeting since I got there. And the superintendent called down to Toronto and the safety—the Ontario Hydro safety engineer came north three hundred miles and we had a full-day session for all of the exempt degreed professional people. About 10:30 or eleven o'clock in the morning, the safety engineer went over to the black board and he wrote down a string of numbers vertically. And he started with something like— These aren't the exact numbers, but he started with something like 38, 33, 29, 24, 22, 18, 15, 11, 8. I remember the last number he wrote down at the bottom of the list was eight. Anybody know what these numbers are? And room silent. So he said, Come on. And he urged us, and nobody knew. And I spoke up and I said, Would you write another number down there? And he said, Sure, what number do you want? I said, At the bottom of your list, would you put down 0.2. Okay and he did it. Then he said, Anybody still not know? Everybody still not know what these numbers are? The room was silent. And he looked at me he said, What do you think they are? I said, I believe they're injury frequently rates in injuries per million man-hours worked, a million exposure man hours. And he said, You're right. He said, Now do you know what 38 is? Nobody knew. I didn't know. And he said, Well that's the mining industry, or something like that. He said, You know what 33 is or 32? Nobody knew. He said, Well that's the construction industry. And he went on through and he got to the lower and lower numbers. We got to office workers and secretaries and that kind of stuff. Then he got down to eight. And he said, I'm very proud of eight. He said, That's the Ontario Hydro injury frequency rate and disabilities per million man hours worked, or exposure hours. Then he turned around and looked at me and he said, What's 0.2? Then he said, No don't tell me. He said, All morning I've been listening to you, and you've been talking differently than everybody else in this room. He says, You don't work for Hydro, do you? And I said, No I don't. He said, Let me guess, I know, you work for Du Pont, don't you? And I said, Yes. He said, Only Du Pont has a safety attitude like the attitude you've been displaying.

MS: Yeah I guess it really did make a difference.

PG: I ran across an Ontario Hydro worker one day at the plant chipping concrete because he wanted to get to a buried line so he could put an electrical connector in the line at that point. He had an air hammer, and he had a cold chisel, and he had his fiberglass Ontario Hydro safety hat on. He did not have gloves on, he did not have safety glasses on, he did not have the cold chisel in the bit of the air hammer. It was all rounded off on the top and the air hammer was sort of skipping along over the top of the thing. I waited until he stopped and when he stopped I said, Bill, are you doing that job safely? And he says, Yeah, I got my hardhat on, and he tapped his hardhat, (makes noise) right back to chipping see. Never thought about safety glasses, never thought about gloves, never thought about the mushroomed head of the cold chisel. All he knew was Ontario Hydro had an electrical hazard, electrical shock hazard, and he was wearing his fiberglass safety helmet. That's all that counted to him.

MS: Yeah, that's amazing.

PG: So I really think that Du Pont did a helluva fine job in terms of safety. They said during the construction of the plant, eight workers lost their lives. They said normal construction job, forty-five to fifty would have lost their lives.

MS: Yeah that is a remarkable record (unintelligible).

PG: And Westinghouse gloats, Hey we got four million injury-free man hours. Well Du Pont'd go for thirty-five or forty or forty-five million man-hours.

MS: Right, yeah. That is kind of amazing.

PG: I got both eyes and all ten fingers and I'm happy I worked for Du Pont.

MS: Yeah that is (unintelligible). That pretty much goes through, I think, all the questions that I had (unintelligible). Is there anything else you want to bring up that I haven't thought of?

PG: Oh if we went on and on and on there are a large number of stories I could tell you. I don't think of any at the moment. I think you've done a very thorough job with questions. You've sort of covered the waterfront. And I think for anybody wanting to do a reconstruction of how Savannah River came to be and how it was built and how it was operated and what went right and what went wrong, what I've already told you along with all the other people you guys are going to interview, gives probably a pretty thorough story. The only thing I could do by telling you more stories is telling you more cute stories, that have kind of surprise endings.

MS: Those are not bad. And what we might do, if you think some up and you decide, Oh I think I want to tell that, we can add (unintelligible).

PG: I'll give you just one very brief one. The guys in Chalk River were developing a portable unit about the size of a fairly big portable typewriter to detect the presence of tritium in air in case a heavy water leak occurred, but they were having difficulty getting it, and the NPD reactor where I worked had put in a fixed tritium monitor with outlets in four different rooms. And I talked with the health protection guy, who said, You know what's wrong, every one of the rooms that they put this sampler in are the wrong rooms. And the rooms that really need a sample point aren't included, but they've already got all the pipes an the walls and the walls—concrete board and everything, and they can't change it now. I've heard that Savannah River has portable tritium sniffers that do work. Could you get two of them up here on loan? So I phoned down to my buddies here and I got two of them on loan, and they were invaluable because the development of the Canadian tritium sniffers was—continued to be delayed. And it turns out that we had a major spill of heavy water at the NPD reactor in December. Here we started up in March of '62. We had this major spill in December of '62.

And the tritium sniffers were a godsend in terms of protecting the Canadian employees during the operation of the cleanup from this big tritium spill. Now I mean I'm filled with lots of neat little stories like that where Savannah River came to either its own benefit or the benefit of some outside organization or some auxiliary side issue that was assisted by what we did.

MS: Right.

PG: But there are people at Savannah River all over the place that come—can come to you with additional stories like that. (dog barks)

MS: Right. Yeah. That pretty much covers, I think everything else. I'd like to go through— There are a couple of terms that—

PG: Sure.

MS: We don't need to do this on tape, but I just wanted to make sure I've got the right spelling.

PG: Okay.

MS: And then there is another question I just wanted to ask about what you thought of the future of nuclear energy is, although that's not our mission here, so I can turn this off, I guess.

PG: We can continue with the tape going for anything that you'd like on the tape.

MS: Yeah, we'd probably have to turn that off since (unintelligible). I guess at that point we'll do that stuff but let me just take this opportunity to thank you very much for the stories and also the information and the—and willing to sit there for this length of time for two sessions (laugh) which is, I'm sure, considerable (unintelligible). I appreciate (unintelligible).

PG: No, I have plenty of time.

MS: I want to thank you (dog barks) again for that.

PG: You're welcome.

MS: And I'll go ahead and shut this off.

END OF INTERVIEW

Oral History Interview – Lawrence Heinrich

Larry Heinrich is from Missouri. He earned a degree in engineering physics from the University of Kansas, and applied for a position with Du Pont in 1951, while he was still at university. His first assignment was at Argonne National Laboratory, in Building 316, where developmental work was conducted on the Savannah River reactors. After a year at Argonne, he transferred to the Experimental Physics group at Savannah River, where he worked in Building 777-M. He was involved in many of the original calculations needed to ensure the safe and efficient use of the Savannah River heavy water reactors.

In 1955, Heinrich transferred into Reactor Technology, where he did further calculations needed for production and reactivity. His understanding of the function of the reactors, and the history of the mixed lattice operation of the Savannah River reactors, is unparalleled. He is currently retired and living in Aiken, South Carolina.

Interviewee: Lawrence A. "Larry" Heinrich

Interviewer: Mark Swanson

Date of Interview: April 17, 2007

M. Swanson: This is the 17th of April, 2007, and this is Larry Heinrich. And Larry, if you wouldn't mind just for the record, if you would state your full name and date of birth.

L. Heinrich: Lawrence A. Heinrich.*

MS: And what's your educational background?

LH: I have a degree in engineering physics from the University of Kansas.

MS: When did you begin working at Savannah River Site?

LH: Well, in 1951, the personnel people for Du Pont came through the universities and were hiring people for work, eventually it said at South Carolina at the Savannah River Plant. And I talked to them and applied and eventually got a job and clearance, and my first assignment was at Argonne Laboratory at the group in Building 316 that was doing the development work for the production reactors at Savannah River and also for the reactor for the submarine, Nautilus. We were working on both of those. And I worked there for about a year and then transferred down to the Experimental Physics group at Savannah River. The facility at Argonne consisted—that was related to Savannah River, was a two-thirds size mockup of the production reactors. And this was the second test of that. The first one was a subcritical test of a thermal column of a source that they had out there, doing the design work, and we were looking at the flux shapes around the fuel and getting the general reactivity characteristics of the reactor, then transfer it down.

MS: This was at Argonne?

LH: Argonne laboratory, outside of Chicago. Argonne did the development work for the reactors, the development work for the reprocessing was done

*Personal information has been removed from the transcription

at Oak Ridge, and the development work for much of the other was done at KAPL, Knolls Atomic Power Laboratory. And then it sort of all fed together—the D_2O development was done elsewhere, but then the D_2O plant was built at the site. What would you like to know about the reactors?

MS: Anything that you want to tell me. One thing that might be useful is why did they decide to go with heavy water as a moderator, versus graphite?

LH: The reason they went— The impetus for the Savannah River Plant itself was to provide material for the hydrogen weapons, tritium. The existing plant at the time at Hanford could make small amounts of tritium, but not large amounts of tritium because the nature of their reactors. They were graphite-moderated reactors and one of the problems that you get into when you try to make tritium in graphite reactors is that you get into positive power coefficient systems, something that you ignore or try to keep out of if you're at all able to do so. It's the thing that killed the Chernobyl reactor. So the reason they went to D_2O was to be able to make tritium and the characteristic that was important was the smaller absorption cross section of D_2O compared to graphite, so you could get a higher reactivity of the reactor and make tritium.

The design concerns—the things that drove the design of the reactor, was the lack of heavy water, which we had to make, the known ability to make fuel at that time, the size of the tanks that had to be built at New York Ship. The Savannah River Plant actually consumed the entire stainless steel output of the United Sates for two years when it was built. The reactor tanks themselves were built at New York Ship. And we built the largest tanks that could be floated down the Intracoastal Waterway and up the Savannah River and discharged at the site, so that was a limiting condition there.

The problems that we had to face at that time were knowledge of how to make fuel and how to connect aluminum and stainless steel, which is why we went to a reactor that had both moderator and the coolant all on the same circuit, so to speak. The tubes holding the fuel were aluminum and the bottom plates of the reactor and the top plates were stainless steel, and it was not known at that time how you could bond aluminum with stainless steel. We could do that now, but we couldn't back then. So we went with a single moderator system. They had built or been able to design fuel and get a good contact between the cladding and the fuel using one-inch slugs of uranium that were 8.1 inches long. And so we designed a fuel piece that was called a quatrefoil. It had four columns of one-inch slugs in there. And one of the things that we were doing at Argonne was to measure what was called the Wilkins effect. It was discovered by a physicist by the name of Wilkins, strangely enough, who never worked for Du Pont, but this is a streaming effect of neutrons around the bottom of the gap between one piece of fuel and the next. And we were—

MS: I'm sorry what was the—Wilkins?

LH: Wilkins—the Wilkins effect.

MS: W-i-l?

LH: W-i-l-k-i-n-s, yes. He was one of the few African American physicists at the time. So as an amusing sideline, we had a fellow come in and try to hire on to Du Pont and his name was Wilkins too and he claimed that he was one of the guys that—he was the guy that discovered this effect only he was not the right color, so he did not get hired. We knew that at the time. At any rate, the story of the development of the Savannah River reactors, is basically the story of developing new types of fuel in the reactors, and being able to operate the reactors at higher power. The name plate capacity of the Savannah River reactors was 275 megawatts for R, P, L and K and 300 megawatts for C-reactor. C-reactor had a little slightly larger tank and we could put in a reflector, D_2O reflector. When the reactors were fully developed and before we went to a mixed fuel charge, we had increased those power levels by a factor of 10, so we were fairly successful in doing that.

MS: I've got a question about the—you were talking about the bond between aluminum and stainless steel, they didn't—weren't sure how that was going to work out?

LH: Yes—

MS: I don't understand why they had to have heavy water, the moderator and the coolant all be heavy water as a result of that being a problem.

LH: The reason why it had to be was this bond between the aluminum and the stainless steel, otherwise, if you tried to use light water as coolant, which was a consideration, then you would get leakage into the heavy water, heavy water side that would contaminate your moderator. That was the reason why we went to heavy water cooling and heavy water moderation.

MS: How long were you at Argonne?

LH: About a year.

MS: One year? Do you know when that was?

LH: From June 16th to March 3rd. We left because my wife was pregnant and we had to get down here and get settled before the baby was born.

MS: Okay, what year was that?

LH: March 3, 1953. I was construction liaison engineer in Building 777 where they were building the prototype, or the full-size prototype of the production reactor.

MS: Was that the first job you had at Savannah River Site?

LH: At the Savannah River Site, yes itself. Let's see, production liaison engineer for that building.

MS: What can you tell me about the 777?

LH: The object of 777 at that time was to do experiments on the reactors. We did not have the reactor computer codes that we have today and all of the experiments, such as the flux shapes and the reactivity, had to be measured experimentally. We had another reactor in that building too, it was a General Electric—called a General Electric Standard Pile, SP, and it was used to make—be a neutron source for a small tank sitting on top of it where we would put experimental lattices in. And we finally developed that into not only the source itself, but a modification of that particular reactor into the reactor that they use to test fuel elements in the 300 Area, was a byproduct of that. And I was involved in that and a fellow by the name of Bob Axtman, who was also involved with effort.

MS: Yeah I think that Dan Pellarin mentioned him.

LH: Other people in that group were Jack Crandall, Gerhart Dessauer, George O'Neil and just a number of people, some of which are dead, some of which are still around, some of which are gone their separate ways by this time.

MS: How long did you work at 777?

LH: Until 1955. And in the fall of '55 I transferred out to the plant into Reactor Technology, into the Works Technical end of the business, where I did production calculations and reactivity calculations. Back in those days, we didn't have computer codes for the reactor, everything had to be done by hand. And for calculating flux shapes and reactivities, we had to go through the Bessel Function Equations for the reactors at that time, which was— It was a long and involved process, but it worked nevertheless.
The Savannah River reactors were unique in several ways. First of all, they were very flexible; they could make other things other than just plutonium and tritium. And we did of, course—we made a lot of uranium-233 and cobalt-60 and californium, some polonium-210 and other things like that. But they also were the first time that large reactors were built with a control system that could be used to shape the neutron flux distribution. We had sixty-one control positions in the lattice, which was called a fused hexagon lattice of six fuel positions surrounding a control position. And in that control position there was a septafoil with seven—with positions for seven control rods in it. Two of the control rods were cadmium, three of the control rods were full-length lithium-aluminum rods, and two were partial length lithium-aluminum rods, which we used to shape the axial flux distribution by positioning them. And part of the procedures of calculations that we went through were the calculations on where you would put the partial rods, either the one or two when—depending on the position of the full rods, which were used to control the reactor, the power of the reactor. So that was one of the jobs that we had at that time.
We also did the production calculations as to how much plutonium was be-

ing made, because at that time, that's where the primary balance for material management was done. The first calculation of the plutonium was done based on the calculation of how much the reactor was producing. Now this is a bad way to do it, but that's how it was done. And then what they did was compare that with what came out of B-Line in the 200 Area and say, Well where's the rest of it, or how come we have more than what you calculated? It's not an easy calculation, the uncertainty in calculating that number by hand is about plus or minus 5 percent.

MS: There was some method that you said—it may have been a technique or whatever that you mentioned by name, but I don't remember—I never heard it before, like one of the—when you're doing the production calculations.

LH: Well the production calculations were done just with differential equations. The flux shaping was done using Bessel functions.

MS: That was the name. Yeah, that was it, yeah.

LH: Bessel—big tables of Bessel Function books. And you would determine the argument—

MS: It's a standard thing, I just don't know it.

LH: —the argument of the Bessel Function and plug that into your calculations.

MS: How do you spell that?

LH: B-e-s-s-e-l.

MS: Okay. I'm sorry, go ahead.

LH: The Savannah River reactors were initially equipped with six heat exchangers per reactor, and a pump— Each system had a pump on it called the Byron Jackson pump. Early in 1960, we modified that and went and added another heat exchanger to each of the six reactor systems, so we had twelve heat exchangers in each reactor, and we changed out the pumps from the Byron Jackson to another pump, a Bingham pump, B-i-n-g-ha-m, Bingham pump, and that increased the flow rate through the reactors of D_2O to about 155,000 GPM and we could increase the power level, so that's changed.

Now, in the Reactor Technology group, what we were doing was also designing new types of fuel assemblies. The limitations on the power of the reactor were basically the central metal temperature of the uranium, which you had to stay under the melting temperature, and the sheath temperature which would cause boiling at the interface between the coolant and the cladding that was on the slugs, and if you had that boiling occur, then the temperature would rise because you weren't getting any coolant on the aluminum sheath and the sheath would melt, so we had to stay under those two things. So the push was to have increased the surface area and at the same time decrease the thickness of the uranium so that the central metal temperature went down and the sheath temperature went down also.

The first thing we did was to take these slugs that we had, these uranium slugs, and put a hole down the center of them. And that worked a little bit better. But then the next step was to go to a larger slug, which had two pieces of uranium on there with four coolant surfaces. This involved being able to clad—the technology of being able to clad with this new type of fuel assembly. So we were working with the fuel production organization to develop this kind of cladding. And eventually we also went from natural uranium up to slightly sweetened uranium. And we got up to power levels between 2500 and 3000 megawatts in these reactors. So this was an effort that was almost entirely done within the Works Technical organization of Reactor Technology. So what we were doing was increasing the production of the Savannah River Plant by essentially a factor of 10, over that time.

MS: How long did you work at Reactor Technology?

LH: I worked at Reactor Technology until 1980. And I ended up as a group leader out there with a group of about a dozen physicists working for me and we were doing various—involved in various other projects like designing charges for the production of uranium-233 and generally supporting the operation of the plant. In 1980, I was transferred up to the Advanced Operational Planning group, which was set up at the request of what was the Atomic Energy Commission, a fellow by the name of Baronowski was heading up the production side of that. And what he saw a need for was

an organization that would connect all of the various sites that were involved in the weapons production—the military, what they needed in terms of weapons, what the weapons could be made of, which would involve the two laboratories doing that work, Los Alamos and Livermore, the production facilities such as Hanford and Savannah River, and all of those facilities—well, and Oak Ridge of course, which was producing the enriched uranium for weapons and doing the enrichment and also making lithium-6.
But all of these came together in this advanced operational concept, and each site had an advanced operational planning group, and then there was a central group that worked out of Oak Ridge, which was called ACOP, Central Operational Planning, Advanced Operational Planning, something like that. And they reported to Baronowski, and the object of the game was to coordinate all of the facilities to minimize the cost and make sure that we were providing the military with what it needed in the way of weapons. So I worked in that group— I'm sorry, I said 1980. I actually transferred up there to that group in 1969, so 1969, not 1980. Because in 1980, I went to work for the environmental group out at the site, which was really involved in evaluating foreign technologies and how they were progressing. This was— You can call this—this was the spy network. So we were looking at other things.

MS: That was in 1980 and after?

LH: Yeah. And I worked in that type of business until I retired.

MS: When did you retire?

LH: Well I retired a number of times. The first time I retired was when Du Pont left in '89 and I retired from Westinghouse about three years later, went to work part time at Westinghouse, retired from that, worked for Sandia Laboratory—living here but working for them for about five years, and retired from that and went— Al Boni, who was heading up the environmental group that I was working for before in 1980 said, Come back and work for me part time, so I did that. In 2005—yeah, 2005, November of 2005, I retired— Was it 2005? Yeah. I retired, 53½ years of continuous work in the operation.

MS: Well I think you beat out Cy Banick, who worked as sort of a historical advisor to us when we did this initial project years ago.

LH: I knew Cy quite well.

MS: Going back to Reactor Technology, so you would have been at Reactor Technology from like 1955 to '69 right?

LH: Yes.

MS: Which reactors did you work with the most or was it—

LH: I worked with all of them. I was actually assigned for a while in the support group that we had in C-reactor, and then when we made the switch to the new pumps and put in the containment system on the reactors, I was the person that went from one reactor to the other, representing Reactor Technology in making that change, so I worked in all five reactors.

MS: Did you have like a main office in C area?

LH: Yes, we had an office in C-reactor.

MS: Was that 706 or—

LH: Well Reactor Technology had an office in 706. When I was working in C-reactor itself, I had an office in the reactor building.

MS: Who were your supervisors during that period?

LH: Ed Hones, Frank Kruesi, James Smith, Paul Robencamp, Otto Morris, John Maloney. Those were the main ones while I was—

MS: What about— Who were the more memorable co-workers that you can recall?

LH: Well of course— Frank Kruesi was one of the most influential people out there. Paul Robencamp. Luke Fox was also—he's dead now. Paul is still alive. Back when I was up in Technical division, I worked for Jack Crandall. And it turns out that when I went back up to AOP, he was head of that group so I worked for him again. And the guy that I worked for in the Environmental Technology section was Al Boni, B-o-n-i. And he's just retired too so— Frank Kruesi is now out in Boise, Idaho. He was our link to the Hanford people. He was doing experimental work on plutonium criticality at Hanford.

MS: Was this before Savannah River Site?

LH: Yes, back during the war. He's still alive as far as I know.

MS: We had occasion to interview Paul Dahlen, who was also at Hanford and then went to work at CMX.

LH: Paul ended up head of the Reactor department too. Knew Paul quite well. We used to eat lunch together.

MS: And I guess you had to have a security clearance for your job and everything. Did you have to have a security clearance before you hired on at Du Pont?

LH: Yes. I got my security clearance before I reported for work.

MS: And when you first moved down here, did you live in Aiken or—

LH: Yes we moved into Crosland Park, it was being built at the time. And there were about three or four hundred homes completed and we bought one and went down to Southern Mortgage and signed the lease and went back and couldn't find it. (laugh) It was raining cats and dogs, luckily, so we got one at the top of the hill, but we found it. I lived there up until '58 I think, yeah '58.

MS: Talking about having worked in Reactor Technology in particular, was there any equipment that was used that was particularly memorable or any equipment that you designed that you remember? Thing is there are so many, it's hard to single out one of them.

LH: There's so many—everything—everything was a cooperative effort. There were lots of people that worked on it. The axial flux monitor was one that I was involved with where we took a wire and fed it down through one of several axial tubes in the reactor, left it there for a short time, brought it out and measured the radiation along it so that we could get a picture of the axial flux distribution. Another phenomenon that I was very closely associated with was the phenomenon called xenon oscillations. When you have large reactors that operate at high power, they have a tendency to look at themselves as the summation of parts, and you have little regions that can operate all by their lonesome because they can go critical on themselves. And from time to time you will find that the reactor gets unbalanced. And if you look at total reactor power, it will remain constant but the power in one region will go up and the power in another region will go down. And this is a phenomenon called a xenon oscillation. It can take a number of different modes of oscillation—top to bottom, side to side, around the reactor and you can actually have one in the vertical direction where the center of the reactor will go—the power will go up and down in the top and the bottom and then reverse itself basically. And it's all due to the half-life of the intermediate isotope before you get to xenon. So developing the control concepts for how to handle this was a process that I was most responsible for.

MS: What about when they were doing the—when they were making the special products, the curium, all the way to californium and all that, how did y'all work with that?

LH: Well the impetus for that was to produce californium-252. We had made some plutonium-242 before that. And what we did was start out with some plutonium that we produced earlier and irradiated, make it into fuel assemblies and irradiate it again until most of the plutonium, or 90 percent of the plutonium in there was up to plutonium-242. We did the same thing in making californium-252. We used the plutonium that we had produced and irradiated it, took it out, reprocessed it, put the plutonium back in the reactor, took the americium and curium that we had made and put those into special targets and irradiated those in a special lattice that we designed called a high-flux reactor. Now the high-flux reactor took one of our production reactors— We blocked off about two-thirds of the outer fuel positions and actually had just a small reactor in the center and used a lot of—

MS: Was this C-reactor?

LH: Oh— It was K or L, it wasn't C, I think. Was it? No, I guess it was C. I don't remember. I don't remember which one it was. But we just then designed a fuel assembly that would have an ultra high flow through it and we could get flux levels up to around 10^{16} neutrons per square centimeter per second, which is a factor of 50 to 100 higher than what we used normally, and started out with about 100 kilograms of plutonium and ended up with 2.5 grams of californium, because if you go through the table of isotopes, it only takes 14 neutrons to go from plutonium up to californium-252. Most of those isotopes in between there are kind of squirrelly and they fission, or decay on you, so you end up using about 2000 neutrons to make an atom of californium-252, which is why it costs a million dollars a microgram.

MS: In the work that you were doing, in particular with Reactor Technology, was there any special clothing that you were required to wear?

LH: Well, if we were out in the site, out in the reactor and went into one of the radiation zones, we had to equip just like everybody else did. And depending on whether you were in an area where there had been a moderator spill or something or they had opened one of the moderator lines, then you would have tritium present in the atmosphere because D_2O has a slight—has a rather small cross-section for absorbing neutrons to produce tritium. So any time you broke a line, you would have tritium in the atmosphere, so you'd have to put on a plastic suit with an air supply hose that would—and it wasn't much fun to work in, but you—that's what—that was what—

MS: Yeah, better than the alternative.

LH: It was better than inhaling tritium. So yeah we had to do that, along with everybody else. We had to follow the same rules that radiation control put on anybody that worked in that. The other instance was— Back in, oh let's see it was the early eighties, they had a source rod melt on them. They—

And they pulled it out of the reactor and the source rod was hot enough so that part of it melted and fell down on top of the reactor and the whole reactor—the main reactor room got contaminated and they had to have people come in and do some work from all over the site to get it cleaned up and I was on that crew too.

MS: Yeah was that where they were enlisting people like secretaries from A Area, whatever to come in and work for just a few seconds, mop some stuff up and then leave?

LH: Yeah. I was in there for about twenty minutes, got two and a half R in that period of time.

MS: I guess that meant that you couldn't go back in for a while?

LH: Well, you only went in once, yeah. But you got to put that in perspective. I was informed by the head of the Russian Atomic Energy Commission equivalent at a conference that I was at in Japan that for the first two or three years that they operated the Russian facilities at Kyshtym, the average exposure of people at that site, which included everybody, was 100-hour, and of course we never had anybody get anything like that. They had a lot of people die.

MS: Right. I imagine that in a lot of cases they probably didn't have any choice. It was like, you were expendable.

LH: Yeah, you were. You did—you were hired for the job.

MS: What about— How were you measured for radiation levels?

LH: You had a radiation dosimeter that you could wear. You had a film badge and you had a dosimeter that you could look through and do it while you were on the job and say, Hey I've got enough. And then there was a badge you wore that had various types of material in it that would show how much radiation received, and that was measured after the fact. And then you'd have to give a urine sample in and bottle they measure the tritium uptake.

MS: What was your average workday like when you were working down in the reactor areas? Like for example, where'd you eat lunch and things like that?

LH: Well we— Most of the time when I was out in the reactor area, we ate—we took our lunch and ate it, because we also had a bridge game going or something else like that, and got together and ate lunch together. There was a cafeteria at each area back in those days and you could do that. If you were involved in a project, and there were numbers of times that I was involved in a project, you would work sixteen, twenty-four, thirty-two hours at a stretch and you'd eat at the cafeteria and grab a nap in the ladies restroom, so to speak, because that's the only couch in the building, at night. I can remember when I was running a test when they shut down R-reactor. They had decided to close down R and they asked people if there was anything that ought to be done, any tests that ought to be made on that reactor before they shut it down. And I wrote up a proposal for testing the supplementary safety system. Are you aware what that is?

MS: Only vaguely.

LH: It's a system for injecting a solution of gadolinium nitrate in D_2O as the next-to-last safety system before you dump the moderator and put H_2O into the tank. And this system, it was installed and it had been in all the reactors and it was under pressure and—but it had never been tested. So I suggested before we shut down, on our list, do two things—we'll test it to 1) determine how effective it is at shutting down the reactor and 2) if we ever have to use it, can we get it out and restart the reactor? And the bottom line is that we did one hell of a lot of calculations and measurements and set up various monitoring systems in R-reactor and used some high or very fast recorders to record neutron temperatures or neutron distributions at various places in the reactor and outside. And early one morning after I'd been here for probably thirty-six hours or so, we pulled the ring and shut down the reactor, had a lot of management looking over my shoulder. And it worked exactly as we had anticipated it would. And we then ran the separations system out there for the moderator and took the gadolinium out and actually restarted the reactor to prove that we could do that. And after we did that, we shut it down for the last time, and that was the last time R operated.

MS: That was in 1964, wasn't that, when they closed that down?

MS: What about the— Out of all the different reactors and stuff, what were some of the operational quirks of the different reactors? I know they had some leaks in the elbow joints—

LH: Yeah. We had— We developed a— We found out a phenomenon called "stress chloride corrosion." And if there's any sort of an anomaly in stainless steel and there's chloride present, it will eat right through stainless steel. And we had a leak develop in one of the discharge nozzles from L-reactor. And I happened to be out there at the time. So we had to do something that had never been done before, which was actually excavate through the concrete shield into this nozzle and build some special tools to cut that section with the leak out, and we ended up with a piece of stainless steel that was about, oh, 6 to 8 inches in diameter, one-inch thick, with a crack all the way through it. And I was in the chain of people that carried that out to—out of the reactor at the time, so I actually held it in my hands. And we fixed it, went back and operated the reactor again. But we found that a number of things– The labels that we put on all of the lines, the adhesive in the label had a chlorine content. And you'd peel the label off and you'd see these little stress cracks coming in the stainless steel. And we finally had to adjust the pH of the moderator to the level where that was—that particular phenomenon was minimized. And a guy that did that was a fellow by the name of Douglas Leader, D. R. Leader, he was involved in that quite extensively.

Had another phenomenon too that we started getting leaks in the heat exchangers that we couldn't explain. The heater exchangers had D_2O on the tube side and H_2O on the shell side of the heat exchanger. And we would get a—start monitoring the shell side, which turned up with D_2O in it. But we had—we adjusted the pressure so if there was any leakage at all, the D_2O would leak out, rather than the H_2O leak in, because once it got into the D_2O we couldn't—it would be a lot harder to get it out. And the solution to this problem was somewhat prosaic. The basins—wherever the water came in from the river before it went into the building, had large screens over the nozzles where the water flowed from the basin into the building. The water that came up from the river, had gunk it, you know, and there would be limbs and leaves and stuff like that, because you're pumping through an eight-foot pipe. And the custom was to take a large sort of like a whisk—push broom– and clean off the screens, and the bristles on the push brooms were made out of nylon. Occasionally they would break off, and they would go through and get into these—wedged into the heat exchanger between two or more of the thousands of tubes that were in there and they'd sit there and vibrate. And nylon, soft as it is, will in time wear right through that stainless steel tube. And—

MS: I'd never heard of that problem.

LH: Yeah well it was a unique problem and the guy that found it was this guy Leader, too. He worked on that.

MS: Yeah I think we interviewed Doug Leader. This was like for the earlier project.

LH: That was—he found that out, and of course when we did was change brooms. That was the solution to that problem.

MS: Yeah it just goes to show—and the whole process of doing everything at Savannah River Site, there were so many different operations going on and all interconnected.

LH: Another thing that we found out that we had not anticipated was that there were several places in the H_2O system that goes through the building where there are sort of dead spots. And we found out that there is a snail that lives in the Savannah River—

MS: Yeah, I heard about that—

LH: (laughter) and that we ended up excavating those things out by the ton. They would sit in there and breed and actually restrict the flow of H_2O through the building.

MS: Also too, when their— Of course, they built 183 basin in R area in anticipation of needing some clarification facilities that they didn't need—

LH: Didn't need that, right—

MS: Right, and they found that out at CMX.

LH: Yeah, and that's the reason why R and P areas are a different shape than the other building—the buildings. R and P were designed by the engineering department in Wilmington and they wanted to make sure that they had plenty of room to get things in and out, the large heat exchangers because the heat exchangers are almost half the size of this room. So those buildings are much larger than L, K and C.

MS: And there was something too about the heat exchangers in R and P having to be— They're on some kind of like track.

LH: Yeah, they're disconnected and then they come on a track into what's called a handball court. You lift up a concrete slab and then you could go down with a crane and lift the heat exchanger out.

MS: Apparently, though, they did away with the track or something in like L, K and C.

LH: No, they still have the track.

MS: But there was something about it wasn't as wide. You could simply pull it out directly from— You had some concrete slab. You could pull it up directly without having to pull it back—

LH: Right—

MS: There was something about that whole thing. And of course the reactors themselves in L, K and C, the reactor buildings were smaller.

LH: But the reactors were the same. The only different reactor is C, which is a larger diameter.

MS: Right, yeah. And in fact when you start reading the engineering and design history, it's amazing that each of the reactors, in some small way—not the reactor tank itself, but the building and the different parts of the building like the assembly/disassembly areas, each of them are different if you really look at the details. They just, at some point decided, Oh we don't need that forget that, go on with the next one. What about—I think we already covered that. Let's see, so you were here before start-up then, right?

LH: Yes.

MS: What was it like to work in the reactor areas before start-up?

LH: Well I— The only reactor area that I ever worked in before start-up was C-reactor because when the other reactors were starting up, I was in the Technical division. But I visited the areas quite extensively. And it was hectic. Everybody— There was a great sense of urgency to get the reactors on line. We actually went critical with R reactor in December of '53. And we were doing everything we could. It was a mark of accomplishment, I think, for Du Pont management that this was the only site in the weapons business that started up on time, or before, and under budget. It was brought in under the budget that was actually designed for. And we were operating five reactors, two reprocessing plants, a tritium production facility, and all of the fuel production facility with about between five to six thousand people on the site in production and a thousand people in the laboratory—less people than you have out there today with everything shut down.

MS: Right. Yeah, that is true. At one point in the early nineties, I think they had close to thirty thousand people out there.

LH: Oh yeah. Well that's— DOE wrote the contract with Westinghouse which said Westinghouse's fee was related to how many people they were managing. So Westinghouse (laugher) hired everybody. Y'all come.

MS: Well why do you think—this is sort of off the track here, but why do you think that— It does appear that by the 1980s—certainly by the mid-1980s, DOE and Du Pont were sort of getting it cross-wise, I guess. Considering what Du Pont did for them, I don't really understand exactly why.

LH: Well, two things. When the plant started up, the presence of government personnel on the site was limited to one wing of the 703 building. And part of that was empty. They had less than a hundred people on the site in AEC. And if somebody in the AEC wanted to visit one of the areas—and they had no presence in any of the operating areas at all—if they wanted to visit, they went to the superintendent in Du Pont who had charge of that area and they worked down through the level of management to set up a time and place for them to come out and see whatever they wanted to see. But it was— But Du Pont was running the show. That was when the Atomic Energy Commission had a policy of hiring people who were scientists and familiar with nuclear energy.

After Jimmy Carter came through and did his marvelous things, the Department of Energy, ERDA, was set up within the entire government and people came into the Department of Energy that had no background whatsoever. And a guy might be watching wetbacks coming over the Rio Grande one day and the next day he's at Savannah River. And they wanted to have complete control over the site. And I can see their reason for wanting that. They were liable if something happened. The problems that came about were that they didn't have the people with the background to implement that policy. And it caused a lot of hard feelings and yes, Du Pont said, We're going to— The statement that they made was, We're going to do this as long as we feel that we can provide a unique service to the government. And the keyword in that statement was unique. And it was obvious at one point that other companies could come in so they asked to be relieved of their contract. And that's when Westinghouse came in.

And Du Pont had, of course, built the Hanford plant, too. They were— Du Pont was unique in that it had its own in-house engineering and architectural arm. They did not have to go outside the company. And the company actually lost a lot of money because of its nuclear work with the government because it— While it got paid for using its own engineering department, that department was not available for the use of the commercial facilities in the company. So they were anxious to get out of the business. They did consider briefly coming back into the business a couple years ago when the contract came up, but decided against it.

MS: Well why do you think—this is off topic for sure, but you might actually know something about this, so I figured I'd ask—Why did they decide to change the Atomic Energy Commission? Why not just leave it as it was in the 1970s when they were doing the ERDA thing and then eventually Department of Energy?

LH: That was Washington politics. And for one thing, the Atomic Energy Commission was originally set up during the Second World War and they had a number of scientists in there that were in the process of retiring or dying or going their separate ways. And they either had to go into a recruiting of people that would be—for the government, that would not meet government standard requirements or mesh it in with the entire government and make everybody eligible to apply for these jobs. And they chose the latter, which I think in my estimation, for what it's worth, was the wrong decision, but that's the way they chose to do it. And they enlarged greatly the scope of the Commission by going into ERDA, where it was responsible for all energy development and that kind of thing and the Department of Energy today, which has a number of different missions other than weapons—production of weapons branches. There was a lot of talk of transferring the weapons—nuclear weapons production oversight to the Department of Defense. That did not happen for a number of reasons, one of which I don't think the DOD wanted it, and they realized that they would have to face some of the same problems that DOE was facing if they did that, so that didn't happen. But in my estimation, they should have done that for, what it's worth.

MS: What about—let's see— What are some of the most important areas within the reactor building that you would consider important to record for posterity? I realize that's pretty open-ended but it's designed that way, I think. If there were any—any particular reactor building, is there any area that really stands out?

LH: Oh— Well, there's the control room, but the control room doesn't really tell you very much. If you— The really important and the interesting parts of the reactor is the reactor itself for -40 up to +120-foot levels. And with the actuator system in place and the reactor itself, those are the things that I would consider. The main design features, the guts of the whole process, is the reactor and the actuator system, those areas. Those areas are the hardest ones to do because they're still hot.

MS: Right. Yeah. So in other words, if I had to guess I would say that'd be more significant than the assembly area on one side and the disassembly on the other, which is sort of mechanical. What about— And again, this is kind of a loaded question but out of all the five different SRP reactors, which would be the most historically significant, in your opinion?

LH: Well—

MS: It doesn't have to be just one, it can be—

LH: C-reactor, of course is the newest one, is the biggest one. The L-reactor was unique in that it was the first reactor that was controlled by a computer. P- and R-reactors were unique in that they used a cooling system that recirculated their water through Par pond and— Have you talked to Kris Gimmy?

MS: I have not. I can't remember—

LH: Kris was the man who developed the computer controlled system for the reactors. And this was the first reactor anywhere controlled by a computer. And he's one that should certainly be—interviewed for this project.

MS: Yeah. High flux was that done in C?

LH: I think so, yes, high flux was in C-reactor.

MS: And then of course P was where they did that neutrino work.

LH: P had the neutrino experiment in it, yes, that's down at -40. But of course I think that's all gone now.

MS: Yeah, I'm sure that's been pulled out. But that work was done at -40 level?

LH: Yeah.

MS: What about— I know we've talked about this already to some degree, but was there any installed equipment that was considered unique to the reactor areas? I know you mentioned already the—

LH: The supplementary safety system was one of course. The control system for the control rods was a servo system that was the most advanced of its time, at the time it was installed. And—

MS: I should know this and I don't, but what is servo?

LH: Well servo system is one in which you demand—you adjust a demand and the system then has the unique capability of adjusting itself to meet that demand. So you say, I want the rods to be at this position and the system will sense that and it will move the rods to that position. You don't actually move the rods yourself.

MS: Oh okay. So you can tell it to move to a certain position. You don't have to actually eyeball it and make sure it goes in that—okay, right. So it's kind of like a—sort of a form of an automated system.

LH: Yes.

MS: Talking about that, though, I should know this and I don't, I know what the actuator system is and all that, but why—what does the word "actuator" actually mean?

LH: Well, the actuator consists of a number of things. It's the system that holds the control rods and the safety rods, comes down and sits on top of the reactor when it's operating. When you go through the discharge, charge procedure, you have to raise it up so that the crane can come in.

MS: But why is it called an actuator?

LH: I don't know.

MS: I don't even know what that word means. Is that because it makes it actual?

LH: Yeah, it was a thing that actuates the reactor, I guess. And the cranes themselves, the C & D cranes, are systems that are unique.

MS: Right. They were designed by American Machine and Foundry?

LH: AMF, yeah.

MS: I'm sure with a lot of input from Du Pont and everything.

LH: Yeah. But they were very important because of the things that could go wrong. You had to be able to grasp a number of different types of things with a C & D machine. And you had to be able to provide cooling through the C & D machines if something got stuck. So—

MS: Was the C & D machine also part of the servo system?

LH: No. That only worked after the servo systems had pulled the actuator up above the crane haunches.

MS: Well I think that covers all the questions I can think to add right now, but if there's anything else you want to add that I haven't thought to ask—

LH: I can't think of anything. I guess the—the effort on the part of the people who were doing the development work—new types of fuel assemblies, new types of control rods and—that work was all done and done very well. The thing that we haven't touched on is that when the mission of the site was meshed in with the navy program and with the accumulation of depleted uranium, the whole method changed from a single-uniform lattice in the reactor to a mixed-lattice complex. The reason for that was that Admiral Rickover's submarines required some ultra pure uranium-235 because their time at sea was limited by how long the reactors would operate, depending on how much pure uranium-235 was there. Well this uranium-235 has a very large value to it in terms of feed and separative work. And when the navy got through with their fuel, there was a lot of 235 still left in there that had a lot of book value of feed and separative work. And the navy would have to eat this as part of their budget, and then we'd have to find something to do with this fuel. At the same time, Oak Ridge had been making the 235 by isotopically separating the 235 from 238, and they had fields full of drums filled with uranium-238. Question was, what to do with that? And the third thing was that we were interested in producing plutonium-238 for use as power sources for the space program.

Well all three of these came together at Savannah River. And we changed the entire concept of the reactor operation to a mixed lattice that would take the enriched uranium from the navy program and put it into half of the fuel positions, take the depleted uranium from the isotope separations operations at Oak Ridge and put it into the other three, and run the reactor, process the depleted uranium to recover plutonium for weapons, process the U-235 and recycle it because now it had a large 236 component in there too, and 236 absorbs the neutron that goes to neptunium. And neptunium is the target you use to make plutonium-238. And the 238 that we built a facility to recover that out at the—in the 200 areas, and make it into fuel pieces for the space program. So you can say that the mission of the plan was focused on plutonium and tritium up to a point, and then it became focused still on plutonium and tritium, but also on the production of neptunium to be converted to plutonium-238 for the space program.

MS: When did all this take place roughly?

LH: In the seventies, sixties, seventies.

MS: What do you think is going to be the future of nuclear industry, let's say in the next hundred years? Totally off target here, but why not?

LH: We'll have to eventually go to nuclear power, I think, to solve our environmental problems, and there's no reason why we can't do that. The only drawbacks to nuclear power at the present time are political, not technical. There's no reason why it can't be done. The rest of the world is doing it, leaving us in the dust, France in particular.

MS: Yeah I've heard they make about 80 percent of their electricity with nuclear—

LH: What I've seen is 85 percent, and we're down in the 20 percent range. People have confused– when we put a number on a plant and say this plant is designed for twenty-five years, they think that at twenty-five years the plant is going to crumble into pieces and go down, but that isn't true, of course. And there's no reason why a well-built production reactor couldn't continue to operate for fifty years or more. The only concern that we had originally was embrittlement of the stainless steel with neutron exposure, and we've shown that that is something that's not going to happen for well over several hundred years. So that's not a problem. With proper maintenance and good operation, there's no reason why a nuclear plant couldn't operate for over a hundred years.

MS: What about the waste material? I know they've got the whole vitrification–.

LH: The high-level waste facility out in the West is perfectly capable of operating. Yucca Mountain is perfectly safe. It's a reasonable solution to that. There were a number of studies done, a large number of studies done, and I was involved in some of them, as to how to get rid of nuclear waste. And Yucca Mountain is perfectly safe.

MS: Yeah I would tend to agree with you there. I think that they've built this facility at a cost of millions if not billions of dollars and it ought to be used.

LH: Well there's— Every time somebody says nuclear, they see a mushroom cloud. And you can drive down the highway and you'll see a flatbed carrying a large spherical steel container with a radioactive sign on the side of it and people pull off to the side, Oh my God, we're going to be killed. And going right down then highway and they pass this gasoline truck, eighty miles an hour, no thought to it.

MS: Yeah well that's true.

LH: I did some risk assessment work. And the chance of being killed— It turned out the risk of being killed by a nuclear incident is about the same as being hit by a meteorite. Now I don't know anybody that's been hit by a meteorite. Now the Russians, of course, were a bunch of damned fools and they designed that RBMK reactor, tried to sell it. We got involved in whether we should use it in our program and I looked at it and said, I wouldn't touch the damned thing with a pole, because it had a positive metal temperature coefficient, it had a positive power coefficient. It was just a bad design all the way around. But the systematics of Russian policy is that once something has been approved, it's been staffed and you don't dare change it. So they went ahead and built it, and staffed it with people that didn't understand what they were doing and they ended up with Chernobyl. And I happened to be on the team for the U.S. that was trying to analyze that particular accident. And from overhead imagery, we were able to assess what had happened before the Russians were. So it was really a screwed up thing. It was a bad design all the way around, terrible design.

MS: Yeah that's why— And things like that give the nuclear industry a bad name overall, yeah.

LH: Well just as an example, such a mundane thing. You've got an emergency cooling basin for the reactor. And where do they put it? They put it right under the reactor. Now if you ever need emergency cooling, it's because you've had some kind of an incident in the reactor and you may have melted something down in the reactor, and hot molten uranium will eat right through a tank. And if it falls into water, you've got a steam explosion like Krakatoa, never saw before. So they put the damned thing right under the reactor where, if they needed it, it would blow up.

MS: Yeah that was—

LH: So they cottoned to that. During the— I remember looking at the imagery and we noticed that four or five days after the incident, they had a number of fire trucks, pumpers, lined up at the reactor, and they had exit nozzles going over into the river, which was a quarter of a mile away. People said, They're pumping water into the building. I said, No they're not because if they were doing that, they'd have the pumpers down by the river pumping that way. They're pumping that damned basin out because they're afraid it's going to melt through the bottom of the reactor and blow the building sky high. And it turns out that's what they were doing.

MS: That's probably kind of symptomatic of problems with the entire Soviet system was pretty much like, Design it badly, don't ever question it and just do it anyway.

LH: Once you do it, you sprinkle holy water on it, and it's gone.

MS: And it's gone and done and you live with the consequences.

LH: That's right.

MS: I think that's probably about—that's what happened.

LH: That's true.

MS: Okay, well thank you very much. I appreciate it. I'll go ahead and turn this off.

LH: Okay.

END OF INTERVIEW

Oral History Interview – Walt Joseph

Walt Joseph was born in Chicago.* After a stint in the Army and after graduate school at Penn State, he was employed by Du Pont at the Savannah River Plant, beginning in 1954. He stayed there until 1993, holding down a number of different positions. In fact, few Du Pont employees ever held as many varied jobs at Savannah River.

One of his first positions was in the Savannah River Laboratory, where he worked for 11 years, doing work on many of the first fuel and target assemblies that went into the reactors. He then transferred into Reactor Technology, where his initial work concerned flow-zoning research. He was then made a Reactor Tech supervisor in C area. In 1975, Joseph transferred to the Equipment Engineering Department. Four years later, he became superintendent of the Traffic and Transportation Department.

His most important position came in the early 1980s, when he was put in charge of the L-Reactor Start-Up program. This was the first time that a major reactor had been brought back to life after years on stand-by status. This work was followed by Quality Control Management, after which Joseph stayed on at the site until the Westinghouse transition was complete. Now retired and living in Aiken, South Carolina, Joseph is active in local citizens groups dedicated nuclear awareness and the preservation of Savannah River Site history.

*Personal information has been removed from the transcription

Interviewee: Walt Joseph

Interviewer: Mark Swanson

Dates of Interview: October 21, 1999 (Session 1) and October 26, 1999 (Session 2)

M. Swanson: This is an interview with Walt Joseph conducted by Mark Swanson, historian, with New South Associates being conducted on the 21st of October, 1999 at Mr. Joseph's house. This interview is being conducted as part of the Savannah River Site History Project, documenting the fifty-year history of the Savannah River Site and its impact on the surrounding area. Starting out, we like to get the age—your age and date of birth.

W. Joseph: Okay, 71.*

MS: And your relationship to Savannah River Site? And we can get into that in more detail if you want.

WJ: Well I'm a longtime employee of the site. I came here in 1954 after I got out of the army and graduate school, and was here until oh boy I have to refresh my memory, 1993 at the site, so almost forty years.

MS: Okay. How did you find out about the Savannah River Site?

WJ: I was in graduate school in Penn State and I—someone—there was a notice posted on the bulletin board that they were hiring. And at the time I was taking mechanical engineering with a minor in nuclear. And I went to my nuclear prof, who had been in the Manhattan District during the war, and asked him about what it would be like down here. And he said, Well—he said, Well Walt do you still have your clearance from the army? And I said, No. And he said, In that case, I can tell you it's near Aiken South Carolina, (laughter) and that was all he told me. (laugh) So I came—we came down at Christmas. Paula was wearing her fur coat because it was cold up in Pennsylvania. We got down here, town was mess. There had been a big explosion—gas explosion, in downtown Aiken. And I went out to the site and I told her to look around and check the place and see what

*Personal information has been removed from the transcription

it was like. And when I— At the site, they put me in one room in Building 703 and people came in and talked to me and went out, and none of them told me what positions they had or what organizations they represented or what they were interested in me for. (laugh) It was all very hush-hush. But despite that, they made an offer and I took it, and as soon as I finished my thesis, why we came down.

MS: Okay. Let's see— Was work at the plant considered attractive to those from outside the Southeast?

WJ: Oh I think so. I think it was a—to me particu—it was very attractive. It was an opportunity to be in on something new. It was a startup, it was a new facility, it was a very exciting kind of work. There were a lot of unknowns, and we were pioneering everyday, so it was very challenging, very exciting, very interesting. And there was also the feeling that you were doing something worthwhile for the country. It was in the national interest, the president had said so, and so we all felt like we were making a contribution to the country and having—working hard but doing good stuff along with it, so yes, it was, I think very attractive. We got a— Du Pont tried to hire the cream of the crop and they pretty much succeeded. They got the people they wanted to be down here.

MS: Right. When you first moved to the area, were you directed to live in any particular place or encouraged to live in—

WJ: (laughing)

MS: —whether it's Aiken or North Augusta or—

WJ: No, it was pretty straight forward. The day— The day we arrived I took a—took the shuttle out to the site and got there and checked in. And they said, Well the first thing is to send you to the housing office, thought, good. So I went to the housing office and I walked in and I said, I just arrived today, starting work today, and I need a house to rent. And the lady said, You're in luck, we have one. And I said, One? (laugh) She said, Yes, do you want it? And I said, Sure. (laugh) If there's only one, what choice do I have? And there was literally only one house in Aiken, Augusta and

Barnwell, anywhere else that was available for rent on that day. And so we moved into Crosland Park, on that basis. I called Paula and told her we had a house and I didn't know where but we'd go look for it that night. Yes. (unintelligible).

MS: How would you characterize local opinion about your arrival and local attitudes towards employees from other areas?

WJ: As far as the employees were concerned, we were all in this boat together. And it was—it was very much a—a sort of family feel. All of— Crosland Park, for example, was one hundred percent Du Pont. I mean everybody living there was working out at the site. And so we carpooled together and we all knew each other and we knew we couldn't talk shop, but we were all away from home, many of them for the first time, many people for the first time. And so it was pretty close knit. Now, we didn't have much interaction with a lot of the original Aikenites. And some of them resented having this mob of flat land touristers (laugh) come into their very comfortable, closed society and disrupt everything. And so initially, I think, there was some ill feeling about that or some resentment. It never surfaced with me. I got along fine with everybody, but I heard from others that there were things like that. But I think gradually as they got used to us and as they discovered that the people from Savannah River were making real contributions to the community, that went away.

MS: Right. Had you ever worked on any previous Manhattan or Atomic Energy Commission project?

WJ: No. I was— I graduated from college, went into the army for two years during the Korean conflict, came out, went to graduate school at Penn State. And at the time, I was planning to get my Ph.D., but just—I just ran out of gas emotionally. (laugh) I was older than most of the other people there because I'd been in the service for a couple of years, and I was married and we weren't making any money. Paula was making more money stuffing football tickets in envelopes in the athletic department than I was making in the Department of Engineering Research working forty-four hours a week and trying to carry two courses and do a thesis. (laugh) So when I finished the thesis, I was halfway through the coursework for the Ph.D. and said, Well let's just take a sabbatical, take a couple of years off and get—make some money and it'll look good on the resume anyhow.

MS: Right, right yeah.

WJ: So that's what we did. And every year we talked about it, Well is this the year we quit and go back? Every year, Well this job's really interesting and I'm working on this fun project right now. Let's see how we're doing in six months or a year from now. (laugh)

MS: Right, that'll work.

WJ: Yeah and it never happened, we stayed.

MS: Yeah. Did you have any association with Du Pont before coming here?

WJ: No. No. No associations at all.

MS: Had you had any previous experience working at an industrial plant?

WJ: I'd worked summers, of course, and I worked— I was a full-time employee on the staff at the university but no, other than my summer work, I had no other industrial experience.

MS: Right, right. The next series of questions deal with construction—the construction era, and are normally for Construction employees, although some of them are kind of fun to get into so I think I'll throw these out. By the time you got here, I guess, the largest bulk of the construction was already done, although there was construction that went on—

WJ: It was— That's right. I was here before C-Reactor went up and we did some—we did some work in C-Reactor with the Construction people. That was one of my first assignments. We put strain gauges on the thermal shield of the reactor, not knowing in our naïve lack of experience that the radiation would pop them right off, (laugh) but we run into a lot of those kinds of things.

MS: Right. Were there many transient construction employees or were most of them residents of the surrounding areas?

WJ: Most of them were transient. There were journeymen, in that the skilled people came in for this particular job. There were enormous trailer villages all around the area where most of them lived.

MS: What were food supplies like? Were there ever any shortages?

WJ: No. No, not that we were aware of. There were some adjustments made in terms of what people ate here versus what we had been used to being able to get in Pennsylvania. (laugh)

MS: What were some of the differences?

WJ: But— Oh I think some of the things like the sausages and bolognas and cheeses and a lot of the things that had been made locally up there were not available here. But other than some minor differences like that (unintelligible), we didn't have any problem.

MS: What was traffic like during those early days?

WJ: Traffic was fearsome. We all carpooled, and that was almost a requirement. I mean, they made it very plain to all the new employees you were expected to carpool, and—because they had to cut down on the traffic as best they could and it was awful. It was bumper to bumper, generally moving at pretty high speeds. There were frequent fender benders. When we first came down, there was essentially open range in this area and periodically a pig would walk out into traffic, and it would wind up totaling half a dozen cars. (laughter) (unintelligible) the ensuing rear enders. I remember a couple of those kinds of accidents up near New Ellenton. But traffic was bad. (laugh)

MS: Did Du Pont do anything to actively arrange carpools, or was that pretty much left to your own initiative?

WJ: There were bulletin boards and the newspaper would carry ads and the plant paper, and things like that, but there was also a pretty good network. I mean, somebody new came in, you'd report it in and you started talking around the neighborhood. And they found— You were— I was able to find a carpool within a few days, and I think that was pretty typical.

MS: Did you stay in the same carpools for a long time or—

WJ: Yeah, people came and went. Some people were down on relatively short assignments, some of the Construction folks. Construction engineers were down for a relatively short time and they'd go back to Wilmington after a year or two. Other people were transferred out, new people were transferred in and so it— And people would go out to areas, be transferred from one area to the other, which meant you had to find another carpool. So they were influx, but I guess we—I stayed in the same carpool all the time we were in Crosland Park, and then got in another one for the next location, pretty much stayed in it.

MS: What about— Were there any campaigns to provide vaccinations to children during the early days, or was there enough of a population crush to require that?

WJ: I wasn't aware that there were— I'm not aware of any— I don't remember any such campaigns. Paula might be a better source of that one than I am, but I don't remember that that was—

MS: Right. When you moved down here, did you consider it a temporary move or was this going to be a permanent home?

WJ: We considered it temporary because we thought we were going back to Penn State to finish the Ph.D., and we considered it very temporary.

MS: Right. Were construction workers treated differently by local residents than the incoming operations staff?

WJ: I'm not aware of any difference in the treatment, although it—there might have been some. The construction workers generally were less settled. They tended to be (telephone ringing) oh—

MS: Construction occurred when the South was still segregated. How did this affect construction, or what was segregation like in the early days at Savannah River Plant?

WJ: Well the workforce was very dominantly white male. There were a few exceptions. Du Pont brought in some technical people who were not Caucasian and of course they fit in fine. But the crafts, the construction crafts, the unions, were basically segregated. And there were some groups that were black. The railroad crews that laid the rails and maintained the tracks and that sort of thing were black basically. Some of the other groups were black but by and large it was a white male society. And it really wasn't until, oh I would guess the seventies that we started getting a large influx of females into the workforce. And there were some— That was some interesting times when that happened. (laughter)

MS: What did Du Pont or the Atomic Energy Commission or any of the other subcontractors do to alleviate some of the problems they had during the construction era?

WJ: Du Pont was very family oriented, of course. And one of the problems was the problem of all the people being strangers in a new community. And— But they organized the—with the Operations Recreation Association, the ORA, which is still there, organized very frequent dances and get-togethers, parties. There were a lot of activity—many more activities going on than there are now and sponsored by that organization, just because there were so many people who didn't know anybody and were (laugh) in a strange situation. So they worked hard to keep morale up through that kind of thing. It involved the families. Because that was the only way they could do it. There was— You couldn't tell your spouse anything about what we did, and that made for some tensions at home when the wives just saw husbands go off and didn't know what they did.

MS: But it's okay as long as they bought the paycheck back. (laugh)

WJ: Well yeah— Yes but one of the— One of—things that happened to us when Joe was very little, we used to take him up to my parents in Greensboro, North Carolina, for a week every summer. And when they had him, they always liked to show him off, so they'd have people in to talk to Joe and all that. And he was a twerp, probably a couple years old. We came (laugh) up to get him that weekend and my mother was really upset. She said, You need to talk to your son about what you do. And I said, Why is that? And she said, Well they had this party and one of the people came and was talking to Joe and said, What does your father do? And he thought about it for a while and he said, I guess he's a barber. And my mother was pretty annoyed by that. But we figured out that what it was, was that— Of course we didn't talk at all about what I did at home, but when I needed a haircut, I'd have the carpool drop me off at a barbershop, which was on the way home. And on those days, Paula and Joe would come out and pick me up at the barbershop. So the only place he had seen me other than at home was the barbershop. (laughter)

MS: That'll work.

WJ: Yeah, it sort of worked fine. That was the same place, by the way, where I heard for the first time why they had built the Savannah River Plant here. And the barber confided to me that he knew why the plant was here. He said, I understand it's on the site of the world's largest tritium mine. (laughter) And I said, Hmm, okay.

MS: That might work too. Was there anything good or bad that particularly impressed you about that construction effort?

WJ: The thing that impressed me was the—I guess the focus of it. It was— That was a very intense time. I mean, the people who were doing it were working long hours, often under very difficult conditions and man there was just no deviating. They were going to get that sucker built. (laugh) So it was a very hammer-and-tongs full blast and the torpedoes full speed ahead kind of effort.

MS: Right. Were you ever involved in any design work?

WJ: Yes. Yeah, we did— My first job at the—well after I put strain gauges on C-Reactor, I came down as a heat transfer expert and they put me to work on reactor fuel assemblies, doing heat transfer and hydraulics. And that was a time when we were— The reactors originally were made with solid slugs of fuel, canned in short lengths and stacked up in columns, and they worked. And they were capable with the technology that we had when we started. But everybody knew they weren't very efficient in terms of wasting water. And we all knew that you could get more power out of the reactors if we could come up with a greater surface area, greater surface area: volume ratio on the fuel assemblies. And so my first job was to work on a design which was called the Mark III, an ill-fated design with a—long plates of uranium clad in aluminum, thin—five thin plates put into a tube with little D-membranes on the sides to contain it, on two sides to contain it. And it was a great design, in theory, and it was a stinker to build, (laugh) and it was—which is why it never went into mass production. But it was one of our first efforts to get more surface area, and then subsequently we came up with techniques for making tubes—large tubes with— Again, it was a matter of the metallurgy and being able to develop the techniques to do it. And once we came up with tubular designs, they took over. (laugh)

MS: Right, right. When did they start using the tubes? Is that pretty much right after Mark 3?

WJ: Yeah, that was—that would have been— Again, I don't remember the dates, but it would have been in the late fifties. But the thing that was really amazing was that from the moment the reactors were designed, people were working on designs for better—for improvements. And in the early days, I was in the lab—the Savannah River Laboratory in the Pile Engineering Division, that's where I started. And in the early days, our job almost exclusively was to design ways of raising reactor power. And we started out with fuel assemblies, and it became obvious that we could design— we could design fuel assemblies that would permit power increases. And then one of the next questions was, Well okay if we raise power, what will happen to the reactor tank itself? Are there structural things that will not be able to handle the increased differential thermal expansion? Will we break the tanks if we do this? And at that point, they converted me to a stress analyst, which was kind of neat since I knew nothing about stress analysis when I started. But they converted me to a stress analyst and we worked on reactor stresses for a number of years. And in doing that, we discovered that irradiation did some peculiar things to structural materials that we had not expected. The Russians had done some work on radiation effects on uranium that we were aware of and we translated a few of those papers. But nobody had done any work on structural materials at that point. And we discovered that our concerns about stress in the reactor vessel were pretty unfounded because the irradiation essentially relieved the stress in the structures. The structures got stronger, they got a little less ductile, but they also tended to relax all of the stresses that were in them, which was pretty neat. And—

MS: Why was that?

WJ: Well it's because the— You think of it as simplistically, if you have bar of steel and you pull on it, you stretch it and it's under stress. And if you heat it up, it'll take the—it'll take a permanent set and the stress will go away. You'll relieve the stress. And this, instead of heating it, what we were doing was we were bombarding the structure with particles that rearranged the structure and relieved, just as you would if you changed the molecular structure by heat. So that was an unknown phenomenon. We discovered it basically here and I did a lot of the early pioneering work on radiation effects on structural materials. We'd studied stainless steel and aluminum and zircaloy.

MS: Talking about stress and all that kind of stuff, was there ever any problem with corrosion?

WJ: There were lots of corrosion problems, particularly with the— Well there was stress corrosion cracking of the stainless steel, which turned out to be a—not a major problem, but it was a continuing problem within the life of the cycle. You had to be very careful not to get chlorides in there. And then there were problems with hydrogen embrittlement of the fuel assemblies, which made them more susceptible to rupture, and there were a lot of metallurgical problems that were unanticipated—nobody had ever run into them before—that we discovered and had to figure out ways to solve. It was pretty neat. One of our— One of the early problems we discovered was that we were making our uranium too pure—that the purer uranium would tend to swell in the radiation field as these—as the fission products built in, it would swell up and eventually it would swell to the place where it would stretch the can and break it. And then it would expose the hot uranium to the water and you'd get all kinds of corrosion and oxide and bad stuff. But— And then it would really swell up. But what we discovered was that if we'd mixed in a little iron and silica—(laugh), a little dirt and sand, (laugh) basically into the alloy, it made it stronger, and it would resist swelling. (laugh)

MS: And all this was like—just like hit and miss, I mean, just sort of try different things and see what will work?

WJ: Yeah, well don't like to say hit and miss.

MS: (unintelligible) but—

WJ: But it was, Hey we have a problem, what can we find to solve it? It was— In a lot of ways, it was research, because nobody had found the problem before, but it was research on a very rigorous timetable. I mean, this wasn't something you could just study ad infinitum. The intent was that, Hey we want you to work on this fuel swelling problem Walt. And the expectation was that there would be an answer very soon. (laugh) So— Pardon me a second.

MS: Did superiors solicit contributions or suggestions from employees?

WJ: Oh yes. One of the things that was really fun about working here was that it was so much work, so many things that we didn't know that almost— that—you could—you were free to try almost anything, as long as it wasn't dangerous or disruptive or horrendously expensive. And it was a lot of responsibility and authority. I mean, if you had a job, you were responsible for the job and the boss expected you to go come up with a solution. And as long as you were going hammer-and-tongs toward that solution, they left you alone. There were people you could ask questions, but again, some— we were all so new and the problems were so new that there weren't a lot of folks you could ask questions. When I got into the radiation effects business, there were only three other people in this hemisphere who were (laugh) working on it at all. And my boss had no idea where we were going with it. And I didn't either, but we knew it was important to the design—to the operation of the reactors, and so we went. (laugh)

MS: Right. How were relations between labor and management?

WJ: Oh good. I— DuPont made a practice of avoiding unions. And they came in with a heritage of doing the things that they needed to maintain a contented workforce. They did— They were also a pretty basically people-oriented organization anyway. And there were several unionizing attempts, generally starting with the crafts, where you would expect them, but none of them were ever successful. They could never get enough people to sign up to force an election.

MS: How many was required to do that, just out of curiosity?

WJ: I'm trying to remember. You had to have a percentage of a particular workgroup, and I think it was like 30 or 40 percent had to sign a paper saying that they were interested before—

MS: In order to have an election.

WJ: Yeah. And that—that number may be way off, but it's very rigorously controlled by the National Labor Relations Board. And they had several union organizing campaigns, but they never amounted to anything, and mainly because there was good communication and everybody understood the policies. You didn't maybe always agree with them, but you knew that they were pretty fair and consistent. And DuPont, I say, there was good communication.

MS: How often, if at all, did you see foremen and engineers using models instead of blueprints?

WJ: In the lab, we (laugh) used to—we used anything we could get our hands on. I can remember trying to solve a vibration problem with an electric fan and a—and some pieces of cardboard and rubber bands. (laughter) But—

MS: Sounds like a model plane to me.

WJ: Yeah. Well it was. And we were— We didn't work with a lot of prints in the laboratory. There were models being built of larger pieces of equipment, but most of what we worked with were sketches and drawings in our notebooks and that kind of thing. And occasionally when you wanted to send something off to have a big piece of equipment built, you'd have the drafting group make up a drawing of it. But we didn't— We didn't work a lot— There were a lot of models around of the big equipment, but—and they were used, but—

MS: But it's mostly with the bigger stuff?

WJ: Mostly with the bigger stuff, yeah.

MS: You would have more of a problem conceptualizing (unintelligible) all put together.

WJ: Yeah, it's really great for things like piping, where you're trying to figure out, well we have to get 800 pipes through this space, now which way or how are they going to fit? (laugh)

MS: Right. Yeah. Yeah, that'd be pretty tough. Did you work with Construction at any time after the initial period?

WJ: I worked very closely with them in L-Area, of course, that was in 1980, 1983. And we had, oh about 800+ construction people on that project. And I worked very closely with them on that. It was— That was a very interesting job and a very challenging job. And again, it was very, very focused. I mean, our job was to take a reactor that had been shut down for twelve years. And people had essentially walked away from it. It was (unintelligible) standby, but in point of fact, it hadn't been maintained, equipment had—was just sitting there rusting. And we walked into the area and we had three years to get it up and running. That was our— That was our mission. And it was a very challenging job, and I worked closely with Construction. I was the project—(unintelligible) call it the L-Startup Project Team. I was the superintendent of it. And I had a counterpart who had the construction function in the area and then I had a counterpart who had the design function in Wilmington. And it was a really interesting job.

MS: I imagine so. How was Construction different tin the early eighties when you did that project versus the earlier years, or were there any major differences?

WJ: I don't think there were major differences. Du Pont Construction is a—Du Pont Engineering Department has always been an entity onto itself. I don't know if anybody explained it to you, but Du Pont made its money—made its big money—when it was converting from explosives to other products by having some very creative people invent things like Nylon or Dacron or whatever and then being able to get them to market very quickly. And to do that, they had their own engineering department, which did all the design for their industrial plants and was called on to do much of the design for Savannah River. And they had all their in-house design experts on everything from soils to steel fabrication, and the whole bit. And then they had their own construction force that built it, and they built nothing but DuPont plants. Now at startup, that construction force was augmented by a lot of subcontractors because it was way too big for the Du Pont construction force. So the initial construction was managed by Du Ponters but included a lot of subcontract organizations. By the eighties, the construction force was all Du Pont, basically, and the subcontractors were people who had been working for Du Pont for years and years, most of them.

MS: Right. The next series of questions deal with plant employees that are sort of general in nature. Just for the record, if you would restate when you first started working at Savannah River Plant.

WJ: Oh yeah. I started working at Savannah River in, I believe it was, August of 1954. Yeah.

MS: And why did you want to work there, and were there any reasons for not wanting to work there?

WJ: Oh, I was excited at the prospect, and nuclear energy was new. It wasn't—There was not much known about it. It wasn't being taught in the universities. I got the first minor in nuclear engineering that Penn State ever offered because they didn't—they didn't have a nuclear engineering department.

They had one course taught by one professor, but I convinced the—my advisor that that course plus two courses in the physics department constituted a minor in nuclear engineering. (laughter) So it was new and it was exciting, it looked very interesting, and the opportunity to be involved in a startup of a major facility, that played into it. There was again, the feeling that it was in the national interest, I was—that pleased me. And then there was also the fact I was— I had lived in North Carolina while I was in undergraduate school there, and was looking forward to getting back to a warmer climate and getting back to the South. So there were a lot of reasons why it looked good. The reasons that it looked—the negatives on it were largely associated with Paula, who had not been that far from home before, and I uprooted her from her—and she had a very close-knit family—and uprooted her from that and moved down to a strange and exotic place. And the early—some of the early impressions were not good for her. I— Well, when we came down for the interview visit, she was, as I had suggested going around looking for what kind of place would this would be to live, and she went to the Chamber of Commerce, which at that time was housed in a little log cabin on Union (laugh) Street, and went in and asked about— She said she was—they were thinking about moving down here and wanted to know about housing and that sort of thing. And they said— The lady in the log cabin said, Oh, you want to live in Aiken. We're fourteen miles from the plant and if it blows up, you'll be safe here. Now that was the Chamber of Commerce. (laughter) Paula was not wildly enthusiastic when I signed up for the job, and then she came down and got jaundice almost immediately after coming down, and was sick for quite awhile. And when we arrived it was 107 degrees, the place was in a major heat wave. So there were some—

MS: And I guess there wasn't a lot of air conditioning.

WJ: Oh no, we had no air conditioning. No air conditioned cars, no air conditioned houses. It was probably three years before we bought our first window air conditioner. (laugh)

MS: Yeah it's like— How much did you know about Savannah River Plant, what it produced, when you first started working here?

WJ: Very, very little. Very little. We— As I say, they told me nothing on the interview process, and my thesis advisor who had, or my nuclear engineering prof, who had been in the Manhattan District worked at Oak Ridge, wouldn't tell me anything because I didn't have an active clearance. And so I really knew almost nothing about it until I came here. And even when we were—when we first came, the work was very compartmentalized and we learned what we needed to do our jobs, but— And my initial—almost all of my career was spent supporting reactors. So I didn't have much opportunity to find out what was going on in the Separations area or anyplace else, and matter of fact, was discouraged from learning anything. Probably the best piece of information that ever came out in those early (laugh) years was a Reader's Digest article, which appeared a couple of years after I started work here, which told me more about the site than I had ever known. (laugh)

MS: Wow. So you didn't really know, for example, I mean, what was being made, or you must have known that, but you didn't know exactly how it all—

WJ: We knew the job was to make plutonium and tritium, and that those were somehow used in weapons. We had no information on weapon design, and I didn't have any indeed until I got into a job that required me to work with the weapons designers much later. In the early days, we knew we were making fuel assemblies of particular alloy concentrations and that kinds of thing, and we knew there were target assemblies in there that would make other stuff, but we had no handle on where it was used or how it was separated or any of that. It was pretty highly compartmentalized.

MS: Okay. Was the mission of the plant a reason to want to work there or not to want to work there?

WJ: I thought it was a reason to want to work there. I think most of us felt good about something—about working on something that was in the national interest. So I think it was a reason to work there.

MS: Okay. What was your very first job assignment?

WJ: Very first job assignment was the heat transfer—reactor heat transfer and hydraulics. They— I had taken an number of heat transfer courses at Penn State, and that's what they hired me for, and I went straight into Pile Engineering to do heat reactor transfer and hydraulics. And as I say, my first job was the Mark III plate assembly. It was an ill-fated design but an interesting concept and it was our first effort to get an extended surface element for the reactor so we could raise power.

MS: Right, right. What about other positions that you had at Savannah River Plant?

WJ: Oh, I had a wonderful career in terms of versatility. I started in the laboratory doing the science, (laugh) well applied science, research and development work. I went, oh— I was in the lab for eleven years, and I got progressively more specialized until at the end I was an ex—

END TAPE 1 OF 3, SIDE 1
BEGIN TAPE 1 OF 3, SIDE 2

MS: —different positions.

WJ: Oh okay. Yeah after—after eleven years in the lab, I was getting so highly specialized that I decided that I liked people better than I liked things. And so I asked for a transfer, which was regarded by my lab colleagues as some sort of insanity. (laughter) But I asked for and got a transfer to Reactor Technology, where they put me to work doing reactor flow zoning. I was the official flow zoner for a couple of years, and that is designing the orifice plates that control the heavy water flow to the reactor as individual assemblies so that you can optimize the—so that you can match the flow to the power level and not waste water. And that was a very interesting job, and I did that for a couple of years, and then worked my way through a variety of jobs with, oh safety systems. We did some of the early work on analysis of multiple alarms, how do you—how does the operator know which alarm to respond to if four alarms come in simultaneously, and that sort of thing. And then they sent me out to be a supervisor in the 105-C, in the Reactor Building, and I supervised the technical group out there, still in Reactor Tech. And from there, I went to Equipment Engineering Department in 1975, where I spent four years as the supervisor of their Mechanical and Metallurgical Section, and that was fun because we did development work all over the site. And that was my first introduction to the Weapons

Complex because we did a lot of work for the tritium facility and worked with the weapons designers on what kind of things could be fabricated and handled in an actual production facility. Then in '79 (laugh) John Gronigan called me in—the plant manager called me in and said, Walt, we're going to promote you to be superintendent of Traffic and Transportation Department. And I told John then, I said, John you could have looked long and hard before you found a job I know less about than that one. (laughter) But it turned out to be a really interesting assignment because it was all the—every—all the riggers, the railroads, the people who mowed the lawn, the truck drivers, the maintenance guys who maintained the vehicles and the heavy equipment, crane operators, a very diverse group, eight hundred people, and got me all over the site. In that job I was inside boilers and on top of coal silos and out in the swamp breaking down Beaver dams. The railroad guys taught me to run the switch engines at night when there was nobody around, (laughter) and it was a great job. And from there I went to the L-Startup Project. I can remember that one vividly. I was working— I had been sent to a training class in Wilmington. I was up there— They called me out of class to say that I had a phone call and it was my boss, Mack McGuire, who was a neat guy, a guy I could have a little fun with. And he called. He was on the phone. He said, Walt, he said, I've got a piece of paper here that says they're forming something called the L-Startup Project Team and you're the superintendent. He said, Should I sign it? I figured, Well this is my chance to have a little fun. I said, Mack, what would you say if I told you I didn't want that job? There was a long pause and he came back. He said, Walt, can you find another job while you're up there in Wilmington? (laughter) I said, Just kidding Mack. I'm ready to go. So that was an interesting assignment for three years, had a lot of fun with that. And then I went—from there I went back to Equipment Engineering, as—this time as superintendent of the department and I had—so I had the electrical and the computer part of the development organization as well. Then when they set up a—when DuPont decided they were going to get serious about quality and try to put in some quality assurance programs, they tapped me to start that up and I did. That was in '85. And I stayed with that and they added to it the continuous improvement, or what they called the Commitment to Excellence Program, which would be what we'd now call Total Quality Management. And when DuPont left in '89, I—they asked me to stay on and continue that function for them. So I stayed with them until August of '93 (unintelligible) made an offer I couldn't refuse. So I had a pretty varied career that got me all over the site doing a lot of interesting things. And after the first eleven years, I didn't stay on any job more than four years. (laugh)

MS: Well I imagine you did get to see a lot of the site then, moving around a lot.

WJ: Yes I did.

MS: I was going to ask these later, but I think I'll just go ahead and ask them now, something more specific about certain aspects of those jobs. What was the— When you were doing Traffic and Transportation at the site, how had that changed over time?

WJ: Oh that was a very interesting job. When I— When I got there, Traffic and Transportation was sort of low man on the totem pole, in terms of the pecking order of the site. It had been run— Traditionally it was an up-through-the-ranks organization, all of the managers and the superintendent, the superintendent that I replaced, had started out as mechanics or riggers or something else and had worked their way up to good positions, very tough, very hard nosed, very austere organization. If you walked into a T&T lunchroom, the refrigerator was a mass of rust. If you asked them where they got it, they said, Well, maintenance bought a new one and they let us have their old one. And the same thing was true of the equipment. I mean, everything they ran looked crummy. And my first job with T&T was to convince them that they deserve better than somebody else's handoffs, and to give them some pride in the organization, to help build some pride in the organization. And to that end, Oh we did a lot of things, but one of the—typical example was they would overhaul major pieces of equipment, a bulldozer for example, or a heavy truck tractor. And it would cost like $150,000 to rebuild the engine and the transmission on a thing like that, and then they'd send it back to the field and it would still be rusty and beat up and banged and crummy looking. And so (laughter) after I'd been at T&T for about a couple of months, I went down to the automotive shop and I got my manager down there and I said, Okay, from now on we have a new rule. I said, Every piece of equipment that gets a major overhaul is going to be painted, so that when it goes out of here, it looks like we spent

$150,000 on it as well as runs like it. And he said, Oh we can't do that Walt. I said, Oh yeah you can. I've been out here and I know you have a maintenance shop and I've seen your paint shop and I know it isn't being used, but I've talked to the guy who used to do some painting down there and he says he doesn't have much to do and so we're going to paint stuff. Well okay. And I kept checking on him and pieces kept going out rusty. Finally one day I'd reached my end point. I went in and I said, Max, you have a—it was a Henderson truck tractor, which had just gotten a major overhaul, just back. And it was a mess, (laugh) I mean it really looked bad. But inside it was all new. I said, You're going to paint that truck tractor before it goes out of here or you're not going to ship it out. He says, Well we need it Walt, because it was what used to haul casks around the site. I said, I don't care. I said, Don't tell me about needing it. I told you before you're going to paint it. Now it's not going out of this shop until it's painted, you hear me? Okay Walt. I went back to the office and about (laugh) fifteen minutes later, I got a phone call and there's this lethal voice on the end. He said, Hey Walt, about—about that truck tractor. He said, I'm sorry but we have looked around everywhere and we can't find any gray paint. He said, The only paint we have is some baby blue. And I said, Hey that's great Max, paint it baby blue. And I hung up the phone. (laughter) And that truck tractor came out baby blue, and the driver loved it. He personally took it back in so that they could paint his wheel rims white, and then he wanted a picture and we got the plant photographer to come out and take a picture of him with his truck tractor. He said, I've never taken a picture home to my wife, but this really looks good and I want to take it home. And it was lots of little things like that, just helping the group build an identity and develop a sense that they could—that they deserved—that they were good and they deserved good things to happen to them.

MS: Right, right, yeah. That's kind of interesting because you don't really hear too much about Traffic and Transportation.

WJ: Oh no. They— That's it, they were very—very low key organization. When you wanted riggers, why they'd come out and do rigging and then they'd go back. And when you wanted—when you wanted something hauled, you'd call T&T and they'd haul it. But nobody paid a lot of attention to them. They were a service group, and as I say they (unintelligible).

MS: Where were they based at?

WJ: They were out in B-Area. And— Part of it was in Central Shops, part of it was in lower 700 actually. But— And people treated them badly. We had an incident in the 400 area shortly after I got into T&T where the production supervisor needed some work done on a leaking flange in the H2S system. H2S is highly toxic gas. And told the T&T foreman to get it done, that it was holding up production, there were urgent needs. And they took a couple of short cuts in doing it. The procedure was very specific on how they were to do that job, and it was to be monitored and they were—they had to have a backup guy standing by dressed out and ready to go in, in case of accidents and all that. And they took a couple of shortcuts. The backup guy was there, but he wasn't on the scaffold with the worker and—because they were rushing to get it done. And the worker inadvertently got a snootful and was knocked cold, and had to be dragged off and given mouth-to-mouth resuscitation, which all of those guys were trained to do. And I met the ambulance when it came in. I got a phone call and I met the ambulance when it came in. The foreman was in tears. He said, Walt, he said, You don't know how it is out there, because he had been told to do something that he knew was a shortcut, and he did it because it was a customer. And of course I— The guy came—recovered fine, and no harm was done, but it really upset me so I put together a training class for all my foremen. And I brought them up front in groups of about fifteen or twenty at a time. And I spent a whole day with them. And I gave them a solid dose of Walter's philosophy. And we had a nice lunch in the cafeteria, I treated them like real folks. And I told them— I talked to them about all kinds of aspects of leadership. But the one that I wound up with was—I said, Now if you think your first responsibility is to your customer, go ask him for a raise. I said, Your first responsibility is to your people in T&T department. You take care of them and then we'll take care of the customer. And the guys, when they went back to their areas were—some of them were hell on wheels. They got their supervisors all riled up. And my—I can remember one of my chief supervisors telling me, he said, Walt, I'd wish you'd quit doing those training sessions with the foremen. When they come back, they're impossible to live with. I told him, I said, Hey if you'd listened to me and did what I told you to do to begin with, you'd get along fine with them.

(laughter) So that was a very interesting assignment.

MS: Yeah, that sound like it was, yeah. Going to the—talking about the L-Reactor startup, which was in the early eighties—

WJ: Yes—

MS: —what was the differences or what were the differences between the L-Reactor, let's say in the early eighties, versus the way it was before it was shut down, in other words, when it was in operation in the fifties and sixties? Were there any significant differences?

WJ: Yeah, huge. The thing that happened with L, it was placed on standby, which meant that you couldn't steal parts from it. You couldn't route parts for the other—for the operating reactors, unlike R, which was cannibalized. L was supposedly on standby. But there was no maintenance, zero, and there was no attempt made to upgrade the reactor as improvements were put into the other areas. And so in eleven years of continuous improvement in the operating areas, when we—when we came into L, first a lot of the equipment was rusted up and disabled totally. And second, we had eleven years worth of modifications to put in, into the area. And some of that was pretty straightforward. We had to put in things like the M2 containment console, which is the big console which is a—it's hardwired logic, which took specific actions in the event of a major-loss-of-coolant accident. You have a major leak and the M2 console kicks in. The operator doesn't have to do anything, except watch the lights. (laugh) And it was a— That was a major thing, which I—

MS: And the name of that is again—

WJ: M2 containment console. And it had been put in while L was on standby, it had been put in the operating areas. And it had been built by an outside vendor, the three operating ones had been built by an outside vendor. And when we got there, that vendor was out of business and a lot of the components were no longer available easily. And so we had to— It was—actually wound up being built on the site with components that the guys pulled out of used parts—out of parts bins, not used, but out of parts bins and stuff like that. And— But that was an (unintelligible). Another example (laugh) was the diesel engines. There are two big thousand-kilowatt electrical diesel generators in each reactor building. And these diesels hadn't been run, hadn't been turned over for eleven years. And so the bearings were bad, they were shot. They were unusable. And we had to find somebody who would overhaul them. The diesels originally were made for use in World War II submarines. (laugh)

MS: They're kind of old, yeah.

WJ: And nobody made parts for them. We finally found an outfit that overhauled Mississippi River tugboats that came in. And the guy looked at them and he said— He said, I tell you what. He said, Let me give you two new diesels and I'll take these. (laughter) He said, These are better diesels than they make today.

MS: Wow.

WJ: And I— And we told him, we said, Hey we can't do that, got to have them standardized with all the areas, so we really want these overhauled. But they actually came in and had to build parts for a lot of them, but they overhauled the diesels. One of the real tough ones was the charge and discharge machines. The C&D machines, which take irradiated fuel from the reactor out to the discharge and exit canal, where it goes under water and into the basin, and then brings—that's the discharge machine—while the charge machine is bringing fresh fuel from the presentation point and charging it into the reactor. So these two machines work in tandem. They're very, very sensitive machines, have to be extremely accurate in positioning. And all kinds of modifications had been made while L was in standby. Unfortunately, the modifications made had been made in probably a dozen individual projects. One project would do this and let's change the cooling water system. Another project would change the grippers, another project would do—and so on. And unfortunately, there were no as-built drawings of the machines in the operating areas, which meant that we had to—we couldn't just upgrade what we needed and go directly to the end point. What we had to do was had to install each individual project just as it was in the operating area in chronological order, because what we put in on Project A might be removed on Project G. (laugh)

MS: Yeah that'd be pretty good (unintelligible).

WJ: It was a very challenging job and—but of course when we finished we had as-built drawings of the C&D machines first time. But those were typical of— I guess the one that was really— The other one—big job that's worth noting is the heat exchangers. The heat exchangers are railroad car-sized stainless steel thing, very, very tight tolerances. And they were all sitting there in L because they had not been cannibalized. But what had been happening was that as a heat exchanger developed leaks or problems in one area, they'd take it over and just swap it out. So L had its twelve heat exchangers all right—

MS: But they weren't good ones.

WJ: —but most of them were gone. And so we— The decision was made that we had to buy new heat exchangers. And of course we wanted them—they cost a million dollars apiece, all stainless steel, very high tolerance, very careful assembly and we wanted them built in this country if we could. We could not find a vendor in the U.S. who would build them. What we wound up doing was we bought the heat exchanger tubing in the U.S. and shipped it to Japan, where two vendors collaborated. One of them built the shell and the other one built—shells—the other one built the head and assembled them. And then they shipped them back—the final heat exchangers back to us. And they worked great. I mean their quality assurances jam up and everything worked fine. But it was— It grieved me that we could not—that we were no longer capable of building that kind of equipment in this country.

MS: Was it because they—you couldn't find somebody that could physically do it or you just couldn't find somebody who was willing to do it?

WJ: We couldn't find anybody who could physically do it. The people who had been able to do that in the fifties were no longer able to do it, which is an interesting commentary on the state of American manufacturing.

MS: Yeah, that's true. That's true. What about— You mentioned that you worked at—or with quality assurance, that program. What exactly is that?

WJ: Well, okay. Du Pont had its own engineering department, which did design and construction. And as part of that, Du Pont had its own set of specifications. Du Pont's specifications controlled how everything in the company was designed and built. They had specs on steel for buildings and they had specs on piping, they had specs on pain, everything else that was built— Everything Du Pont built was built according to what—a standard set of specifications. And they were pretty tough. They were very good. As the— And of course when the plant was built, the plant was built to Du Pont's specs basically, except in areas where things were so unusual that there were no specs and then they invented their own. But most of it was built to Du Pont's specs. The— And of course at that time there was no nuclear industry. What nuclear there was, was all on AEC sites, and it was all committed to weapons production. That changed, of course, when the nuclear industry grew up and you started having commercial power plants. And they were—because of environmental concerns, because many of them were close to inhabited areas and so on, they developed specs for themselves, which originally were based from Du Pont, because they came down and—Rickover came down when they built Shippingport and studied our specifications and talked to us about how we did things. But as the industry grew up, it developed its own set of requirements and regulations. And of course the Nuclear Regulatory Commission was set up as a separate agency to evaluate the performance, and particularly the safety, of commercial nuclear reactors. And the NRC kept developing more and more specific requirements. Every time an incident occurred, they would develop a new NRC guidance. So— And meanwhile Du Pont was not making any changes in theirs. Eventually, all this stuff got codified nationally by the National Codes and Standards Committee, the ASME. And they issued a set of national codes on NQA, Nuclear Quality Assurance. And quality assurance is a set of management rules, if you will, on how you re—become reasonably assured that your product, your facility, whatever, will meet its designed specs and will be safe to operate. So when that happened, the DOE said, Hey Du Pont, we'd like you to play by these national consensus standards instead of Du Pont specs. And there was a long period of, You mind your business, we'll mind ours (laugh) kind of thing, because Du

Pont felt, with some justification, that their specs were there first and the plant had been built to them and it was—they didn't see any need to try to ratchet around something that was not part of the original design. But the pressure got steadily more persistent and finally Du Pont said, Okay we'll see what's required. And at that point, they called me in to run the Quality Department, which was intended to set up, for Savannah River, a quality assurance program that would comply with NQA-1, which was the national standard at that time. And it was— It was not an easy task because there was a lot of resistance, as you can—as you might imagine. At first we had to figure out what it was. And we found—we— Several of us became members of the NQA Committee in various capacities. I was on the operations working group and operations subcommittee of the NQA committee. And one of the guys who worked for me, Ken Goad, was on the main body of the NQA Committee. So we had several people involved in the process of setting these standards, so that we could know what was coming and so on. And we wrote the quality assurance program document, which was put in place at Savannah River, and which built on what we had already done, but also included a fair amount of new stuff that had not been done previously. Now when I say that, I'm talking about Du Pont. DOE had had a QA effort based—sort of a rudimentary one based loosely on NQA-1 for a number of years before that. They had one as early as the early eighties probably. But with Du Pont it took a little longer to get it—to put it in place. So that was my first job with that. We put in this— We designed and installed a quality assurance program and we trained auditors to go out and check and see if people were doing the things they said they were doing and doing the things that they should be doing. And quality assurance is mostly a paper trail activity. Then about—a little after this, Du Pont got interested in going the next step, which is a quality improvement program. And they started out with some training that was provided (laugh) by a guy—oh shoot what was his name? I can't think of it, well— Anyway, they started out with some training on management style, leadership, how you train your—how you teach your organization to work together, heavy on teamwork, heavy on people skills, heavy on—a very cerebral process, very— And this came down from corporate as a—as something that they wanted done and they gave that to me too, since QA, by that time, was sort of—started to roll along on its own. They put it—rolled it into my department.

And we created something we called Commitment to Excellence, which was the Savannah River variant of this continuous improvement program. And we went out and talked to all the gurus who were then starting to get active in the quality program. This was in the early days of people like Phil Crosby and oh, we had— We didn't get Denning and Joran down here, but we had a number of the other people who were sort of big guns in the field come in. Steven Covey came in. And we sort of picked and chose from among all of that material and designed our own program and designed our own processes and set up a little group we called the Coaches Council, of people who had responsibility for the various organizations on the site and would go out and teach them and coach them and lead them through some of these continuous improvement process. And that was the activity that Westinghouse asked me to continue when they came in. And they had a very much—very much more structured—less people oriented, but much more structured process which they called total quality management, and so that was what I did for them for a few years before I retired.

MS: Okay great. I know you mentioned earlier about safety computers in the reactors.

WJ: Yes.

MS: Do you know when those came in and what was the— Aside from the— I was wondering just what was— Aside from the obvious thing of, I guess, wanting to have the reactors run more safely, was there any particular reasoning behind putting in safety computers when they were put in or was there just the— Were these ones they could actually physically put in there that would actually work?

WJ: The reactors at Savannah River had to, to our knowledge, the first computer applications in any nuclear reactor. And the first computers were installed, oh very early. You really ought to talk to Kris Gimmy about it, but I would guess it was in the early sixties. And they were strictly data collection devices. There was a console in the—in the reactor control room, which the data operator, the same guy who went around and collected data from all the control room instrumentation, could use to call up specific information. He could call up temperature profiles. It would give him things like axial flux profile, what does a neutron flux look like at various locations in the reactor? What do the temperatures—what does the temperature profile look like in the reactor? It would analyze— You could— It would do data collection and pretty simple analysis. And that was a first. Then— (laugh) Let me digress and tell you a story on that. Kris Gimmy, who is the Reactor Technology engineer responsible for the early design and installation of computers, and he made actually a career out of that later. But for these first ones, he was a guy who was a little bit of a humorist. A little— Like many of our technical guys, he was sort of idiosyncratic. And so he used to have his reactors' computers—the data computers programmed so that they would do things like they'd recognize you and say, Happy Birthday Art if one of the crew had a birthday on that specific time, that message would come up. And he had— He did things like that. At one point they were having trouble with the computer, which they couldn't understand. It would temporarily go off line and get erratic and then come back on. You noticed it always tend—seemed to be on the four-to-twelve shift this was happening. And they finally tracked it down to the janitor who was cleaning the computer room and was kind of banging his mop around and would bang the computers. And those early computers were vacuum tubed, and they were a little sensitive to being banged. And so they spoke to him a couple of times, didn't happen, nothing happened. But they notices that when he was working there, if a message came up on the typer, that he would stop and look, and—just to see what it was, he was interested. And (laugh) so Kris put in a little program and the next time they—one evening when the janitor was back there and the data operator could hear him banging away, he typed—set up this program and the message printed out on the machine, Please stop bumping my cabinets, you're hurting me. (laughter) And he said the janitor came out with his eyes about two inches across, and they solved that problem. But those were data logging computers. And then as computers got more sophisticated and as our analysis of the potential reactor accidents got more sophisticated, it became apparent that we could build in some additional protection using the computers, and so they designed what we called four on the floor. And four on the floor was basically four separate small computers, two of which collected data, so the one was continuously online and the other one was a backup and they switched on and off so that they sort of (unintelligible) each other and kept active. And all of them had the up-to-date data in them, so that if one computer did fail, you still had active data from the other one. They shared the information back and forth between them. And then the other two were safety computers. And the safety computers were designed to detect abnormalities in flow, temperature, signals, and to actually Scram the reactor before perhaps the operator could sense—could detect an error, a problem. And so— And again, there were two of them. And they shared data, but either one of them could do the Scram. And that was the four on the floor concept. And again, that was, to our knowledge, the first search application in the world of computer technology to reactor safety circuits.

MS: Okay. Going back to like the job in general, what pressures were there to your job, like, whether it was like production quotas or strict adherence to procedure, information limitations? Of course we've gone over some of these in various aspects.

WJ: I think the primary criterion was safety. Du Pont had an absolute phobia about safety, which was natural. It came out of their experience in the explosives—in the black powder business where they blew up the company a couple of times and killed one of the Du Ponts (laugh) and with that background they went into nuclear energy also with a very well-established safety mindset. And safety was the absolute bottom line. I mean they made a fetish out of it. You had to hold a handrail when you went up and down steps. If you didn't, somebody would tell you about it. And lots of little things like that, that seemed trivial, all added up to creating the world's finest safety records, because Du Pont set safety international records continuously at various sites. Safety was the one thing you could get fired for instantly. And again, in my early—my early days in Crosland Park, I was in a carpool with a health protection supervisor in the lab. And he came out one evening shaken because he had just discovered that one of his health protection inspectors had decided that he didn't need to go down to the high level caves and record radiation data that morning because the data had been constant for weeks and weeks and weeks, and it was always the same number, and so he just penciled in what it was and hung it up on the board, on the status board, not knowing that a cask had been delivered that evening, the night before. And it was discovered by one of the technicians, who was also required to monitor before he went in, monitored, found that the reading was not what was posted, notified his supervisor, and the gentleman (laugh) in my carpool was off at a meeting somewhere. And when he came back from the meeting, he discovered that his man had been summoned up to Dr. Wahl's office, laboratory director, confronted with the evidence that he had falsified data, had his badge removed, was walked to the gate, and told that we'll get in touch with you, but you're fired. (laugh) I mean, it was that quick. Human resources subsequently had to run him down and do all the things that were required to get it done officially, but he was gone. He was gone in a matter of an hour from the site, and that kind of—kind of treatment really made an—had an impact. The other thing was that if you had a—if you were a supervisor, a manager of any kind, and you had an accident, even one that was not where you didn't cause serious injury, even a minor injury or abnormal condition, at eight o'clock in the morning, you were in the plant manager's office with the staff and the safety—the superintendent of the Safety Department and you had basically two jobs when you went in there. You first had to describe the incident, whatever it was, in considerable detail. And second, you had to tell them exactly how you were going to make sure that that incident never occurred again. And it didn't matter if that incident occurred at 7:30 in the morning, at eight o'clock you were there. (laugh) So— And those were not friendly, Hey Walt have a cup of coffee kind of meetings, (laugh)

MS: Called on the carpet kind of.

WJ: That's right. They were very intense and people went out of those meetings very thoroughly interrogated and perspiring. (laughter) And you knew that was going to be the case. And everybody knew it. I mean safety was the thing. Probably more than anything else, it was—or more than anything else, it was the thing. There were pressures to produce. And those were— Those pretty much took care of themselves. If you didn't produce, you didn't stay. (laugh) I mean it was pretty much like that. DuPont did not do a lot of preliminary training, I guess you'd say. Most of us were thrown into jobs and you were expected to succeed, and if you didn't they'd take you out, put somebody else in. (laugh) Just like my job at T&T or—I described or as a young engineer when they called me in and told me I was going to be a stress analyst. And I said, (laugh) I don't know much about stress analysis. They said, Well we need a—we need some work done and we think you're the guy to do it.

MS: Yeah, talking about changing positions and stuff within DuPont, was that something that you had some leeway on? Were you like— Did you like make it known that you wanted to work at something else and they would accommodate you or was it more or less that they would approach you and say you were going to do this? The impression that I've gotten so far is that it's the latter.

WJ: It's almost exclusively that. In my particular case, I did ask to be transferred out of the laboratory. And I had to ask a couple of times before it happened, just because nobody could believe that I wanted to leave it. They were treating me very well, it was a fun job, but I just wanted something different. But after that, all the moves were things where I was told about them. I could have refused, I suspect, but it was pretty much agreed that you didn't refuse a move. And in my case, I was very lucky that the moves were all onsite. Actually, I was twice considered for offsite moves, neither of which I wanted—

END TAPE 1 OF 3, SIDE 2
BEGIN TAPE 2 OF 3, SIDE 3

MS: We were at—

WJ: Oh we were talking about the, yeah, sink or swim.

MS: Right, we can go ahead.

WJ: Can we?

MS: Yeah, um-hm.

WJ: Okay. Yeah Du Pont did not do a lot of training. It was primarily on the job. And when you got a new assignment you were expected to go study up on it, figure out what it was and then get on with it. And there were a few exceptions. They sent you to school a couple of times. We had a vibration problem when I worked in the lab that we couldn't—nobody could solve and so they sent me down to Georgia Tech for a week and took an advance vibration course, which was interesting, since I'd never had a basic vibration course. (laughter) But they expected you— There were pressures, and as long as you handled them, you got more assignments and better assignments. And when you reached your limit, by then they tend to leave you where you were, (laugh) and in some cases they'd reassign. Du Pont had a very active program on personnel management. All of the superintendents got together each year and you were required to talk about your top performers and your bottom performers. If you had half a dozen guys who were really exceeding the norm substantially who you thought were going to be—had the potential for moving up a couple of levels, then you had to present their names and their pictures and a plan on where they needed to go next and when they needed to go there. And each of the superintendents was required to do this. And so you went with your best guys and it was like a shopping mall (laugh), because somebody would say, Well this guy needs some experience in the production organization and we think he'd be ready in six months. And reactor superintendent would say, I'll have a vacancy in three months and I'll take him. (laugh) We'll put him over in thus-and-so. And they'd cut deals right there on the spot, and HR would formalize them and that's—they'd happen. Now the same thing would happen with the—with your lower performers. You'd go in with your low performers and you'd say, Now here's a guy with a master's degree in chemical engineering and we've tried him in this job and he doesn't have the technical capability to handle it, but we think he would probably do well working with—he likes to work with people and we think he'd do better in a—some sort of assignment where he gets a chance to work with people. And so there'd be some discussion and somebody would say, Well we'll try him out as a senior supervisor in Separations, working one of the crews or something like that. And the deals were made that way, every year.

MS: That's interesting, I've never heard about that.

WJ: Yes. Well Du Pont was—had a very enlightened personnel management system.

MS: Sounds like it, yeah.

WJ: And that guaranteed that the top guys were—had opportunities to move and that they moved into places that were compatible with some long-term career goals. And it also guaranteed that your guys who were not doing well at least got a shot at something else to try, so before they were consigned to the—to outplacement or something ugly. So that worked well. The other thing we had to do in Du Pont was you had to have a truck list. And a truck list was a list of all of your key positions in the organization and then who would fill each position if the incumbent was run over by a truck. (laugh) It had a fancier name than that, it was called the replacement something, but everybody—we all called it the truck list. And so— And you had to have it by name. And you had to have several names behind each of the jobs. So that if I had a chief supervisor working for me and I had to have a list of who could replace him if he was not available. And as long as you had that list, that meant that when somebody came to you and said, I want your chief supervisor, I have a better job for him, you could say, Fine we can do that and I'd like so-and-so. (laugh) And it was all—it was all worked up in advance, and you had some logical sequence of moves planned.

MS: I always heard that Du Pont was really people oriented and everybody seems to—that has worked with both companies says that Du Pont definitely was—out of the two was the—

WJ: No question. Du Pont was— And I had some experience— My father was a senior manager with Western Electric and I worked there a summer and I got to study their personnel policies and so on. He showed me a lot of the stuff that was handled around at the upper levels, so I know how it's done in at least a couple organizations other than Du Pont now between Western and Westinghouse. And Du Pont was hands-down the most people oriented, and had the most effective systems. With Du Pont, there was much less the good old boy network than there is with Westinghouse, for example. Du Pont picked good people and it didn't much matter where they came from. And it meant that their staff was much more diverse. They didn't live together, golf together, watch football together (laugh) kind of thing, because they were a much more diverse set of human beings. They came from wherever the talent was. And I think it made it a better organization from that standpoint.

MS: Right yeah. Well this kind of segs into our next question which is, What did you think about Du Pont's management of the plant, especially compared to, let's say, Westinghouse's management of the plant?

WJ: Yeah well, I thought that the—I think the Du Pont system was vastly superior in most respects to what came in with Westinghouse. But—now I'm going to qualify that. In fairness to Westinghouse, you have to remember that their contract was different from the DuPont contract. Du Pont was in it in the national interest. They were in it because the president of the country asked them to be in it and they weren't making any money out of it. Their contract said that we run it like a Du Pont plant and we get a dollar at the end of the contract. And that allowed them— The fact is, they made some profit from it because it was a great training ground for new people. It allowed them to expand their technology base and cap out—pull out good guys when they found them here that they might not have found otherwise and so on. But Westinghouse's contract was different. Westinghouse's contract said, Okay we will run it in accordance with all the DOE orders and regulations and we will make a profit on it. We will run it as a profit-making enterprise. And so that made it a lot tougher. Du Pont ran it the way they ran the commercial plants. They used their systems, their processes. They paid their salaries. They did— They had control. They did it according to their specs until we put in a QA program, and that was only in the very end, and it was probably one of the things that pushed them out of the contract. Whereas Westinghouse said, Yes, Mr. Government, we will do whatever you tell us to do. And if we do it well enough, you're going to lavish money on us. (laughter) So it's not fair to compare the two management styles, because the basis is so totally different.

MS: Okay. Did you win any awards for safety or production suggestions or for other actions or contributions?

WJ: Oh gosh.

MS: You don't have to detail it. I was just (unintelligible).

WJ: Yeah we won— I won— I was part of organizations that won numerous safety awards. Du Pont had a whole hierarchy of safety awards which came out at regular intervals basically. They had board of directors awards and so on. And these involved prizes, small prizes which you could select. You could select from a list of potential prizes, and they could be anything from— Oh I got a—I have a pocket knife out there which was—

MS: Oh I thought maybe there were automobiles. (laughter)

WJ: Oh no. Nothing that dramatic but plenty of— There were lots of awards and there were lots of diplomas and certificates and that sort of thing. The top organizations on the plant in safety performance were always recognized in staff meetings and get to tell about how they got to be so good and brag a little in front of the rest of the staff. There were lots of those kinds of things around safety. There were similar things around quality. I got a very nice letter from the DOE. It didn't come to me, actually it came to Du Pont's vice president in Wilmington about the work that was done in L-Area after that was over, very nice letter which mentioned me by name and several of my key guys. So those— We got a fair number of attaboys for things done well in the safety arena or in the productivity arena. Then we used to get things— We'd get things from the weapons people when we helped them with a design that they needed when I was in equipment engineering, solved some of their problems for them, and we'd get autographed photographs of missiles or (laughter) or certificates or whatever that we could put up in the conference rooms.

MS: Right. Okay. This— We've sort of addressed this before, but I'm going to ask anyway, what was the attitude towards safety at the plant among employees and among managers?

WJ: Oh it was a fact of life. I mean, it—

MS: Also did that change through time? Did the attitudes—

WJ: Not as long as Du Pont was there. Du Pont would not allow it to change. If— As I say, if you got—if there was one thing you could be fired for it was safety. I mean it was an absolute. And you could— You had immediate authorization to fire for poor safety performance. Somebody broke a rule deliberately—broke a safety rule deliberately, that person was gone (laugh) in almost every case. There might be extenuating circumstances, but I fired two people in my career out there. And one of them was a crane operator who had had an argument with his foreman in the morning about an overtime assignment and went out to the job site where his job was to suspend a bu—a cage holding a pair of maintenance mechanics who were working in a valve pit. And they were working on a valve, which was something like twelve or fourteen feet up above a concrete floor, this pit. And they were working out of a cage that was hung from the crane. And our safety rules required that although the crane had a brake and a safety brake and everything else, that the operators stay in the cab of the crane anytime people were suspended, were involved—

MS: Just in case, yeah.

WJ: Sure, just in case. And the foreman drove up to the job site to see how things were going and the crane operator got down out of the cab to continue his argument. And the call came in and I had him up—called up to the office and I fired him right on the spot, because I had no choice. I mean it was—that was flagrant viola—flagrant deliberate violation of the safety rules, and I fired him. I felt badly about it. He had fifteen years and two kids. (laugh)

MS: Yeah. But it's— Yeah.

WJ: But you—if you're going to instill a safety discipline in an organization, you have to—

MS: You can't have exceptions like that.

WJ: No, you cannot allow flagrant exceptions.

MS: Right, especially just to have an argument. (laugh)

WJ: Yeah, that's right.

MS: Yeah, that's—

WJ: So I think everybody understood safety as a condition of employment, and even if—even those people who were not perhaps habitually committed to it knew that they'd better do it on the site (laugh) if they wanted to stay.

MS: Right. Yeah, I've had people tell me that Du Pont's concern with safety was so overbearing that it was almost like entering a propaganda machine. As soon as you went onsite it was like billboards and signs and–

WJ: Napkins in the cafeterias and—

MS: Right, yeah, the whole thing. It had its effect.

WJ: Oh yeah. There's no doubt about it. It was pervasive, everything you did, and it was sent home and you were expected to conform. I had a very excellent chief supervisor at one point who was a likely candidate to make superintendent, and I was pushing him hard to do that. And one day the plant manager called me in and he said, Walt, is John still riding his motorcycle? And I said, Yeah, I think so. He said, Have you told him to quit? And I said, Well I've suggested it. He said, Do it. I said, Okay. So I went out, I said, John—called him in and I said, You know, motorcycles create many more accidents than automobiles, and they're usually more severe. And Du Pont has a safety image to maintain, and it would be in your best interest if you put up your motorcycle. (laughter) And that's gross intrusion into his private life.

MS: Yeah that's true, yeah.

WJ: But I knew he was looking for a promotion, and I felt I owed it to him.

MS: Right, yeah. And it's one of those things, if you're going to get into the corporate culture—

WJ: You have to get into the corporate culture. (laugh)

MS: If safety's a big consideration, you'd better get (unintelligible).

WJ: Better get with the program. I had another guy come up to me one time because we had put our motorcycles, which were a big no-no. And when we built the parking lot in L, I put the motorcycle parking pad at the far end of the parking lot, farthest from the building, all the way out. And as soon as I had done that, one of the maintenance mechanics showed up in my office complaining that he was being discriminated against, and that his motorcycle didn't take up much space and it ought to be up at the head of the lot. And I told him, I said, If I had my way, I would put your motorcycle parking pad out in the woods in a patch of poison ivy. (laughter) I said, You understand that? Is that clear enough? He said, Yes sir. (laughter)

MS: Yeah that'll work, yeah. So I guess you didn't have too many people riding bikes?

WJ: No. We— During the gas shortage, we started a—we started a bike riding campaign briefly. And then there was an accident at one of the Texas plants, a bicycle accident, a serious injury and the plant manager just called me and said, Cancel it period. Never mind how much gas we save, all that stuff, cancel it. And we had just purchased a whole batch of brand new bicycles which went into excess.

MS: Okay. Purchased bicycles for employees?

WJ: For employees to ride on the site.

MS: Onsite.

WJ: See in 700 area, for example, it made sense. You could ride a bike down to lower 700 and from 703, it made a lot of sense. But there was an accident at one DuPont plant, and all accidents were publicized immediately around the corporation. And when that accident was publicized, the plant manager called me in. That was when I was in T&T, said Cancel it, no more bikes. (laugh) So I said, Yes sir. (laughter)

MS: I bet they had good bikes, too. (laugh)

WJ: They were good. We bought some good, heavy duty bikes. We bought, I think, twenty or thirty of them as a trial—

MS: Right, right.

WJ: —and excessed them within a couple of months. (laughter)

MS: What were the most important measures that were in place to insure the protection of your health?

WJ: I think basically, to my mind, the most important of all was the Health Protection organization. HP was required to monitor—and I'm thinking now radiation protection and we'll talk about safety. HP was required to monitor any radiation area and to establish criteria for entrance. And the criteria would say—would tell you what you had to wear, what kind of protective equipment you had to wear, what kind of self-monitoring you had to perform, and whether or not you were allowed individual access or whether you had to go to the HP office and get a permit and bring an inspector, perhaps. They were very detailed. And so you had pretty much confidence that you weren't going to find any great surprises. Because HP, in every area, monitored the area first thing in the morning and was required to have posted on the board by eight o'clock what the conditions were in every part of the area. So if I wanted to go into the heat exchanger bay in L-Area, I knew exactly what was in the heat exchanger bay in the way of activity. Now from the safety standpoint, we had safety engineers. Had a safety engineer generally in every area, although some of the small areas might share one. But there were—there were a cadre of safety engineers. And these guys were mostly up through the ranks, people who had developed a very strong appreciation for safety. They were well trained. They knew well the OSHA, the Occupational Safety and Health Administration rules, they knew all the DuPont safety rules. They knew all the site safety rules. They knew all the area safety rules. And they were the final arbiter on safety in any given area. They made— They were the ones who said, You can't go in there without safety glasses, and they'd post a sign or you can't—you have to have hearing protection or you have to do this and that. They also went around to enforce things like barricades. If you're digging a hole you have to have a barricade. OSHA requires two horizontal bars supported by rigid posts at the end, all this kind of thing. And they knew all those rules and made sure that the area was operating safely. And then as part of that, all supervisors had to go with a safety engineer on a safety inspection monthly. That was part of their training. And it also assured that every area got multiple inspections by different sets of eyes. So you had to do your monthly safety inspection with one of the area engineers and fill out a form on what you found, and it was very—it was taken very seriously. If you missed two or three of them at the next staff meeting, the plant manager would ask you why. (laugh) So it was not something you sloughed off. And the safety engineers had a great deal of clout. They were not— They were not top echelon managers or probably even very highly paid, but they had an enormous amount of clout. If a safety engineer thought an area was not being run right, he could go straight to the plant manager with it, and occasionally did. When I was in L-Area, one of my luxuries, because it was a crash job, they let me select my first cadre, select the first twelve people from—for the organization, and I got to select my safety engineer, and I picked a guy named Ray Russell who I thought then and still think was probably the best safety engineer on the site. And he was— He and I worked very closely together. He sat in on all my staff meetings. He and I did personal safety inspections. At least once a week we went out personally together. And he rode herd on construction for me, even though they had their own safety engineer because sometimes their rules were a little different from ours. And it was our area and therefore they played by our rules, or if their rules were more stringent, we changed ours. (laugh) So we had a lot of help in keeping safe, both from industrial accidents and also from radiation.

MS: Right, yeah, okay. What was the attitude towards security at the plant and how did that change over time?

WJ: Security was interesting, because the initial emphasis on security when DuPont came was on espionage. There was concern about secrets. And so there was a lot of emphasis on locking your safe. If you left your safe open, you had to come in—whenever it was discovered, you had to come in and inventory it. And that meant you'd get a phone call at two o'clock in the morning that some security guard had gone through and found your safe open and unattended. And so you got up out of bed and went in and (unintelligible) (laugh) your safe, and vowed never to let it happen again.

MS: Yeah, right, yeah.

WJ: And badges, forgotten badges were a big deal. Some— Oh, A Square Johnson, who was a tough manager when he had Reactor Technology, tough superintendent had a rule. He said, There will be no forgotten badges. I'm tired of— I'm tired of reading forgotten badges on my reports. There will be no more. Forget your badge, go home. (laughter) And that made for some interesting situations.

MS: I imagine so.

WJ: But there was a lot of emphasis on that kind—the security of documents, the security locking of safes, locking of doors, proper identification, challenging strangers. One of my first (laugh)—one of the first things— One of my first tasks that I can still remember, I had been in the laboratory a week, maybe a week-and-a-half. My boss called me in and he said, I want you to give these papers to Hood Worthington. And Hood Worthington, at that time was a—he was like the technical director of the Atomic Energy Division. So he was the lab director's boss, several steps up my ladder. He said, I want you to give them to him personally. I said, Right. So I went over and—went over to 703, where I—where he was supposed to meet his shuttle to go to the airport, or go to the train, rather, in those days. And (laugh) I got there and I was standing around. I had told the—because I didn't know what Hood Worthington looked like. And I had told the receptionist that I had a package for Hood Worthington. (laugh) So this gentleman comes up to me and he said, I understand you have a package for Hood Worthington. I said, Yep. He said, Well you don't need to stand around and wait for him. He said, My name's Tom Squires and I'll give it to him. Tom Squires was Hood Worthington's boss. And I knew that vaguely from an organization chart. And I said, No, I've been told to give it to Hood Worthington, and I'll give directly to him. (laughter) And I did. But that was just part of the training that they gave you. You really worry about the security. You don't let stuff go where it isn't supposed to go. So—

MS: It sounds like also in later years there was more concern about terrorism.

WJ: Yeah, in later years, the emphasis changed. It shifted sort of subtlely from espionage to sabotage to terrorism. And in the— And DuPont was really not willing to get into the counterterrorism business. They didn't see it as compatible with their safety orientation. It's pretty hard to write safety rules for repelling down a rope from a helicopter carrying forty pounds of machine gun (unintelligible). (laugh)

MS: Right, that's true. I talked to somebody that said that just—DuPont wasn't interested in shooting people—

WJ: No—

MS: —and that's what it really boiled down to.

WJ: That's right. They basically were—would really have preferred not to have live ammunition (laugh) as a starting point. And so they— As long as the security was safes and badges, they were comfortable. When it started getting into—even in sabotage, they could deal with it a little bit, by barricades and locks and fences and intrusion alarm systems and that kind of stuff. When it got into terrorism, they were no longer willing to play in that arena, and that's when Wackenhut, of course, came in and Wackenhut was—that's what they do.

MS: Right. Did you do any work at the plant prior to getting a security clearance?

WJ: No. I was fortunate in one respect. I was supposed to start work in June, but I had trouble with my thesis project. I did three theses for my—(laugh) for my master's degree or parts of two others. And the third one was—I ran a little late and so I was a little late getting here, and as a result they had a clearance for me when I showed up. I went straight into the Q-cleared badge.

MS: Right. Were there any major incidents in the areas that you worked while you worked there?

WJ: Oh yeah. Oh yeah. Oh we had— I guess the biggest— Well, in the areas where I worked, I was involved in the source rod incident in L-Area, which was—would have been—

MS: I think it was 1970, wasn't it or—

WJ: Yeah, it would have been right around—right around 1970. I think it was '70. I was not in L-Area at the time, but I was in Reactor Tech in the Special Studies Group, and they yanked me out of that and put me on a team. Actually, I was on two teams. We— The recovery task was divided up and into various specific activities. I was on the cleanup—the reactor room cleanup task, and I was also on the disposal of the contaminated filter compartments task, and both of them very interesting. The— And again, that was an accident. That was the worst—to my knowledge, the worst accident that occurred at Savannah River, in terms of release of activities—of activity, and it occurred when the cooling requirements for antimony-beryllium rod were mistakenly calculated. And the rod was allowed to be held out in air for longer than it should have been, and it melted over the reactor tank. And molten antimony-ber—irradiated antimony-beryllium dripped down on top of the tank and airborne particulates went up and went through the filter compartments, which removed 99.97, I think was the number, almost all of the material from it so that almost—essentially nothing measurable got out to stack at the reactor. But it left us with a contaminated reactor room, and a contaminated set of filter compartments on the roof, which had to be cleaned up. And we started in the reactor room with mechanical devices. We developed— Equipment Engineering worked with us and developed all kinds of hardware which we could lower—which we could bring into the room on the charge machine that would do—that would vacuum and we had pinhole cameras that would identify spots of activity and then we'd vacuum on those spots and scrape on them and all kinds of remote tools, but in the final—at the end, we had to put people into the room to clean it. And—

MS: I heard— I don't know if this is true or not, but I've heard that you could even—you would take volunteers to do that kind of work.

WJ: We did.

MS: Because you wanted very limited exposure in that area, and that even like secretaries, if they volunteered, could go in there for (unintelligible) short period of time.

WJ: I made the proposal on putting people in the room to the management team. And I told them that it had been—we had done all we knew how to do mechanically, and it was the end of a calendar year, it was early December. And I said, We need to put people in and we need to put people in who do not normally get radiation. And we need to put them in for enough time so that they get a dose which is a substantial fraction of their annual exposure limit, and we calculated what that would be and I need your authorization to do it. And it was very quiet in there because it—that was a— That went against the grain of the safety program. And nobody really wanted to do it. And Frank Kreusi, who at the time was a technical director in Wilmington, was down visiting the site and was sitting in on the meeting. And there was this long pause. And Frank said, Walt I'm going home tomorrow night, but if you'd like, I'd like to be the first person in the room. And that broke it. I mean, that was it. And I've loved Frank Kreusi ever since. He went in with a— It took us the better part of an hour to get him dressed up, full plastic suit, breathing air, all of that—all the self-monitoring, all the monitoring stuff hung all over him. We gave him something like a fourteen-foot pole with a kotex on the end, soaked in alcohol. And it had a release—quick release wire on it. And he ran out, poked it at one point, which we had identified for him on a big blowup of the reactor tank top out there. Poked it at one point, went like this, pulled up, took it over, pulled the release, dropped it into a container and came out in seven seconds over the reactor tank. (laughter) And after that we ran several hundred people through, who most of them were from areas—were from the 700 area, people who did not get radiation normally, and we did not have a single case of an excess dose. All of them got well under their allowable dose, and we cleaned up the room. (laugh) Started out with swabs and wound up with hand-held vacuums, and then at the end we went in with steam lances and blasted it. (laughter)

MS: How long did it take to do all that?

WJ: About three weeks, round the clock. We worked twenty-four hours a day. Because a lot of the guys would— A lot of the people would say, Well I'll work my day shift and come in on four-to-twelve, just stay over, come in, spend an extra couple hours. (laugh)

MS: Were people allowed to go back if they volunteered, allowed to go back for a second time or—

WJ: No. No. No. No. We held it down, and it was very tightly orchestrated. HP was there every time, all the time, round the clock. And we did continuous readings on whether—where the activity was and made sure that it wasn't—that a swab didn't pick it up from one place and drop it someplace else, because we were looking for little particles. And it was very tightly orchestrated and it worked like—it worked very well. And as I say, Frank Kreusi's been one of my heroes ever since. He was a great guy. (laughter)—is a great guy. He's retired now.

MS: We've already talked about this to some degree, but I'll bring it up now anyway, but how did plant operations and management change when Du Pont left and Westinghouse took over?

WJ: Well it changed dramatically. Most— Not quite all but all but a few of the Du Pont management left with them. There were one or two exceptions—Bob Mahr, Ben New, a couple of the others. But almost all of the management team was new. And they generally knew each other from other Westinghouse assignments, but they didn't know much about the site (laugh) other than what they had picked up during the days when they were bidding on the contract. And they came in with a totally new (unintelligible) basically. And so it changed. I mean they brought West—all of the Westinghouse policies, procedures, and people in at the top. The workforce, at that point, was hungry for a new—for an authority figure. Everybody knew Du Pont was leaving and they were— There was, I think, initially a sense that, Hey Westinghouse was going to be a good fit, that they brought a lot of technical expertise, experience in the nuclear business, that they would work well. I think— I thought then, I'd think now, I told Ambrose this, that Westinghouse made a serious tactical error early when they came in. They were so anxious to establish something new that they re-titled the site, called it the Savannah River Site rather than the Savannah River Plant. And none of the logos had Westinghouse on them. Everything had SRS. And people— The workforce said, Hey isn't Westinghouse proud we're here? Why won't they put their logo on anything? I get my paycheck from Westinghouse. Why don't they want to be associated with it? Why is this SRS stuff out here? We're used to being Du Pont, now we'd like to be Westinghouse and they won't let us. And it's a trivial thing, but it wasn't. There was a sense of identity lost when Westinghouse came in, and needlessly. They didn't have to be that way. They had a backlog of goodwill to tap into had they taken the appropriate steps early. And they found it out after a few years, but a lot of the damage was done by then.

MS: Yeah, right. How did the newer environmental legislation change operations?

WJ: Oh it made substantial differences. The L-Project was a perfect example. We started L with the intent that the reactor should be ready to op—should be operable in three years. And it was a crash program, just absolutely flat out wide open. And it was based on the prevailing understanding of the environmental regulations that limited the impact to the river and the surrounding—the area surrounding the plant. During the last year of the project, several intervener groups and the state finally determined that the state had jurisdiction over the streams on the site, not at the boundary but on the site itself, even though that was government property. And they filed a lawsuit to compel DOE to complete a formal environmental impact statement. DOE had done an environmental assessment, which is a prelude kind of document, and had found no significant impact. But that was on the river. The state and the intervener groups insisted that the streams were under state jurisdiction and therefore, the limits applied to the streams, which meant the reactor effluent. And as a result, they spent two years building a 1,000 acre lake.

MS: L-Lake, right?

WJ: L-Lake, to protect 1200 acres of wetlands downstream (laugh) from the effects of high temperature. And that was the first time that the state had asserted jurisdiction over a stream on the site, and had far-reaching consequences because it meant from then on every task on the site was subject to state scrutiny through DHEC and really had to be negotiated. Just about every activity on the site had to then be negotiated with the state.

MS: Did DOE not try to contest that or as a—

WJ: DOE started out— We— DuPont told DOE early that they were making a mistake by going with an environmental assessment, that they should go ahead and do an environmental impact statement, do the full-blown statement even though we thought the results would come out the same way, and do it early. They said, No they didn't need to, and decided that they had jurisdiction, they made the rules. It was really a case where DOE, I think, misjudged the attitude of the state administration and paid the price for it in terms of losing a lot of their authority over the operation of the site. I'm not saying that's— I don't know whether that's good or bad, but it is true that DOE lost a lot of their capability to manage the site and that DHEC now plays a significant role in all decisions which affect anything on the site. And L-Area was really the first of those. And of course it delayed— Well it delayed restart by two years while the lake was built, and then because of the rules which were drawn up on the maximum temperature in the lake, it meant that we could not—that L could not be operated at a reasonable power level during the summer months. So that even after five years of hard work and $186,000,000 expenditure, the reactor was shut down in a couple of years because it wasn't feasible to run it in accordance with the regulations that DOE and DHEC had agreed to. In retrospect, the regulations were stupid, but— And I still question whether it's at all com—wise to build—

END TAPE 2 OF 3, SIDE 3
BEGIN TAPE 2 OF 3, SIDE 4

MS: We have some like—some general socioeconomic issues, questions that we'll go into. These are more general. How has the plant location in the CSRA impacted the economy of the area?

WJ: Oh generally— Of course it's been a very positive impact. The plant replaced several small communities and a lot of fairly relatively marginal farming enterprises with a very large number of relatively high-paid employees who spend their money in CSRA and contribute to the CSRA in other ways. So it's been a very positive impact.

MS: Right. How has it impacted lifestyles in the area? That's kind of a general question but—

WJ: Oh it's had a lot of impact on lifestyles. And you can— Plant people, because they are—were when they came, a very diverse, generally fairly well educated, relative to the people who were here affluent group, were used to things that weren't here. And I think that a lot of things like little theatre groups, like the cultural activities, sprang from the people who came in with the site. Similarly, the political structure was totally different. When we came, this was a one-party area. And I was active with several other (laugh) site people in setting up the first Republican Party in Aiken County, and it was a pretty interesting experience. And it wasn't that I was a big Republican, but it was that after a couple of years it was pretty obvious that what was here was a good old boy network and that it was not much opportunity to select candidates who reflected anything other than that network. So a group of us got together, and our first county convention— Conventions are required by state law to be held on a specific date in a public building. And our first county convention for the Aiken County Republican Party was scheduled to be held in the courthouse on this particular day. This particular evening, we arrived at the courthouse and found it locked, and—even though it had been reserved. And not only that, but the—any of the custodial people whose names were—had been given to us, we were not available by phone. And so we held our first county convention in the parking lot of the court house. But we also set up the first poll watching activity. I was responsible for setting—bringing in the first poll watchers who were ever here, and we established a two-party system. And some of the local folks were not wildly enthused about that. I remember the mayor, Charlie Jones, at the time (laugh) and I were counting votes in an election probably in the late fifties, local election of some kind. And he was complaining bitterly about the number of votes in the election. He said, Before you folks came, he said, We used to close the polling places about five and if we didn't have enough votes, we'd go down to the firehouse and get a few of the firemen to vote. And he said, We could be out of here by five-thirty. (laughter) And here we were counting votes and it was probably seven o'clock, and he was not amused. (laughter) But— So I think the site brought a—had a major impact on the culture of the area, and it—not only—well in political—not only in the formation of a two-party system, but in the number of site people who became mayors and council members and school board members and those—all of the various civic groups, I think got a transfusion (laugh) and changed, and I think largely for the better.

MS: Right, okay. How about education? How has that been impacted?

WJ: I think education has been impacted, again, by the transfusion of people who came in and started running for school board seats, and also the number of people who helped out with things like Junior Achievement to like science days, like career fairs. Most of us at the site participated in several of those kinds of activities, or many of us, and we were encouraged to participate. Now having said that, I'm also—I have to tell you, I'm disappointed in the county's education system. I don't think we have nearly lived up to the potential of this county. And I think it's under—it's grossly under funded. And I think some of that is because we have so many retirees who see no benefit in spending their tax dollars on the school, (laugh) and that's unfortunate. We need to do better by our schools. But I think they are better than they would have been, let's put it that way.

MS: Right. What about community services like utilities, roads and police and fire protection? How have those been impacted?

WJ: They've had to expand, all of them. The schools had to expand, the police departments had to expand. Certainly the road system is better than it would have been because the four-lane highways were put in here when the site was built just to get traffic in and out of Savannah River.

MS: Right, yeah. Of course you've got the Clover Leaf at the site, first one in South Carolina.

WJ: Yeah, (laugh) first Clover Leaf in the state of South Carolina, right. So all of those things have expanded, and again, I think largely beneficially. Now there's pressure now on widening Whiskey Road and I—I guess I have to come down opposed to that particular expansion, simply because I think some parts of Aiken need to be preserved in their—

MS: Oh you mean up in town?

WJ: Yeah, in original states as part of the charm. I would hate to see them put a four-lane road right through the center of the town.

MS: Yeah, right. The next series of questions deal with broad topics for all of those who worked at the plant for a long period of time. First one is, Is there anything that stands out in your mind as the greatest accomplishment at the plant during its history? These are all kind of general, but—

WJ: Greatest accomplishment. That's— I think the greatest accomplishment was the construction of the site. I think the—it was an unparalleled activity in terms of magnitude and scope. It was nothing comparable to it until the space program came along. It was— It was managed by a relatively small group of people who made extremely daring and generally correct assumptions, used very good judgment, built in flexibility, built in the capability to deal with other jobs and other missions and other products, and really contributed to a site that's been there fifty years now and has performed in a really exemplary fashion. I think the record of the site has been testimony to the superior judgment that was exercised, and it's really remarkable. You think when that site was built, there was not even a consensus that the hydrogen bomb would work. I mean, here is a billion dollar facility being built on the theoretical supposition (laugh) that a weapon would work—

MS: Yeah that's true, yeah.

WJ: —and the decisions that were made in terms of the process selection and the size of the site and the scope of it, I think were remarkable. And they were made in just a space of a few months during 1950. And they were made even before Du Pont had a contract. All they had was a handshake with AEC, and they were—their people were out going hammer-and-tongs on it, for months. You just can't visualize that today.

MS: That's true. You can't—

WJ: In our legalistic society, there would be—

MS: Yeah, you couldn't do that kind of thing with a gentleman's agreement.

WJ: No, no, absolutely not. So I think that was a remarkable accomplishment to design it and build it in a space of just a few years and have it operational and to have it operational as in a fashion that allowed it to expand and continue as long as it has is a fantastic accomplishment.

MS: Does anything stand out as the greatest problem?

WJ: Greatest problem. I think the— Nothing really— I think the greatest problem was the—for the site, was the lack of preplanning for future missions. When the cold war collapsed, I think— I don't think anyone was prepared, at that point, to say what it was that the site should be doing in the future. I think it caught everyone off guard, by surprise, when the Soviet Union folded its tent basically, and as a result there were a number of years of just floundering where they were talking about, We ought to do this, we ought to do that, which was hard. It was destructive to morale and really a lot of the ideas were just, Let's keep jobs here. And you don't want to justify on that basis. If there are things— And I think there are things that the site could do better for the country, those are great, we ought to go after them. But I'm not in favor of just making work to keep people employed. (laugh) I think— I don't think subsidies to buggy whip manufacturers are justified. (laughter)

MS: Yeah. Speaking of that, do you think the plant operated more effectively during some periods than at others?

WJ: Well I think it was very effective in the early years, particularly, because it was run as a unified entity under Du Pont with sort of overall guidance but not direct involvement by the Atomic Energy Commission. And it was run in response to a strong perceived national mission. And so that it was—there was a great sense of urgency and that got everybody on the same page, singing the same tune. So I think it ran better at that point than it did later as that sense of urgency began to diminish. And as conflicting environmental legal requirements cropped up on the scene, I think we lost a lot of that. I think it was inevitable. (laugh)

MS: Right. Yeah. Can you describe your feelings about the work or in other words, what aspect of your work do you identify most closely with, whether it's the plant itself, the contractor, the government or the mission, if it's even possible to separate all that out.

WJ: Which one do I identify with most closely? That's a hard one. I identified very strongly with the site and its people, but that was—that's hard to differentiate from Du Pont, at least in the early stages, in the early years, because they were, to everyone's mind, (laugh) one in the same. For those of us here, Du Pont was Savannah River and Savannah River was Du Pont. It was no feeling that we were stepchildren or (laugh) in any way out of the mainstream. So it's— I think that probably more than the mission, because we got the mission basically from Du Pont, they got it from AEC. But what we knew about the mission came from our leaders who said, Guys we need to raise power or we need to look into irradiating thorium or whatever the mission was. And nobody said, Well gee why would we do a thing like that? (laugh)

MS: Right yeah.

END SESSION 1, OCTOBER 21, 1999
BEGIN SESSION 2, OCTOBER 26, 1999

MS: Right, yeah. The next set of questions— I'm sorry, this is the beginning of Session 2 and it's the 26th of October, 1999. The next set of questions deal with the laboratory and research. What is the purpose, as you see it, of the Savannah River Laboratory?

WJ: In the— The basic idea of the Savannah River Lab was to provide technical support to the operation of the plant. Eighty-five percent of the laboratory effort was to be directed at R&D in support of a plant, so it was very focused. It was hard to call it research really, it was primarily development, although some of it got pretty far (laugh) out on the research scale. Fifteen percent of it could be applied to work that had no immediate plant application if it was felt that it was headed in a direction that the plant might require later on. At one point—(laugh) At one point in my career, I was doing stress analysis on reactor vessels and in doing that, I got involved with photoelasticity, which is using polarized light and plastic models to review stress conditions. And it occurred— And the plastics that we were using weren't very good, although they were the best that were available at that time. And it occurred to me that in a company like Du Pont there had to be some plastics experts. So I called the Experimental Station in Wilmington and talked to them and I wounded up getting a couple of the guys interested and sort of on the—off the cuff they started formulating some plastics for me and equally off the cuff I was making models out of these plastics and evaluating their performance. And one day my boss called me in and he said, Walt, he said, You understand that we can spend 15 percent of our time on work that is not directly related to the site. And I said, Right John I understand that. And he said, Well, he said, You're taking the 15 percent for the division. (laughter) I said, I understand John. That was the end of my plastics research career. (laughter)

MS: That kind of segs into the next question is, What were the most valuable or rewarding research opportunities made available to you because of your work in the lab?

WJ: Oh I think the—really the most exciting work that I did in the lab was the—measuring the effects of irradiation on residual stresses in stainless steel. This was a hot issue for us because we were concerned about the ability of the reactor tank and the various components of the tank to survive, particularly the thermal seal, to survive large temperature differentials. When we started raising power, the temperature differentials were much larger than they had—these components had been designed for. And we had some—sort of a gut feeling based on almost no experience—well no experience, that radiation might make some changes in these stresses, and so we designed two very simple families of experiments to determine what effect this might be. And sure enough, it turned out that it was a major effect and this was pioneering. Nobody else knew it at the time. No one had tried this. And we found out that radiation really did reduce the stress levels in the tank and the shield with time as the exposure built up. And therefore we could—the vessels would tolerate much higher stresses than had originally been contemplated. And that was a lot of fun, and it got me in the forefront of some of the research establishments. I remember going to a meeting out at Hanford on irradiation effects, one of the very first such meetings. And I gave a paper on this. It was brand new, hot off the press. And I was a young kind of—I guess at that point I had five or six years in, maybe, with the company. And I gave my paper, and a gentleman stood up in the back of the room and introduced himself. And he introduced himself as a man who was really a—one of the foremost authorities in stress analysis, a huge name, author of numerous books and dozens and dozens of papers. And he said, I have read your paper and I don't believe a word of it. (laughter) And I stood there for a minute with my mouth open and I—finally I said, I'm sorry for you, next question, (laughter) and moved on. It was very controversial, but it turned out to be right because the second set of experiments that we ran with an entirely different sample geometry proved the first one. And it has subsequently been demonstrated by a number of other investigators. So that was exciting.

MS: That's pretty good. Did security issues impact the value of your research or the other research conducted at the laboratory?

WJ: I don't think they impacted the value of it. They made it difficult to report some of it in the open literature. We had to be careful to present it in unclassified way when we were going to the open literature. So it might not have been as soul satisfying from that standpoint. But the research was good. It was just that we couldn't always discuss it with lay people. Now within the DOE, of course, we could talk about it and we had good mechanisms for doing that. The security requirements did force a certain rigor in the research process. We all had— Each engineer had a research notebook and we were required to enter all our data, all our information, into the notebook and to have it signed and witnessed and that was for patent protection, and that sort of thing, but it then had to be locked in the safe every night. So you were continually going in and out of the safe. Any time you left the office or left the lab, your notebook had to go back into the safe. And there were (laugh) lots of opportunities for open repositories. (laugh)

MS: Out of curiosity, What— How did Du Pont deal with patents?

WJ: Patents belonged to the government, but Du Pont—again because of the corporate strong emphasis on research, insisted on the same rigor as they would have if it had been their own. So they require all of the dating and signing and logging in of information, just as though they were going to patent it for Du Pont, but in fact, the patents were issued to the U.S. Government.

MS: Okay. Do you feel that your ability to contribute to your field was hampered or enhanced because you worked at Savannah River Plant?

WJ: Oh I think enhanced. I mean, there were so many opportunities to do different things and there was so little known about the business we were in at the time that anybody with ideas was—that pertained to the operation of the site was given pretty much a free reign to go get it, (laugh) get—run the experiments, design the whatevers, and we did a lot of very interesting things, and a wide variety of them. We worked on a lot of things that were—where if you went to work for General Motors, you might spend five years designing a new door latch (laughter) for one of their sedans. There at Savannah River, we were continually bopping around between hot projects, no sooner finish one than there were three or four others. (laugh)

MS: If it's possible to generalize, were you encouraged to or discouraged from taking part in conferences, publishing findings, or otherwise making your research known to the larger scientific community?

WJ: Within the limits of security, we were encouraged to— Certainly, we were encouraged to write the reports, and then to a lesser extent, we were encouraged to report them. We were encouraged to report them at DOE-sponsored conferences. Going outside the DOE family was sometimes a little tougher, but we were basically encouraged to do that.

MS: Are there any research efforts that you were particularly glad to have been involved with?

WJ: Well I think I mentioned the stress relaxation of stainless steel. That expanded into a whole series of experiments on radiation effects, on strength and hardness of stainless aluminum, zircaloy. Did some very interesting work on novel methods of joining stainless steel and zircaloy. Zircaloy is a metal which is relatively strong and does not absorb many neutrons—yes, one "l"—but is very expensive. Stainless steel, of course, absorbs lots of neutrons and is very strong. And so the idea was that you wanted stainless steel piping coming to the reactor, but the components in the reactor.

And we're talking now about power reactor applications were generally zircaloy. And most of the power reactors did then, and still do, use mechanical seals with gaskets and they leak occasionally with serious safety implications. So we invented a one-piece seal which you got by making a compound billet, an extrusion billet, which was zircaloy at one end and stainless steel on the other. You shoved this through an extrusion dye and you came out with a zircaloy tube with a little transition in between and the upper end of the tube would be stainless steel, which you could then weld into your piping. And the trick was to get that interface zone between the zircaloy and the stainless as short as possible and still wind up with an excellent bond. And we were able to do that and demonstrate a really nice joint. A lot of people, unfortunately, couldn't do it, (laugh) because it was rather tricky and so it never caught on. And then of course the power reactor business in this country dropped off dramatically so there wasn't much demand for it. But it was an interesting and neat piece of work.

MS: Are there any research avenues that you wish the laboratory had been able to pursue but didn't?

WJ: (laugh)

MS: You mentioned the 15 percent. (laugh)

WJ: Yeah, I think it would have been fun to finish up that photoelastic plastic project because I think we were very close to having a material which was far superior to anything available at that time. And so researchers around the world would have benefited from it. So that would have been fun. But no basically the lab worked on things that would support the site, and that was the mission. And you were allowed to do a few things that weren't site specific but not a great deal. They sent me over to work with the—in Georgia for the medical college while I was in the laboratory. I had a little project where they loaned a few engineers to the medical college. And I wound up working with a cardiologist over there who was interested in coming up with an alternative way of measuring blood pressure, nonintrusive. Standard blood pressure cuff gives you an average around—an average pressure around the circumference of the arm. And it's very much dependent on the amount of muscle and fat in the arm and the elasticity of the arm, and so it's not terribly accurate. And we were looking at a device which was similar to that, but employed little strain gauges, very—miniature strain gauges mounted on little rubber plugs on the inside of the cuff so that you could position the cuff right over the artery in the upper arm and get a much more accurate reading, much less dependent on the arm mass, and that was pretty interesting. He went— The gentleman I was working with was on loan from a hospital in England and he went back with the design and the concept. And I haven't seen it popping up in my local physician's office, so I don't (laugh) know whether it ever caught on or whether there were difficulties, but we made a couple of prototypes that seemed to be working very well.

MS: Okay. The next series of questions deal with upper level manager issues. Why was Du Pont chosen instead of GE or some other potential contractor operator?

WJ: Oh I think clearly Du Pont had the capability and the experience that no one else had. Du Pont had been—had been active in atomic energy since the very early days. Crawford Greenewalt, who in 1950 was president of Du Pont, had been assigned as the liaison to the Manhattan District for the Chicago CP-1 reactor, the first nuclear—sustained nuclear chain reaction in the world. And Du Pont had designed, built and operated Hanford, had done much of the early design work on Oak Ridge, had been very heavily involved in that, and then after the war they got—they asked to be relieved of the Hanford contract so that they could put their people back to work on peacetime applications, but they kept a cadre of people working on various AEC projects up until 1950 when they—when AEC started looking for a contractor, and at that point there just simply was no one else in the country who knew as much about atomic energy as Du Pont did and who had the in-house design and engineering and construction capability to design it, build it and operate it. So I think they were the— Well, I've recently gone through some of that material and they were the hands-down (laugh) choice with almost no discussion. Monsanto was mentioned, a couple of other companies as possibilities, but Du Pont was the clear winner.

MS: Yeah I've heard that also because they had the engineering department—

WJ: Yes, they could do their own design in house without having to bring in a lot of architect engineering people and get them trained. And they had their own construction corps, which formed the nucleus of what they needed to build the place.

MS: Right, yeah. Why do you think Du Pont accepted the project? Traditionally they say it's because the president asked them to do it, but it was more complicated than that.

WJ: Well, I really think it was almost that simple. Du Pont saw it as a contribution to the country. They did not want to profit from it. As a matter of fact, early AEC tried to force them to take a fee and Du Pont's position was that they had—because of the—some of the criticism that had occurred after World War I with the merchants of death sort of stuff for organizations that had profited from the war, Du Pont wanted to make no more money from any military-based contract. And so they took it, I believe, almost entirely because of—because they thought it was the national interest and they insisted on the letter from the president. They would not have done it otherwise, Greenewalt made that plain that he would—they would not do it otherwise. Now there were other benefits to Du Pont, fringe benefits. They didn't make any money from it. But of course they did have a large staff of people here who could be transferred back and forth with other Du Pont sites so that they gave them access to a huge technical resource that they could skim off and put where they wanted them. But that was later. Initially it took a lot of good (laugh) people from their commercial operations. So I think it was almost that simple.

MS: Okay.

WJ: Saw it in the national interest and went for it.

MS: The reason I said it that way was it wasn't just that there was like a one-way street. I think there were negotiations with—between Du Pont and the Atomic Energy Commission as to like, We want you to do it. Well we want this and we want—

WJ: Oh yes—

MS: —sort of give and take (unintelligible). The letter was part of that without a doubt.

WJ: Yeah. That's right. I think Du Pont, when they decided that they were going to consider it, also sat down and thought of, Well what are our conditions? And they had several conditions. They said, Well we're not going to do it on the government pay scale because we don't think we can get the people we need. Therefore, we are going to pay— We are going to re— We're going to pay these people and have the same benefits for them as any Du Pont commercial employee. That was part of it. And that went against the grain a little bit, but—because it meant that the Du Pont people were, in general, making more money (laugh) than the AEC people at the site. But it was the only way Du Pont could assure that they could get the high caliber technical folks that they needed. And they said that they would not consider operating the site if they did not design it and build it (laugh) nor would they design it and let somebody else build it. They wanted the whole thing. And that was partly, I think, to protect the integrity of the Du Pont image. They felt that if they designed it, built and operated it, they could control it to do—to be successful, whereas, if they lost any one of those three, there was always the risk that somebody else could mess it up and it would reflect unfavorably on Du Pont.

MS: Right. Okay. How did the organization and management of Savannah River Plant differ from practices at Du Pont's other commercial operations, or did it?

WJ: Well of course I never worked at a Du Pont commercial operation, but I had a lot of interactions with them, and I would say very little. Certainly the employee practices were identical. If Du Pont Commercial had a bad year, there were no bonuses at Savannah River, (laugh) for example. We were part of the Du Pont company and the personnel practices were identical, as were the safety practices and the deign standards and specifications, all of those kinds of things. So I would say that it was very much like a commercial site. There was not a profit motive, of course, but— So there probably wasn't as much emphasis on pleasing the customer. But in terms of the day-to-day operation of the site, it was very similar.

MS: Did the contract with the government offer certain advantages to Du Pont that were not available in its commercial ventures?

WJ: I don't believe so. I can't imagine what they—such advantages might have been. Certainly, they didn't get any patent protection or any of those kinds of things. And they made no money from the contract. So, no, I would think not. The difference, of course, is it allowed them to reimburse or to reimburse their—pay their employees at a higher standard than the government would have, but at the same standard as Du Pont Commercial would have, no more but also no less. So I don't know that Du Pont got any special advantage from it.

MS: Okay. What are the most important organizational structure changes that took place at Savannah River Plant?

WJ: (laugh) Organizational structure changes. Well again, Du Pont was a—was a pretty traditional organization. They changed the names of some of the businesses. I started off Pile Engineering, for example, and they later changed that to Reactor Engineering (laugh) to reflect the current usage of the term. But the organization structure was remarkably inflexible. Du Pont did not change the organization much. Organizations grew and subdivided maybe, but—and a few later in the—late in the game, a few new organizations came into being like the Quality—Site Quality Department and some of those, but the basic organization of the site into Production, Works Engineering, Services, were—was pretty standard and didn't change, certainly not over the first ten years.

MS: What were some of the strengths and some of the weaknesses of the management structures they had at the site?

WJ: Well, I think the strength probably was the very focused (laugh) management. I mean there was no question as to where the focus was. You focused first on safety and then you took care of safety, you took care of your people and then you took care of production, and that was— Safety was always the top priority, but the others came pretty close behind. And I think we talked previously about the people policies, and I think those were—I think they were outstanding. They really worked to get good people into positions where they could move and advance and flourish, and they worked to take care of the people who were not producing well and see if they could find a spot for them. So those were very high. And then there was a lot of pride in the fact that they never missed a production deadline, a delivery deadline. We never failed to deliver to the customer on schedule. So I guess those were the key things.

MS: What about any weaknesses or—

WJ: Well I think Du Pont was accused of being, and justifiably so, of being arrogant. People who started the business were very knowledgeable, very knowledgeable because they'd been in it— I mean, all of the managers, when I came here, were people who had been at Hanford, had been at Argonne, had been at the University of Chicago, had been at Oak Ridge. They were— They knew the business very well. And they knew they knew it, and they were very confident, very self-assured, and I think all of us picked that up and developed the same sort of mindset. And sometimes that took us into areas where we were arrogant, particularly as some of the old hands who were also very experienced in AEC began to leave and new people came on board without much nuclear background when it became ERDA and they brought in people with experience in coal mining and (laugh) that sort of thing. I think we came across, and were, arrogant to a fairly substantial degree because we thought we knew it and we didn't think they always did. (laugh) So that's probably a deficiency of the company.

MS: Okay. Have there been any basic changes or trends in management philosophy during the history of the plant?

WJ: Well I think the big transition from Du Pont to Westinghouse was a major change. And there again, the change was driven by the contract. Du Pont had this contract that said, We will run the plant. We'll run it like any other Du Pont plant, and we will not—that means we will not necessarily comply with all DOE orders and regulations and that sort of thing, and we're not going to make a profit from it. We'll run it our way and you can give us a dollar when we leave. Westinghouse came in and their contract said, We're going to run it in accordance with DOE orders, regulations, procedures, and if you, Mr. Westinghouse, do that, you'll make a profit on it. And so Westinghouse was very acquiescent. The DOE said, Jump, they said How high? Whereas Du Pont might have—would have questioned a lot of the things that were done, Westinghouse would not. They simply did them and charged for it. (laughter)

MS: The next set of questions deal with fuel and target production, the raw materials.

WJ: Yes.

MS: Could you describe the role that this area played in the operation of the plant?

WJ: Well I think the production of the fuel and target components was one of the—was a key—major key to the success of the plant. Again, in the early days, we did not know much about the properties of uranium, certainly did not know much about the properties of some of the other things that went in that were later put in the reactors, had a lot—a major learning experience. We were not— The work at Hanford—

END TAPE 2 OF 3, SIDE 4
BEGIN TAPE 3 OF 3, SIDE 5

MS: Okay.

WJ: Yeah the fuel and target technology— Of course there was no target technology essentially when we started designing the site and, the idea of using mixed lattice charges with fuels and target assemblies only came much later. And as the science developed, as the guys in the laboratory came up with new and improved designs and concepts and the physicists worked out new productions and power capabilities and all that, it fell on the people in the raw materials area to build these things. And many of them were very unique and different, had not been done before. This whole notion of tandem extrusion with composite billets was a new for the nuclear business concept and had not been used very extensively anywhere up until that time. A lot of the work that was done to provide good heat transfer media between the core of the natural uranium slugs or tubes and the aluminum cladding was pioneering because—and very necessary because if you left an airspace between the core and the clad, that had a higher resistance to heat flow and you wound up with a high temperature spot on the side, which might melt its way through and then you had major troubles in the reactor when you exposed the hot uranium to water. It would swell up and release oxide and do all kinds of nasty things. In the early days, we had a number of fuel failures from those kinds of things until we began to get our fabrication processes down to where we could deal with them. So that was very important to the success of the reactors and ultimately to the site.

MS: Okay. How did operations in fuel and target fabrication change over time, and what were some of the most important developments? We've talked about some of those already.

WJ: Yeah I think the most— The first biggest development was going from solid slugs to tubular assemblies, even though the first solid slugs were almost just standard (laugh) solid slug designs with a hole down the middle and aluminum cladding. But it was difficult to get those—to get them sized and tight, to get the bond. And then when we went to the larger tubular designs, that was another major step forward. And when we went to the mixed lattice charges, where we had three so-called driver assemblies which produced neutrons and then three target assemblies which were designed to absorb them, that was another major step forward. So the whole design of the reactor fuel and target assemblies to allow greater productivity and greater power levels was very important.

MS: Okay. What procedures were changed to increase operational efficiency, if there's anything you can add in addition to what we've already said.

WJ: Oh, most of the efficiency— Most of the efficiency improvements came about from increasing power levels. Not all. There were some other efficiencies that were achieved by coming up with different ways of charging and discharging fuel and target assemblies to make the downtime more rapid. And of course one of the biggest ones was to reduce unscheduled shutdowns, to reduce Scrams. In the early days, we had unscheduled shutdowns fairly frequently because of fuel failures and other problems, and as these problems were solved, the reactors got to where they could run for longer and longer periods without having to shut down, and that helped efficiency a lot.

MS: Were there any marked assemblies that were particularly enjoyable to work on?

WJ: No, I don't think so. They were all fun. They were different and they were interesting. Flow zoning sometimes— When I was a flow zoner some of the assemblies gave me problems because they would be—they were not designed to samp—so that the pressure cap sampled individual flow channels, and that made them a little more difficult to flow zone properly. But, no they were all okay. The (laugh) one that wasn't fun to work on was the plate—Mark 3 plate assembly, which was my first job. And that was a nifty design that was virtually impossible to fabricate. (laugh)

MS: Was there ever any consideration given to outsourcing the production of certain elements that went into the fuel and target assemblies?

WJ: No. No. No, there were so few people in the world who knew how to do it.

MS: So aside from raw materials coming in—

WJ: Yes—

MS: Like the material required to—

WJ: Oh yeah. The hous—the housing tubes, the extru—the aluminum extrusions and that sort of things were all—all came from out—offsite, but the actual assembly itself was done onsite.

MS: Okay. The next series of questions deal with reactors. And I think we've already asked this and, maybe we have not. In fact, we have not. Why was heavy water chosen over graphite and natural water for the SRP production reactors?

WJ: Well, you want a coolant which is effective in removing heat from the assembly. In general, the options there were liquid, water or gas—the English elected to go with gas-cooled reactors, or liquid sodium and some of those designs which are used in the breeder reactors. Water certainly is the most simple and most effective coolant available. Then having said that, if you're going to have it cooled with water, what is—what are you going to use to moderate, to slow down the neutrons in the reactor? And again the options there were graphite, which is a pretty effective moderator or water, heavy water, which could be used for that. Graphite had some difficulties, which we were just beginning to recognize in the fifties. It's not dimensionably stable in irradiation field. So it grows and swells and distorts, and that means the channels through which your fuel assemblies go get—warp and twist and do—the dimension changes are not large, but they're enough to be noticeable in something that's as tightly controlled as a nuclear (laugh) reactor. So the ideal was to have water cooling and water moderation. And that pretty much— And then you said, Well do you want heavy water moderated and light water cooled? And that's a possibility, but it just added more complexity to the reactor than if you made the whole thing heavy water, heavy water moderated and cooled. The Canadians had pioneered some—a water cooled reactor in the Chalk River in the—right immediately after the war, and people at Argonne had been running calculations in some limited test, which showed the feasibility of the concept, and so it was a fairly bold decision, but it turned out to be a very valid one. (laugh)

MS: Can you describe the events and the atmosphere in the control room or elsewhere at Savannah River Site when the reactors first went critical?

WJ: I wasn't here for the— I wasn't in a control room when—during the first criticality. At that point, I was in the laboratory, and while I was doing work on the reactors, I did not get into the control room. Control rooms were pretty carefully screened. I covered a lot of startups (laugh) when I was in Reactor Technology several years later, and basically they were not all that tense. They were certainly very focused. Everybody was paying attention to what was going on but it was not— I guess nobody was running around in circles and hollering. (laugh) It was fairly— It was a routine thing—you came in, you did it, and you checked everything very carefully before you moved on to the next stage. So— And the procedures were very specific on how you did that. So you played by the rules basically.

MS: What was the atmosphere like when the reactors were shut down for the last time?

WJ: Well again, I wasn't in any of the areas at that time, but I think generally the atmosphere was one of disappointment, sort of a sense of, Gee we worked so hard, they run so well. (laugh) It's much the same as if a favorite car has to be retired or something like that, but not because they were mechanically unsound or could not be kept going, but simply because the need was no longer there. So I think there was that sense. At the same token, there was some sense that, Well they did the job they were designed for. (laugh) You can't argue with success if you— We succeeded to the point where we put ourselves out of business by ending the arms race, and so that certainly is to the good.

MS: Right. What did you look forward to in doing your job and what did you dislike about it?

WJ: In the reactor business, I found it very challenging to interpret what was going on in these large, complex machines. They were enormously well instrumented, far better than any of the commercial power reactors, very well instrumented, lots of data, and you could find little interesting anomalies that were very challenging. When I was in C-Reactor, we ran a series of tests on something called the xenon oscillation, which has to do with the control of the reactor if the neutron flux becomes unbalanced at some point from one side to the other, and the fact that that unbalance builds in a decay product which takes many hours to show up and then tends to overcompensate it, and so you can actually wind up with the—with a flux level oscillating from side to side. It was a—something that was discovered at Savannah River and had not been anticipated previously, and we wound up—in order to get a really good handle on it, we wound up running a series of tests where we deliberately created such a situation at low—at relatively low power and let it oscillate and watched the oscillation build and then developed—physicists in the laboratory developed a theoretical model for how to correct it. And then we tested that and proved that it did. So you had things like that, that were very interesting, very challenging. Again, in C-Reactor when I was there, we had a small reactor leak. It seeped D_2O into the cavity between the reactor and the thermal shield. And it wasn't a large amount, but it was putting—because it was tritium and the heavy water, and it was putting some tritium up the stack, which was not something we wanted to do. And so we shut down and actually again the Equipment Engineering people and the Construction Division people and the Design Division people deigned a device that went into the reactor through a three-inch hole in the top, went all the way down to the bottom and welded a plate on the interior of the reactor tank, which was a—never been done before. And of course I was a technical supervisor in the reactor at that time, so my guys covered it three shifts around the clock for several weeks and followed that work, and it was very interesting. It was just a lot of interesting, challenging things. And then of course there was always the challenge of trying to optimize the reactor charge and milk the absolute maximum power possible out of the reactor. We set the site record for reactor power in C-Reactor, as a matter of fact. So all of those things were challenging and interesting, as well as the usual personnel (laugh) problems and issues associated with managing a high-tech operation. So it was fun. I enjoyed going to work most of the time.

MS: How was versatility incorporated into the design of the reactors?

WJ: Well the— When then reactors were first conceived, nobody was sure of what they were going to produce. They knew they wanted to make tritium in them, but they weren't that sure that the hydrogen bomb would work and that they (laugh) would really have a need for tritium. It was by no means a certainty. And so the AEC was looking for some sort of fallback position which said, Well we can make plutonium in large quantities if we don't need the tritium. And Du Pont, in the design, designed a very flexible concept which would allow assemblies up to three inches in diameter in a— The only thing that was fixed was the lattice spacing. Everything else could be varied in there. And they provided for individual assembly insertion (unintelligible). And the reactors were capable, then, of doing, oh all kinds of things. They made isotopes that were not even thought of (laugh) in 1950 with assemblies that had not yet been designed and could not have been constructed at that time. They did things like operating small cores in the center of the reactor, leaving all the outer positions vacant and using all the water through about 10 percent of the assemblies, which meant that you were capable of producing very, very high reactor fluxes, neutron fluxes and do a lot of—you could do a lot of pioneering work, you could produce exotic isotopes in small numbers in that kind of charge. And so it was a conscious effort on Du Pont and AEC's part to come up with a flexible design, and they were very, very successful at doing it.

MS: What could have been done to make the reactors better or more versatile, if anything? Was there ever any consideration given to that?

WJ: Oh there were a lot of things that were conceived. There were several pushes to see if we could come up with a way of generating electrical power from the reactors as a byproduct of the production operation. And that came up two or three times that I can remember. And of course the answer was always that, Well it turned out that it just was not economically feasible because the water temperatures were too low and the pressures were too low to come up with any halfway economical system for converting them to electricity, converting that warm water to electricity. That would have been a help but (laugh)—but it would have not been compatible with the initial design (laugh) of the reactor for production. So other than that, they did very well. And of course they were upgraded continuously with better monitoring computers and safety circuits and all that sort of thing. So the— As far as production and versatility, they did very well. The thing they didn't have that was later acquired for power reactors was containment. If you're familiar with the power reactor concept, you see this huge steel dome over the reactor structure, such as HWCTR for example, had such a thing. But that was a later concept. The Savannah River reactors were designed for what we called confinement, which meant that if there were to be an accident in the reactor, the fission products, the debris, would go up the stack and would go—pardon me, up through the ventilation system to the filter compartments on the roof and there it would be trapped 99.97%, I think was the number, would be trapped and very little actual activity would escape up the stack. At the time, that was a very advanced concept and far superior to what was at hand for any of the other reactors. But subsequently, of course, the commercial reactors were required to go to the big steel dome and the containment and all the rest, and then that made the power reactors politically ecologically maybe vulnerable, at least because—because they were different and we had to justify their difference in terms of lower pressure, lower temperature, et cetera, not always successfully.

MS: Did the goal of versatility have a cost in terms of reducing other potential production goals or missions?

WJ: No, the other way around actually. The versatility permitted additional additions which were not visualized at the time the reactors were designed.

Without that versatility, they probably would not have been able to operate for nearly as long.

MS: Okay. Were there any production programs that you were particularly excited about being involved in, were particularly interesting?

WJ: I think there were a lot of— I was excited (laugh) about a lot of our production activities. The production materials for space probes, for example, was a very interesting one. At that time I was no longer in the reactor business, but I was involved with the Equipment Engineering Department people who designed some of the encapsulation and niobium spheres and stuff like that, welding exotic materials under very exacting conditions was—it was a very interesting program and yes, I enjoyed working on that.

MS: What were the most important changes to the reactors?

WJ: I think the improved capability to deal with alarms, starting out with the manual prioritization of alarms and going through the M2 console, which automatically took actions based on a specific combination of alarms, which would indicate a major leak. And then I think that the alarms were one and the second was the monitoring and control capabilities provided by computers. Both of those were new and pioneering work at Savannah River. Both of them far exceeded what was available in any other known reactors at that time, and they were—both took us in the right direction in improving reactor safety and operation.

MS: What were the major operational differences among the five reactors, or were there any?

WJ: Very—basically very few operational differences. The differences that were there were largely dictated by (telephone ringing) the kinds of— Eh—

MS: Did any of the reactors develop a reputation for being better at producing certain products?

WJ: Not substantially. There were minor differences between them, but basically they were so comparable that these differences were pretty small and very subtle, small differences.

MS: What about— How did reactor operators and other personnel feel about a particular reactor being designated the pilot reactor, or was that not a big thing?

WJ: I don't think it was a big thing. I think generally a new—there were so many different charges that each reactor charge was almost always slightly different. There'd be a different mix of targets or there'd be something—some special assembly or— There were so many unique things that were forever coming out to the reactor areas, that everybody was pretty used to them and there were no— The first time you ran a new charge, there were some—there were always a few more physicists from the lab interested and coming around, checking on how things were going and that sort of thing, but basically it was not a big deal usually.

MS: How did security concerns affect the operation of the reactors, and how did that change over time?

WJ: Very— Security concerns really didn't make many changes over—in the operation of the reactors early. They were always behind gates, behind fences. There were always guards. You always had to have a special number and letter on your badge to get into a—to get into any hundred area, and then to (telephone ringing) get into the reactor building specifically you had to have another designation. So that was that. Then later as the concern shifted from the idea of espionage to terrorism, the security requirements got a lot more stringent in terms of you had to have handprint monitors and all of that kind of thing and there were wider belts of obstacles around the reactor and finally they put guards in hardened facilities in the reactor buildings themselves. But in terms of running the reactors, very little difference.

MS: Okay. Was there any appreciable rivalry between reactor personnel, like was there any competition between C-Reactor and R-Reactor?

WJ: Oh I think there was always a little bit of that. Most of the areas took pride in setting records—safety records, production records, whatever. There was, I think, a lot of pride in that sort of thing. There was the same sort of competition to a lesser degree between shifts. I mean, one shift in the reactor building would be—was always telling the other guys how much better they were (laugh), that sort of thing.

MS: Right. How did reactor cycles change over time?

WJ: Cycles got longer and longer, which meant fewer and fewer shutdowns per year, which was—again produced more efficiency in operation, and that made it also easier on the operating people. The operating guys really liked long cycles when things were not—because they stayed relatively constant with time. The short cycles were painful because when you're down is when you have to do the charge and discharge and all of that plus it's the time when you do all the maintenance and so on. The only problem with the long cycles was that it was very difficult to get the maintenance in. If something was going sour on you, one piece of equipment was going bad, a fan or something that you needed, why you had to limp with it, limp along with it until you can get a shutdown to fix it in some cases.

MS: Right, right. How did power ascension affect operations?

WJ: The increasing power with time, put us a lot— Well, I'm not sure it really did all that much. It was a matter of being aware of it, but we were operating against many of the same limits at high power as we were at low power. We had to add things like a little blanket gas pressure was added to increase the boiling point of the water and that allowed us to get a little higher, some things like that, but not greatly, not a great deal, as far as the operating people were concerned.

MS: Right. The next series of questions deal with Separations, in that area.

WJ: I probably can't—

MS: Yeah, some of these we (unintelligible)—if you don't want to deal with them, that's fine, but the first one deals with what were your daily or weekly job responsibilities in Separations?

WJ: I— At— In two of my career assignments, I had Separations interactions when I was in Equipment Engineering, first as the mechanical metallurgical chief supervisor and then later as the superintendent. We did support some of the Separations activities. Primarily, we supported the work in the tritium facility, and that got us into a lot of interesting things with high pressure gas and valves and seals and that sort of thing.

MS: Right. Were there any production programs associated with separations that were particularly interesting that you recall?

WJ: No. Again it was— For me, it was all in the tritium facility. And several of those were very interesting. We did some of the work on fabricating. We did a lot of welding work on how to fabricate reservoirs for weapons that was interesting. We did some work on how to reclaim reservoirs for—and reuse them that was very interesting.

MS: What were the most important changes or process developments in the tritium facilities that you worked in, during the time that you were there?

WJ: I probably can't comment on most of them, I'm sorry.

MS: That's okay. (unintelligible).

WJ: I think we're up against some of the classification rules on this.

MS: Right. Was there any rivalry or competition between F- and H-Area operators?

WJ: There probably was but again, I didn't have that much contact with the Canyon operations. And there may not have been much, but I know there was on things like safety, because there was that competition everywhere (laugh) on the site. There may have been on other things.

MS: It seems that the public generally hears more about reactor operations than about separations in the nuclear industry. Do you think the separations has been slighted as a result of that? Do you think that people that worked there felt they were sort of second-class citizens so to speak or—

WJ: I don't think so. I think everybody understood how the whole site functioned as an entity and you can't—couldn't do without any one part of it.

MS: Okay.

WJ: Can we click that (unintelligible)?

MS: Sure yeah. Let's see, the next set of questions deal with waste treatment, and I've got a note here to ask you about the robot story. (laughter)

WJ: Okay. That was an interesting episode when I was in Equipment Engineering the first time. We had a small pipe freeze on top of one of the waste tanks. And when it froze, the pipe cracked, and a small amount—a very small amount of liquid radioactive waste, seeped down on top of the waste tank. So there was this contaminated area. And this happened on a—I believe it was a Sunday, Sunday afternoon that the incident occurred. And I got a call first thing Monday morning in Equipment Engineering. And they said, Walt, we need some way of getting out there and finding out how bad it is, remotely. We need some sort of device that would go out on to the tank top rather than putting people out there because we're not exactly sure where the problem is or how bad it is. And I said, Okay. And it happened we had just seen, at one of the trade shows, a demonstration of a robot which was being built in Canada. It was a very simple robot at the time. It represented state of the art, but it was a little six-wheeled robot about maybe four feet long and electric power through a long umbilical cord to a control box. And it could be— Matter of fact, they were using it for bomb disposal and were use—they had made it for police departments to use for that kind of thing. And I remembered seeing this. So— Because I was told that this was a super high priority and the design—idea was to cut down on personnel exposure, which meant that there was probably nothing more important, I called the manufacturer and I said, I'd like to buy one of your robots. How soon can you get it to me? And he said, Oh well— The guy on the other end said, Well— He said, You have to understand that we have about a six-month backlog on robots. And I said, Well, I said, You need to understand that I want the robot immediately. He said Well, he said, The best I could do is—he said, I can probably shuffle priorities and maybe get you one in about two to three months. And I said, Okay. I said, Let's put it another way. I said, Who are you selling the robot that's being finished this week to, (laughter) because I'll buy it from your customer. And he said— There was this long pause. He said, Oh you're serious. (laughter) I said, I am serious. We need a robot and we need it quickly. He said, How quickly if I could give you what you want? I said, I want it here before the end of the week with a technician that will help us set it up while my guys design and build some special monitoring equipment to go on it. And he said, You're really serious. I said, You got it. I said, I know what the robot costs because at the trade show you advertised it. But I said, We'll pay you whatever premium is required to get that kind of delivery. He said, Let me call you back. (laughter) He called me back in about—I forget, maybe a couple of hours and he said— He said, We think we can get a robot to you. We can probably ship it by rail by the end of the week. And I said, Nope. I said, What I want you to do is rent a truck and drive it straight through with the technician in it so that I am sure that the robot and the technician arrive the same time. Now could you do that by Friday? And he said, Yes. And he quoted the price and I said, Great, I'll take care of the paperwork. I said, I'll take care of the paperwork, you take care of the robot. (laughter) So I called procurement and told them what date that they needed to cut a check (laugh) and that it was a site emergency. And then I told my boss that I had done this. And then I sent—got my guys together and I said, Now what are we going to carry on this robot? I'm not sure exactly what's going to be required, but what kind of instruments do we need to get the data and what kind of controls do we need to move these instruments? How are we going to do that? And what do we have to setup so that we can make any special parts we need over the weekend? And so when the robot rolled in Friday afternoon, when the truck pulled up to the loading bay, I had my gang, a couple of engineers, a draftsman, two or three machinists and a couple of E&I mechanics all sitting around waiting for it. And we unloaded it, they checked out how to run it and started building the hardware to hang the instruments on. And first thing Monday morning we delivered it to the area ready to go, one week. And that's the first robot that was used at Savannah River, and it worked like a little—

MS: When was this?

WJ: That was when I was in Equipment Engineering the first time, so it would have been somewhere probably around '77, in that ballpark, '77, '78.

And it worked like a little charm. We called it Ed, the EED robot. (laugh) But I mean those kinds of things, when you had an emergency, you could—could be done without going through all the red tape and the negotiated contracts and the legal boilerplate. (laugh)

MS: If it had to happen, it could be made to happen?

WJ: Yes, when I had to happen it could go very, very quickly.

MS: Okay. How did the storage and treatment of waste change during your experience in Waste treatment?

WJ: Well of course the biggest change was when we developed the Defense Waste Processing Facility, DWPF. Up to that point, we had been storing highly radioactive liquid waste in underground storage tanks. And although those performed safely, we had minimal kinds of problems with them, there was always the concern that we could have a problem and release that very, very dangerous liquid waste. DWPF was one of the few—I think it was the only facility that Du Pont ever lobbied for aggressively. In general, Du Pont did not try to promote new missions for the site; it simply took what DOE said they wanted and tried to do it. DWPF was the exception because Du Pont had left Hanford with waste in storage tanks when they turned over the contract, and they were— And by that time, some of those tanks were beginning to have leak problems and so on, and DuPont was really concerned that something similar to could happen at Savannah River. And so they actively sent people to Washington and lobbied congressmen and lobbied AEC and really worked to get the DWPF at Savannah River, and that, of course, was a major accomplishment. And the technology was very interesting and again, unique at the time. We—Equipment Engineering developed the closure process for the canister, the radioactive waste canister, which is a very unusual welding process involving putting a large—a massive amount of current into a plug which is—which is oversized to fit into a hole, putting a huge amount of current through it and then a lot of pressure and literally getting the edges of the plug red hot and plunging it into the hole and—called upset welding. And at the time we conceived this design, several of the country's noted welding experts told us it would not work. And we decided to go ahead and do it anyway, because we thought it had a high potential for working, and sure enough it did, and made beautiful welds.

MS: Did your job change any as far as your relationship with or your knowledge of Waste Treatment as more attention came to be paid to waste treatment by the general public because of increased concerns over environmental issues?

WJ: No, my last real connection with the waste treatment business was DWPF. That was the last time I was involved in design for the Separations or the Waste Treatment areas. So I was not involved during the big emphasis on ecological concerns except peripherally. I was aware of them, but I was not personally involved in much of that.

MS: Okay. The next batch of questions deal with Health Protection. Can you describe, in general, the health protection measures taken at SRS to provide safe working conditions?

WJ: Oh yeah. The health protection was regarded as a key part of the overall safety performance requirement. The keys were an organization which routinely surveyed any area where radiation or contamination might be present, so that you always knew in advance what was there. And as part of the survey— Then once the survey was done, the Health Protection organization would specify what kind of requirements there were for entrance into and work within this area, and they'd set up things like step-off pads, where you could pull off shoe covers and put them in the contaminated bags and that sort of thing. They'd say whether you needed lab coats to— A lot of places would need a lab coat to observe, but if you were going to work you had to wear white coveralls, you had to have one or two pairs of gloves, you had to have monitoring equipment, usually both a gamma monitor, a film badge and a pencil which monitored particulate radiation. You might have to have breathing air protection, and in the worst cases you wound up inside a plastic suit (laugh) with its own air supply, which was very uncomfortable work, but made it possible to work in a highly contaminated atmosphere.

MS: What were the most important measures taken to insure worker health and safety?

WJ: I think—(laugh) I think the safety engineer organization that was set up was very important. The safety engineers were generally people with substantial site experience. Many of them were guys who had come up through the ranks, foremen and that kind of job, in the production organizations, and who were trained extensively in OSHA, Occupational Safe—

END TAPE 3 OF 3, SIDE 5
BEGIN TAPE 3 OF 3, SIDE 6

MS: Okay.

WJ: —in plant safety requirements and so on. And these guys—they were set up in their own department. They generated statistics every month on injury frequencies by organization so that if you had any kind of minor injury trend, it was instantly obvious to everybody in management. There were monthly meetings in which the safety engineers reported that kind of data to the whole staff. And they had absolute access to the plant manager. So if they ran into a department superintendent who was stonewalling a safety inspection or a—had a safety concern that he was unwilling to address, they could go to the plant manager and get that situation corrected instantly. (laugh) So it was a— It was a very intense, very focused effort. Safety engineers were keys to it. But then in addition, every month every manager took a—did a safety inspection with one of the safety engineers in an area that he was responsible for and all of the subordinates did safety inspections. So there were continually people out—nosing around (laugh) all of the areas, not just the operating areas, but the administrative areas and down in the basements and up in the—up in the unused spaces of buildings looking for potential safety hazards or violations, and it was a very thorough system. And when you found something like that, it got written up and it got corrected because safety violations had the top priority for the maintenance department. So if the time— If a maintenance crew was working on one thing in an area, working on a production job, and the safety engineer came in with a hot safety item, they'd drop the production job and go do it, yeah. (laugh) So—

MS: I guess you sort of already answered this, but what powers did health protection workers have to locate, stop and change unsafe conditions?

WJ: Well they had stop work authority. If an HP inspector found that you were doing something that he or she didn't think was the right thing to do, they'd stop it, right on the spot, so would a safety engineer. And people stopped because you knew that if you didn't, they could go right to the plant (laugh) manager if they needed to. So when a stop work was called, it was—it happened. (laugh)

MS: Right, yeah. Let's see, the last batch of questions deal with specific products other than the military products. What were the— Out of those, what were the most important items that were produced at SRP?

WJ: I think the most important ones were the space products, because they enabled space probes and explorations that would have not been possible without them. There was no way we could have done some of the deep space. Even the moon shots, where we—where they planted isotopic generators on the moon and they sent back data for—

MS: You talking about plutonium-238?

WJ: Yeah. Yep. They sent back good data for decades, which would have not have been possible with anything else that we knew how to do. And certainly the deep space probes, where they were off for several years en route and still functional when they got there, could not have been done without the isotopic power sources. So I think those were the most significant non-weapons. And then the second order were the research products. A lot of the elements beyond, oh californium and the other elements that were out there and the—I don't know what the cutoff would have been, about 246 or 7, something like that, a lot of those forerunners were made at Savannah River and processed in the lab to produce amounts that could then be characterized and understood and fitted into the periodic table. Nobel prizes were won (laugh) on the basis of isotopes that were produced at Savannah River Site. That was important to (unintelligible) back the frontier of human knowledge and understanding the structure of elements and the whole atomic system.

MS: Was there much of a market for californium?

WJ: No, I don't think so. Californium was one of several things that we produced and tried to interest people in. It was an interesting element as a research vehicle, but it turned out that the market was quite small. We also produced cobalt at a time when cobalt was being considered for use in food irradiators, as an alternative to x-ray machines and those kinds of things, we produced cobalt-60, and produced quite a lot of it and some very, very high specific energy cobalt sources. And some of that's—I understand the food irradiator, the Arby food irradiator is still using SRP cobalt. I'm not a hundred percent sure of that, but I know as of half a dozen years ago they were still using it. But again, the market just never materialized, largely because of public misunderstanding what the effects might be from it and—so that it never really took hold.

MS: Right, yeah. Okay. I think that concludes our organized list of questions. Well let me thank you again for taking the time to do the interview. I appreciate it.

WJ: Well my pleasure. It's— I've always been proud of what we did at Savannah River, and it's good to see that some of it is being captured and will be documented historically so in the future people can understand us better. So thank you.

MS: Thank you.

END OF INTERVIEW

Oral History Interview – Gerald Merz

Gerald Merz was a long-time employee with Savannah River Site, beginning in 1956. He spent most of his career in Reactor Technology, and during most of that time was stationed in first R area and then C Area. Merz held a number of other positions at the plant as well. He spent some time in the 703-A administration building. He also spent about ten years in the Savannah River Laboratory, working on research and design. Even so, all of his work was centered around reactors and the things that made them work, such as raw materials and heavy water. By the time Merz retired from the plant in 1989, he was superintendent of Reactor Technology. After a number of years of consulting for Westinghouse and others, he retired in the mid-1990s. He is currently living in Augusta, Georgia, and is still an avid cyclist.

Interviewee: Gerald Merz
Interviewer: Mark Swanson
Date of Interview: September 11, 2006

M. Swanson: This is an interview with Gerry Merz, and it is now September 11, 2006 at ten o'clock. And Mr. Merz, if you would state your name and affiliation with Savannah River Site.

G. Merz: Name is Gerald, G-e-r-a-l-d, Merz, M-e-r-z, currently not affiliated with Savannah River Site at all. I hired in at Savannah River Site with Du Pont in 1956 and retired from Du Pont in 1989, went into the consulting business for another half a dozen years and then retired again in the mid-nineties and this time it stuck, so for the last ten years I have not been associated with anybody.

MS: And you've already stated when you started working at the plant.

GM: In '56.

MS: Which reactors did you work at, or were you most familiar with?

GM: Well I was actually stationed in the reactor building in R area and C Area. A lot of my time was in an office building named 706-C, which was an old Butler building that they had originally built for an office building. In addition to that, I spent some time in 703-A, which is the administrative area. And I spent about ten years in the Lab, Savannah River Lab, as opposed to SRP, Savannah River Plant—the distinction being the plant is the production facilities, the lab is the R&D facilities. So I split my time between the two, but in all cases, associated with reactors, with raw materials, with heavy water, with everything but separations and waste management.

MS: Well it sounds like the next question is going to be kind of difficult to answer. I was going to say, what was your typical workday like. (laughter)

GM: Get up early, beat the carpool, suck my thumb. (laughter) No, the job that I left, that I retired from, was called superintendent of Reactor Technology, or Reactor and Raw Materials Technology. Under me were about, oh a hundred or so technical people—engineers, chemists, physicists, who did the technical support work, safety studies, efficiency, production studies, for the reactor areas, for the raw materials area and for a little while for the heavy water area, but that was being phased out by about the time I got into it. So a typical day for me towards the end of my career was, get the morning phone calls to see what was going on during the night, and if I showed up at work in the morning and hadn't gotten any calls during the night, it's a good day so no need to be in a hurry, and then discuss it with plant management and with Wilmington, Du Pont corporate management. And then typically read documents that any of these people have prepared, go out to the areas, wander around, talk to people, see what's going on, keep a finger on the pulse of the reactors basically.

MS: Out of curiosity, which reactor was your favorite?

GM: Oh I guess I'd have to say R Area, that's where I spent my childhood. (laugh) I went out to R Area when I was first hired in, that was one of m first assignments. And R is the oldest one. It's, of course, in the worst condition of all of them right now, but just because I was—that was the first one I ever saw, I guess I have a soft spot in my heart for it.

MS: Did you have any dealings with the experimental reactors in 777?

GM: In passing. I was never assigned to them, but worked with the people who were in them. In general, what they were doing was research, development in support of reactor operations, and in effect pioneering the stuff we were going to do next year in the production reactors. So my interest was in the production reactors, but I had to see what's coming down the road and talk to the people who were doing the research.

MS: Okay. What was a typical reactor operating cycle like? I realize that depends on what they made—

GM: No such thing. That's it. You hit it. One of the products we made was a thing named californium.

MS: The transplutonium?

GM: Very trans, yeah. It's element 252. When you start out with it, you put 238 in the reactor and you got to hit it with fourteen successive neutrons to get it up to 252. And had very unusual properties in demand made in microgram quantities. The operating cycle to make that was five days. Every five days, we would shutdown, discharge, recharge the reactors, start back up again, and operate at extremely high specific powers, factor of a hundred or more higher than say a power reactor would. And the reason for that is, as I mentioned, you have to have those fourteen neutron absorptions in a row. And some of the things, the intermediate products, are very short half-lifed, so you got to hit them quick or they're gone. So that's the reason for the very high specific power. And a very different mode of operation when you're up and down every five days, there's a premium on efficiency and, for instance, the best record for charging, discharging, shut down, discharge, recharge, start up again– fifteen hours. And you're used to hearing a power reactor takes a month or more to do that kind of thing.
On the other end of the spectrum would be the tritium producer charges. Our two major products were plutonium and tritium. And for tritium, you'd like to operate the reactor uninterrupted for as long as you possibly can.

MS: For which one now?

GM: For tritium. And if you could operate it a year without ever shutting down, that's what you'd do if you could. And our other major product was plutonium, and that was kind of an intermediate position. The operating cycles would be a month or two. So it ranged from five days to many months, the operating cycles.

MS: We talked about some of the products that were made, whether it was plutonium, tritium and we mentioned some of the transplutonium elements as well, like californium. What about some of the heat sources they made?

GM: Yeah, the primary one was plutonium-238. The weapons plutonium is plutonium-239. And they're entirely different. You'd never know they were cousins. You make them different, they behave different, they react different, you use them for different things. And the plutonium-238, I guess I would rate as our third product in terms of how much of it we made—plutonium and tritium being one and two and plutonium-238 number three. And that was used for heat sources for space missions. You may have heard just several months ago a space shot named Cassini just went up to explore the outer planets. Some of the plutonium-238 that we made a dozen years or so ago was on that one.

MS: I heard about cobalt-60. I know that's not as popular as Plutonium-238, but that was also (unintelligible).

GM: No, not particularly. No, it's a very, very intense gamma source, plutonium-238 is not. The difference being that cobalt, you need much, much more shielding to handle the stuff which is incompatible with space missions. I mean once you get it up you don't care, but it would really require a lot of lead in the handling going up to loading it, ready to shoot it up. So—

MS: That might be counterproductive because of the weight and everything.

GM: Yeah. Cobalt was used primarily as a radiology source, x-ray source, to make piping inspections. Let's see, what else? It was— We made a lot of it— Well for radiation effects. I know when we were making the californium at the very, very high specific powers, we also made some plutonium at the same time to get the most intense radioactive source out of the cobalt that we could get, and we used that for measuring radiation properties of other materials. If we wanted to know could something stand up to high doses of radiation, we'd run it into this array of high-specific activity cobalt and just cook the daylights out of it and see how it did. Cobalt-americium, we made some of. One of the uses for that is fire detectors. The things hanging up in the ceilings have a smidgen of americium in them.

MS: Is that typical for fire alarms?

GM: Yeah. The americium is radioactive and it ionizes the air, or the smoke that's in it or anything else that's in it and produces an electrical current that makes it say "beep beep" if it sees smoke by the effect that the radiation has on the smoke. And it is such a very, very small amount that the things are very safe to handle. You don't get any radioactive dose; you get more from the ground than you do from the ceiling.

MS: I didn't realize that. In the operation of the reactors, I know typically they would bring the fuels in by truck, if I'm not mistaken, but then the final product went out by rail.

GM: Yes.

MS: Is that just in the early days or did they use rail throughout?

GM: No, used rail throughout. And the reason for it is the stuff that comes out of the reactor is intensely radioactive, and you have to load it up under water in a big lead cask, then lift the cask up out of the water, put it on the railroad car. And the reason the railroad car is this lead cask that you ship it in, weighed, I don't know, 70 tons, something like that, which is a bit much for sticking on a flatbed truck. And then you'd drive it right into the Canyon buildings that you've heard about for the reprocessing. On the truck coming in, the fuel has been fabricated in another part of the plant in the so-called 300 Area. And it's not particularly radioactive; it's shipped in aluminum boxes, typically, so there's no high weight requirement or anything and trucks work fine.

MS: As a rule, how many people worked in each reactor area?

GM: I'm thinking about four hundred, maybe somewhat less than that in some of the reactors. I recall when R Area was retired from service in 1964, 450 people worked out of it at that time. I'm thinking in later years in other reactors, it was somewhat less than that, but for good round numbers maybe four hundred. And this includes not only the operating people but all the support people, Health Physics, Power department.

MS: Right all that stuff, and why did they determine to have like a separate powerhouse at each reactor?

GM: Because the reactors are very, very dependent on electricity. You have two cooling systems that much work—the primary, which is a closed-loop, D_2O recirculating system, and then the secondary which is river water. And the water is taken out of the river at the pumphouse, at the river, pumped, ten, fifteen miles, whatever, to a 50 million gallon reservoir in each reactor area, and then pumped from there through the heat exchangers and back to the river again. And all of this requires electricity. And the powerhouses at each area are the least of the redundant power supplies that we have out there. We've got a whole bunch of diesel generators for various purposes, the electricity backup—backs up everything, but a lot of individual things, like the primary recirculating motors, every one of them, six of them, in addition to the big AC-powered motor powered from the grid, the powerhouse has its own dedicated diesel that is online all the time, needed or not, gulping down the diesel oil. Just in case there is a power failure, the pumps will keep spinning at a reduced but adequate flow rate.

So the original thought was we would have two lines coming from offsite, thought to be independent lines coming from the Burkhardt plant, I don't know if you ever heard of that, in Beech Island, small town near here. When I say thought to be independent, we found out subsequently that that's not quite true. Then another larger power plant in the heavy water area of the plant that supplies the entire plant grid. And then four out of the five reactors have their own small powerhouse that provides electricity or could, to that particular reactor. The fifth reactor, C-reactor, the youngest one, didn't have that because we concluded it just wasn't necessary. And the reason we concluded that is we got another off-site power supply, another tie-in to an off-site grid.

MS: Wow. How did the higher power levels they achieved later on the 1950s—how did that affect reactor operation?

GM: It meant that all the operating cycles were shorter. And for instance, on plutonium production, you have to cook it to—for lack of a better word, I'd say medium rare. Overcooked is bad, undercooked is bad. So to get to that desired degree of cooking, how long it takes depends on how fast you're doing it, which is power level. So if you double the power level, you have the time it takes to get to the product quality that you want. It also means pumping twice as much water on both the primary and the secondary side.

MS: Yeah, I could be wrong on this, but I think they initially had like twelve heat exchangers in C-reactor, but the others had to be changed out. And there were six and they bumped it up to twelve.

GM: Yeah, and put twelve of them in parallel, even in C, thinking I recall originally they were in series, pairs and series. Yeah, but what they had to do is they had to arrange the heat exchangers, put new ones in most of the areas, increase the pumping capacity at the river, at the local pond reservoir, on the primary loop, bigger motors, bigger pumps, and built a big lake, Par Pond out there, just because they could not get all the water they needed from the river, so they built the pond as an additional raw water supply.

MS: Right, yeah. The fact that you had—it could be so hot here in the summer, did that have any effect on the operating of the reactor?

GM: Oh yes. Yeah, the amount of power you can get out of the reactor depends on the inlet river water temperature. So the hotter the water gets, the river water, the less power you can get out of the reactor. And the river water temperatures range from in the coldest days that we got an extended freeze, the river water temperatures could get down into the thirties. In the summer, they can get up into the eighties, Fahrenheit. And each degree of temperature elevation is that much less power you get out of the reactor—very much different than, for instance, a power reactor at Plant Vogtle, and then they operate at constant power. Savannah River Plant, we don't, it floats with the river water temperature.

MS: How did reactor security change over time?

GM: Very much so. Originally, Du Pont provided the security. We had our own, in effect guards, police force, many security measures. One of them that we originally had is to get into a reactor building, you had to go through two fences, two gates, and everybody has a badge that they wear all the time, everywhere, which gets you through the first gate. To get through the second gate, you got to give that badge to the guard. He takes it over to another badge rack and finds another one with the same picture on it and swaps with you, which is kind of a simpleminded thing to do but very effective, because they have to have your badge picture on file, not just have you show up with something. Okay in early eighties, at that time, this was designed to keep people out who shouldn't be in, and it was a guarding of information. We didn't want people who had no need to know, to get into a reactor area and see things that they have no need to know. And we guarded information.

In the eighties, the emphasis on security changed and the emphasis now was more towards guarding facilities. The information was starting to be declassified over the years anyway, so there wasn't that much emphasis on guarding information. But terrorism was starting to be noticed worldwide. At that time, DOE, in their shifting emphasis towards safeguarding facilities rather than information, asked Du Pont to buck up their security force to have things like SWAT teams, helicopters, stuff like that. The Du Pont reaction was, We're not in that business. We're a chemical company. Could you get somebody else to do it? Which they did—they got Wackenhut, who has been doing it every since. And they know the business. That's the business they're in.

MS: Wackenhut came in about 1982, '83?

GM: Yeah, it was early eighties, yeah. And at that time, DuPont phased out of the facility safeguarding. We were still involved in the information safeguarding, because we worked with information everyday.

MS: This is sort of like a little bit off the chart here, but I know in the early days, they actually had military installations.

GM: Yeah.

MS: Anti-aircraft installations at Savannah River Site?

GM: Yeah, there were radar sites. There's still— Well I don't know whether it's—the remains of one out by the Aiken Airport, there used to be a radar station. There were several anti-aircraft gun sites on the plant site itself.

MS: Were they located like at individual reactors—

GM: No. To protect the site. And—

MS: That was just in the fifties, though, right?

GM: Yeah. And again, that was at the height of the cold war and the Russian threat was viewed as real, well, was real.

MS: And that's also back the days before, as I understand it, before they had serious— There was more of a threat from aircraft coming over the Arctic Circle than it was from rockets—

GM: Yes.

MS: Because obviously, they're not going to be able to shoot down a rocket probably.

GM: No. (laughter). People wonder about whether we can these days or not.

MS: Right, right, well that's true.

GM: That's a tough shot.

MS: eah that's true. Talking about changes over time, how did reactor safety and the measures for reactor safety, how did that change over time?

GM: Well, it was an evolution when the SRP reactors were first designed, starting in the early fifties, there was nothing else. There was no commercial industry. In fact, commercial nuclear power was illegal, under the Atomic Energy Act of 1946, and did not become legal until the Atomic Energy Act of '54, at which point the Savannah River reactors were already operating, much less designed. So in the early days, we did what we thought was reasonable and prudent, and it was in the judgment of the Atomic Energy Commission, the Du Pont company, and their consultants, others. GE was, Schenectady, very much involved in the atomic energy business. But those involved—and there was primarily research reactors at the time, not production reactors—did what they thought was prudent. The only reactor experience, at the time, was the Hanford Plant, which was built back in the forties. And that originally was a design built by Du Pont too, so Du Pont did have the benefit of that experience. Du Pont then got out of that one in '45 or '46 or so after the war, and GE took it over and it has since changed

hands several times since then.
But with the growth of the commercial industry, which as I say, was not allowed—was not even legal until '54, the commercial industry started sprouting up. They took a lot of their reactor safety information, their best practices, from Savannah River Plant, because that's all there was at the time. As the commercial industry grew, it got to be a mutual exchange of information and certainly the commercial industry then grew and grew and grew and outran Savannah River Plant, which was by that time getting stagnant or decreasing, as reactors were shut down and cold war was easing down.
Certainly, for all of us, Three Mile Island and Chernobyl were kicks in the pants, and there were studies in the commercial industry, in our industry, on, What does all this mean to us? And both Three Mile Island and Chernobyl were different, very different types of reactors, particularly Chernobyl. But Three Mile Island was a very different type of reactor from the Savannah River Plant reactors. So certainly there were lessons to be learned as far as operating practices—how you do procedures, training, that kind of thing, from the hardware point of view, maybe to a lesser extent. One of the things that the commercial industry were building for themselves, and we didn't have and we wanted real bad, was a reactor simulator to use to train the operators on, similar to a flight simulator for pilots. And we and Department of Energy came to the conclusion that we better get on with that one, because that was one of the lessons of Three Mile Island. And we agreed, we got the money and we did it, built us a simulator, which—

MS: In other words, so you can train reactors how to operate—

GM: Train the reactor operators—

MS: Before they actually get to a reactor.

GM: Yeah, and to simulate accidents. A reactor operator is like a pilot of an airplane, kind of a boring job, routinely, but boy you better get with it quick if something goes wrong. And the advantage of the simulator is you can have something go wrong for free and learn how to react to it.

MS: Now these reactor simulators, they actually got these—

GM: Yes. Well, got it. We had one simulator.

MS: Where was that?

GM: In C Area. Not in the reactor building, but in an office building. And it was an exact duplicate of the K-reactor control room. But all five of ours were sufficiently similar that we thought one was adequate to simulate all.

MS: Right. Before I ask this other question, let me ask about neutrinos. Were you involved at all in the search for neutrinos?

GM: Oh yes.

MS: I know—a lot of that went on in P-reactor.

GM: Yeah, well there were two parallel efforts—P-reactor, which I wasn't involved with at all. And they were the first ones. But there was a parallel effort going on in R Area by the Brookhaven folks, and I was very much involved in that one, because that was during the period when I was actually assigned to the R-reactor building. And one of the things that I still recall is the fellow running the experiments for Brookhaven was a fellow named Dr. Ray Davis. And I was a rookie engineer, right out of college. I didn't have any—I'd never heard of neutrinos, much less knew what they were, and he attempted to explain it to me and maybe I had a little trouble understanding things with no mass, with no magnetism, with no nothing, but they're there. And the analogy he made is, If you started a neutrino from the earth, aimed it at the moon through 240,000 miles of lead rather than space, it would be even odds that the neutrino would get there, 240,000 miles of lead, even odds of stopping it. (laugh)

MS: Yes, that's pretty hard to fathom. I've heard that before where a neutrino can go right through the earth or something. It's like, Okay. (laughter) I'll take your word for it.

GM: It was an interesting experiment and I kept track of it, not because they needed any particular help from me, but because it was interesting stuff.

MS: Now why did they select P-reactor? Was it just available, or was there any particular reason for P?

GM: Not that I know of, or R for the other experiments. The only reason that I can think of is R and P were the first two reactors. The reactors are pretty much the same as L, K and C, but the buildings are very different and much larger, more space. So R and P may have been selected just for space availability and easier access to move huge equipment around. The P Area experiment, I'm not that familiar with. The R Area one, we had tons and tons of tanks full of carbon tetrachloride, and we tried to absorb the neutrinos in the carbon tetrachloride because if a neutrino interacts with chlorine, it does give a flash, a photon, that can be observed, can be measured—not by eyeballs but by very delicate instruments. So the objective there was to get lots and lots of chlorine as carbon tet as close as possible to the reactor to get the highest neutrino flux you can and look for the occasional flash like counts per day.

MS: Talking about neutrinos being in like P- and R-reactor, were there any reactors that were considered better for some products than for others or was there nothing with that?

GM: No. I'd rate them all as equivalent. C Area was the youngest one and the reactor itself was a little different in C—bigger in diameter, to give an extra foot or less, eight inches of heavy water around the outside of the core, which acts as a reflector, which means neutrons which would otherwise be lost in the shielding, get bounced back into the reactor. So it made C Area a little more efficient than the other four. But other than that, they were pretty much interchangeable. R Area, for whatever the reasons, was selected as the fuel development reactor and when the lab folks would come up with new types of fuel, and we went through many generations of fuel designs in our reactors, they would usually be tested in R Area. Again, I don't know that there was any particular reason for that other than—

MS: So they'd be tested in R?

GM: Yeah. And I suspect the reason for it was R was the first one in the fuel development programs started early in our history.

MS: And it could be too because they had more space in R.

GM: Yeah, but once you started in one area, you'd just as soon keep going there rather than spread it out. Because some of the experiments were failures, and that makes small messes.

MS: What did they eventually come up with as far as the most efficient— I know they had the different marks and everything, the elements that went into the reactor. What was the most efficient for plutonium at the end?

GM: Let's see, I think we were—at the end operating a thing called a Mark-16, Mark-31. And I assume that was the best we could do, because that's what we were doing at the end after we had tried many other things.

MS: Right. And that was the best for plutonium production, wasn't it?

GM: Yes.

MS: And as far as tritium, what did they use for that?

GM: That was a thing named Mark-22.

MS: Okay.

GM: Very, very different designs, just because the two products are unrelated, entirely different technology.

MS: Yeah and when they got to separations area, that's totally different processing.

GM: Oh yeah, entirely different technology.

MS: Mark-22's got to be virtually vaporized. (laugh)

GM: Well, in the Mark-22 you had two different types of tubes named fuel and target. The fuel was uranium-235 and aluminum. The target was lithium and aluminum. And the plutonium producer, the Mark-16, was uranium-235 and aluminum, very similar to part of the tubes in Mark-22. So both of them got processed identically in H area. The lithium tubes were then something very different, and the Mark-31s, which were uranium metal slugs, not uranium-aluminum—something entirely different too, and they were processed in F area, the others in H area.

MS: Were you involved in the HWCTR project at all—the Heavy Water Components Test Reactor?

GM: Not directly. I stayed basically informed on it, knowing what's going on, but was never assigned to HWCTR or worked in it.

MS: Well we've mentioned the transplutonium program already. When was that probably at its peak, the operation of transplutonium?

GM: When you say transplutonium, I guess I don't identify any particular program as transplutonium.

MS: I guess like a generic term for the whole range of everything from americium up to californium.

GM: Mid-sixties to mid-seventies.

MS: That was pretty much pushed by Glenn Seaborg, wasn't it?

GM: Yeah. From the reactor point of view, those were probably what I'd call the exciting years because we were doing many different things. The californium production was also in that same time period.

MS: And did they ever find any good uses for californium or— You mentioned the americium that goes into the fire alarms.

GM: Yeah, medicinal uses. The thing that is distinctly different about californium is it is a neutron emitter. When it decays, it's got a—I think a 2, 2½ year half-life. Most things, when they decay, give off alpha, beta, gammas. Californium gives off neutrons. And normally you need a big hunk of equipment to make neutrons, like a reactor, accelerator, something like that.

They used it for cancer treatments, made implantable seeds. And exactly what type of cancers you'd want to treat with neutrons instead of anything else, I don't know. I'm not that familiar with the medical end of it.
I think it was also used for radiography of pipes. It had some safeguard uses, because when you shoot neutrons at things, you make them slightly radioactive. You can then look at the radiation spectrum you're getting off of it, and tell what's in the sample. So for instance, if you walk in here with a box and I suspect you have some plutonium in it, I could put californium on one side, and a detector on the other side and tell whether you did or not. Used in very small quantifies, the typical quantity used for things was micrograms. The other thing that we used it for a lot is for a neutron source in a reactor. And what you'd like to do when you start up a reactor is to have a source of neutrons in it and then as you take absorber control rods out, you measure the response of the reactor to those neutrons, and it should get what you've heard people talk about, multiplication. And that's what happens is the neutron's intensity gets multiplied. But you have to have—you can't multiply a zero, so you want to have some neutrons in there for starters.

MS: I think we talked about this some too, like how did reactor cycles different with some of the transplutonium elements versus the regular plutonium?

GM: The cycles depend on what you're making, and for the transplutoniums, your initial target, what you always start out with, is uranium-238. When you're making plutonium—weapons plutonium, that's plutonium-239. So you've got to hit that 238 with one neutron. And when you do that, you make neptunium, which then decays into plutonium, which you separate out in F Area. If you're going up the chain and want to make americium, curium, all of the way up to californium, initially going up to about element 244 or thereabouts from 238 to 244, you just want to cook it and cook it and cook it and cook it and get rid of, in effect, all of the intermediate products and end up with as much 244—that would be a curium, as you can. You then reprocess it, separate it out, make a target out of the 244. And then to take it up from 244 to say 252, which would be californium, you really want to run, run with it and go as quick as you can. And that's why the high flux—the high specific power cycles, the five-day cycles.

MS: How long would it typically take to prepare a cycle, changing out all of the rods and stuff like that before they go down to the reactor?

GM: To actually get them in and out of the reactor or to make them—to start with a hunk of aluminum and a hunk of uranium?

MS: Well, let's assume they've already been made in the 300 Area and they're at the reactor. How long would it take to actually let's say pull out the old stuff, take it to Disassembly and—

GM: Couple of days. As I said, the modern record that we set in one of those californium charges was 15 hours. And those particular charges just had one hundred assemblies in them, which is one of the reasons it went quick. A typical reactor core would have five or six hundred assemblies. And that could take two, maybe three days.

MS: How many people would been working on something like that at that end of it, changing out the—

GM: Dozens, not hundreds but dozens. And of course a reactor shutdown can be a lot longer than that if there are more things to do, and there usually are, than just unloading and reloading the reactor, like if we have annual maintenance testing, everything in the reactor, all the safety systems, which normally are not used because hopefully nothing has gone wrong. If you give them some exercise typically once a year to make sure they're working. And there is a lot of maintenance work to be done. There is new equipment to be installed. So typically maybe once a year we'd have a shutdown that lasted a month instead of a week.

MS: What about reactor leaks and stuff like that? I know that R-reactor supposedly had some leaks before it was closed down in '64, I think.

GM: Yes, it did.

MS: And C had a couple problems I think, some kind of special joint something.

GM: Yeah. We are very fussy about leaks, just because heavy water— It's extracted from the Savannah River. It's a natural, non-radioactive occurring isotope of hydrogen. But as you put it in the reactor, it does absorb some neutrons in the deuterium making tritium, which is radioactive, which is a mixed blessing. You don't like to release anything radioactive, but because it is radioactive, we have very, very sensitive leak detection, because tritium is easy to sniff with modern day instruments. And again, that was a development schedule too, the whole idea of sniffing for tritium to do leak detection. But we would find them quick and fix them if we could. In the case of R-reactor, it did have a leaky effluent nozzle at the time it was retired. Prior to that, it had at least one other, or maybe two, I'm not sure which, that were repaired. And I think I recall several different repairs. I'm thinking I recall one in L, I'm not sure. C had one at the time it was retired that they were attempting to repair, but it was retired from service before it ever was repaired.

But the problem was a thing called stress corrosion cracking of stainless steel, which was something that we unfortunately discovered, and the 304 family of stainless steels are very susceptible to this particular type of corrosion. And in retrospect now the problem is solved. People don't use that type of stainless steel for that service. But you may recall the commercial industry—power industry, had several unpleasant experiences with it too, not in reactor vessels but in heat exchangers, and have all gone to other materials that are resistant to that. So it was a problem more with R just because it was the first and we were starting to get smarter with time. Why C Area had that problem late in its history in the youngest reactor, I'm not sure I know.

MS: We may have to continue it on the other side, but when did computers first come into reactor operation at Savannah River Site?

GM: 1964, I believe was the first one. And then several years later, replacements. The first computer was basically put in to assist with the monitoring. For instance, in a production reactor– in ours, we have monitoring the water coming out of the fuel assemblies, the effluent, the hot water, we have 2400 thermocouples, each one of them reading a separate and distinct temperature. And what the original equipment in the reactor was, was a big plug-in panel and you plug in like with a four-pronged jack read four thermocouples, holler them out. Another guy writes down the numbers on a map of the reactor and it takes better than half of the midnight shift to go through that operation of measuring, recording each of 2400 thermocouples. The computer does that when you push a button. So that was the first generation of computer, which was primarily to assist in the massive monitoring job of all the data that is taken—

END TAPE 1 OF 1, SIDE A
BEGIN TAPE 1 OF 1, SIDE B

GM: I think where we left off, we were about to talk about the second generation of computers.

MS: What was the name of the first computer, or do you remember?

GM: It was called a GE-412.

MS: Obviously from General Electric. (laughter)

GM: Yes. Westinghouse never called any of their stuff GE. (laughter)

MS: Yeah, I'm sure of that.

GM: The second generation then we came out with two types of computers—one called the control computer and another called the safety computer, and two of each in each reactor area. The control computer was the replacement for the original GE computer and it, in addition to doing all the monitoring and data processing, actually could control the reactor, move the control rods. You could punch in a power level and say, Go to 2400 megawatts, and it would, given that everything else was permissive. It would not do stupid things, no matter how hard you told it to.

And the other pair of computers were called safety computers, and their job was to examine safety related parameters—flows, temperatures, and to shut down the reactor if anything got out of specified limits. And prior to that, we had a whole array of analog instruments, mostly 1950s vintage stuff, which were a maintenance nightmare, and not that reliable. We relied, I think, on redundancy. We had a lot of everything, just to make sure something works. With the safety computers, they were much more reliable, much more rapid, much less dependent on an instrument mechanic doing the right thing in setting it up. Of course, they were more dependent on a computer programmer doing the right thing. So there's plusses and minuses with it. But then that set of four computers, we installed in all reactors and—well by that time R was already shut down, so it went into the other four reactors and stayed with them until the end.

MS: How long would it take to train a reactor operator, as a rule? Or was there a rule?

GM: Oh yeah, I'm sure there was. I'm sure there was par for the course, because there was a very rigidly specified curriculum of both book-learning and on-the-site, on-the-job training. When we got the simulators, of course, you had to put in specified exercises on them, not only to get certified originally, but to maintain certification. I'd be reluctant to give you any number. I think I could probably get one for you if it's important by checking with others, but it's a number that changed with time, got longer with time, and in fact, we talk of having four shifts to operate around the clock, four shifts is what it takes, except it never was really four, it was more like five because you needed the extras to cover for vacation relief, sickies, and ultimately ended up being six shifts because the equivalent of one was always in training. So again, that's why I have difficulties specifying an elapsed time because it evolved and lengthened with time. And really, to get the good picture of the training, you can't just draw a line at the initial training, but the continuing training is just as important. So if you wanted to dig in on training, if you wanted to leave me with any specific questions, I could try to find out for you or maybe I could think of somebody that I could sic you on that could answer that type of question better than I could.

MS: Yeah, at this point, I don't think we have to worry about that so much. Certainly if I come up with— We're just getting sort of starting on this particular project, but if I have any other additional questions, I'll certainly give you—

GM: Yeah, on all of the subjects we're discussing—the operator training and certification, the computers and exactly what they were, what they did and what the evolution of them was, there are experts—guys who spent full-time working on exactly those things, which I did not. So to whatever extent you want to bore in deeper on anything, I could probably come up with an expert who knows more about it than I do I can refer you.

MS: Okay. That might be really good in the future because we're— Like I said, we're just getting start on this and we're certainly not limited to the interviews I'm doing this week, just really starting to get us going, I think. But I'd say that pretty much covers the questions that I've got right here, but feel free if you want, if you know of any particular angle that you want to hit that I did not bring up, please feel free.

GM: Well kind of hard for me to do that because I'm not sure I have a very clear picture of what you're trying to do, what your product is.

MS: Yeah, I think— What we're hoping to do is document the individual reactors—not just as individual reactors but also as a reactor group, specifically it's an individual study for these reactors since they will be—they're going to undergo the D&D process, and so it's just an additional way of getting more information about the reactors before (unintelligible).

GM: Yeah well my impression is everything we talked about today might be good background on the history of Reactor Operations, but may have minimal bearing on D&D, if and when we get into that.

MS: Yeah it's like I don't think it has to have any particular bearing on D&D, just—that's the reason that we're doing it, but it's not related to D&D.

GM: Yeah, D&D— Well, somebody is going to have to really zero in on is, What's inside those reactor buildings right now? What are the leftovers?

MS: Right. And that'll be a different part of this same project, but not related to this because obviously you wouldn't know what's been left behind there because most people, last time they saw the reactors, there wouldn't—things have been pulled out—

GM: Certainly— Maybe somebody already has, but I don't have a very good idea in my head what the incentives and disincentives are for getting into that.

MS: Right. We don't need to cover that particular aspect of it now, but we're just primarily concentrating on the reactor history and just—either as general or as specific as you want to get into, or as much as I can get into or whatever. Obviously, I've just seen the reactors only, whereas you were there on a daily basis.

GM: Now I really can't think of anything that jumps out to me as something that would fit the pattern we've been in this morning, something that would be useful to you. Certainly if it occurs to you, X days, weeks, months from now, I would invite you to give me a call any time if it's a quickie or we could get together again if and when you accumulate a bunch of stuff that you want to spend a lot more time on.

MS: Yeah that would be good, because it's always a possibility that you'll come up with—well you always come up with new questions and new answers and all that kind of stuff, and by the time I get through interviewing by the end of this week I'll have some questions to ask that I didn't ask today, and so that sort of thing.

GM: You are limiting your interviews to reactors for the time being?

MS: Yeah, for this particular project, it's only reactors. And so as a group, as individual reactors, I think that just because of the timeframe and all that kind of stuff, that most of the people I'll be talking to this week were kind of associated with Reactor Technology, but we also want to talk to eventually people who were just more reactor operators and get their story as well. We won't be covering that so much this week, but we will do that later.

GM: Yeah, the three groups that we had in reactors was the technology people, the operations people, and the third one was the maintenance people, who you may want to talk to somebody in them too, because they would have yet another perspective and very much a hands-on perspective. And of the other reactors today we talked about the production reactors, you mentioned in passing the research reactors, and I—my impression is they're gone. I'm thinking that they were already cleared out everything.

MS: Yeah 777-M which later became 777-10A that's gone now.

GM: Yeah and 305-M is gone?

MS: I think that one's gone too, but—I know 777 is gone. I don't know what they did with the basement, but I think they've got a slight mound of earth, that's all you can see now.

GM: Yeah, so it's too late to study. (laugh)

MS: Well we did it anyway but it's gone.

GM: Okay. As far as I know, HWCTR is still there.

MS: Yeah as far as I know HWCTR is still there. The shell is there.

GM: Is the reactor still there too? I don't know.

MS: I think that's been gutted. But the shell's still there.

GM: The shell meaning containment building?

MS: Containment building, right.

GM: But the innards you're thinking are gone?

MS: I think they're gone but don't hold me to that. That's just what I— I think that's right.

GM: I wonder who took it and where they put it. (laugh)

MS: I don't know. If I'm right about this, it's been gone for a while.

GM: No, we have always talked of that as being the first one when we really want to get into D&D, we'd cut our teeth on that one first. Research reactors, they don't really count as far as D&D because they aren't that—

MS: They aren't that radioactive.

GM: Yeah. HWCTR was. It was an operating reactor.

MS: Yeah. That'll be interesting to see how that pans out, but you know— Well, thanks again for all of you answers, and if you don't mind, I'll give you a call later on once I get more additional questions or—

GM: Yeah sure. Like I say, if it's an occasional question or two, you can give me a call. And if it ends up being more than that, we can get together.

MS: Okay great, that sounds good.

GM: Generally available. I happen to own four kids and 8.2 grandkids, so I do spend time visiting them.

MS: Okay right. I'll go ahead and shut this down then, okay.

END OF INTERVIEW

Oral History Interview – Frank Pagane

Frank Pagane was born in New York.* After military service and graduation from the Polytechnic Institute, he took a job with Du Pont and the Savannah River Plant. His initial work, which began in August of 1952, was at New York Shipbuilding, where the Savannah River reactors were constructed. After this work was complete, he transferred down to Savannah River Plant, in March of 1953. There he commenced a career in the Maintenance and Power departments. Pagane was involved in the construction and operation of reactor water treatment facilities, the distribution of power facilities, the reactor area emergency power backup systems, and in the Transmission department.

Interviewee: Frank Pagane

Interviewer: Mark Swanson, Historian with New South Associates

Date of Interview: October 5, 1999

M. Swanson: Make sure it's actually got some tape in there. This is an interview with Frank Pagane, conducted by Mark Swanson, historian, with New South Associates, being conducted on 5 October 1999 at Mr. Pagane's house. This interview is being conducted as part of the Savannah River Site history project, which is documenting the 50-year history of the Savannah River Site and its impact on the area and the people who have lived in that area. Mr. Pagane is being interviewed because of his long tenure with SRP. If you would state your age and date of birth?

F. Pagane: I'm 74 years old.*

MS: And your relationship to Savannah River Site?

FP: Well that was my— I had just graduated from Polytechnic Institute and I was assigned to that project. That was my first job, you might say, after having been in the service and college and so forth.

MS: And when did you first hear about the project?

FP: Probably during the interview with—with the representative from the plant and also some literature about—that I'd heard from through— I guess it was Strom Thurman and people of that nature who were pretty vocal about it in the press. I'm trying to think who the governor of the state was at the time. James Burns—he was very instrumental in getting the project at Aiken. But other than that, the only exposure I had had to radioactivity or—was after the war was over I volunteered to be on the Bikini Atoll Test (laugh), okay, but my captain wouldn't let me go. (laughter) In a way perhaps I'm sad but I'm lucky.

MS: They had some problems later. (unintelligible) So you came to work at SRP when exactly?

FP: Well I— I was assigned to the project in August of 1952, August 18th as

*Personal information has been removed from the transcription

a matter of fact. My first assignment, though, was at the New York Ship Building, which is where the reactors were constructed, mainly because the—that shipyard had the best technology for heliarc welding and this was all stainless steel structure so—and that's where it was. So I was— It was rather an interesting project. We set— One of the reactors, which actually went to 105-R eventually, we sent that out, mocked up pumps and other stuff and went through all of the—might say the shakedown of a lot of the equipment—the control rod apparatus, the— We didn't have the heavy water pumps that were going to actually be used there, but we had some water pumps which simulated the flow. There was some auxiliary equipment like the—what they call the foil press and shear, which was to take the empty fuel containers, the fuel foils, and drop them into the disassembly basin, get the slugs out and then run it through a device which flattened it and then cut it up. So that's why they called it the foil press and shear. That was a headache. (laugh) It had to operate under water see so— But anyhow— So we did all of that shakedown testing, you might say. A lot of the hydraulic work was established at that time, the data on the hydraulics of the reactors themselves. I was in the maintenance department at that time, so I was in the peripheral area of it but—

MS: Right. Okay, if you were not living in the area when you first came to work at Savannah River Plant, where did you come from?

FP: Well as I say, my first assignment was at New York Ship Building which—that was in Gloucester, New Jersey and that was in August. In March of '53, we moved down to Aiken.

MS: Okay. Right. Was that— Was working at the plant considered attractive?

FP: To me it was. It was a huge project, massive construction project, a lot of fun. (laugh)

MS: Were you directed or encouraged to live in any particular place, whether it was Aiken or North Augusta?

FP: No. Actually, housing was at a minimum. Actually Crosland, who was quite a home builder, build five hundred homes on the north side of Aiken, and that's where we lived. But people lived all around.

MS: How would you characterize local opinion about your arrival and local attitudes towards employees from other areas that moved in?

FP: I think there was some dissatisfaction. I never truly encountered it other just overhearing conversations. As far as the local merchants and the churches and all, they were very hospitable and I made a lot of friends with the Ford dealer and attorney and so forth, a lot of close friends. But there was some ill will about the pay scale, I guess you might say.

MS: Because it was so high or—

FP: It was higher than say the mills or so forth.

MS: All right. Had you ever worked on any previous Manhattan Engineering District projects or for the Atomic Energy Commission (unintelligible)?

FP: No.

MS: Were you ever a Du Pont employee prior to working at SRP?

FP: No, that was my initial assignment.

MS: Okay. Had you had any previous experience working at an industrial plant?

FP: Limited, I would say, because I was in the service and school so—

MS: When you came down to Aiken, did you have a wife and family?

FP: Yeah, we just—just my wife and I.

MS: Okay.

FP: Card table and a couple of chairs and that was it (laugh) and an old—late '39 Ford.

MS: All right. (laughter) How did you view the communities that you moved into when you first got to Aiken?

FP: Well I would say that all my neighbors and close associates worked at the plant. So other than dealing with the merchants and so forth or church people, that was limited to our exposure for friendships. Our entertainments, our parties and so forth were mainly involved with Savannah River people.

MS: Right. Was it difficult to become part of the new community or was it—

FP: No I—I didn't have any problem whatsoever.

MS: Okay. The next series of questions deal with construction employees. You mentioned that you worked primarily in the 100 area right?

FP: Yes. The 100 areas, there were five of them, of course, R, P, L, K and C.

MS: All right. Okay. Where did you live during construction?

FP: I lived at Aiken in this Crosland Park development.

MS: Okay. What were conditions like in general during that construction era?

FP: Well it was a lot of heavy traffic going into work—to and from work. It was only about—I guess about a fifteen minute leeway between— Construction got on the job about fifteen minutes earlier than us but Highway 19, Whiskey Road, that was pretty heavily trafficked. It moved, though. And of course that was about a—from where I lived and where we carpooled from, it was about a thirty, thirty-five mile run to the hundred areas. So once you got on the plant, it was no problem.

MS: Were there trailer parks and dormitories?

FP: Oh yes all over. In New Ellenton, in North Augusta there were trailer parks all over, mainly for construction people. See the workload, the construction load, was in excess of 32,000 employees, so they had to have these temporary housings.

MS: What about— Did people live in cars or even in tents?

FP: No, I can't— If they did I didn't see it.

MS: Okay. Were there many transient construction employees or were most of the employees residents of surrounding areas?

FP: I would say that there were a good many transients. Some of them—our boilermaker crew—people, for instance, which is a limited skill, they commuted— A good many of those and pipe fitters commuted from Charleston, if you can believe that, on a daily basis.

MS: Wow. That would be tough. What were food supplies like?

FP: No problem. No problem whatsoever.

MS: What about— What was traffic like during construction? You alluded to that on Whiskey Road?

FP: Well it was a little bit heavy, but it moved.

MS: What was it like on the trip to work?

FP: A lot of fun. Guys just kibitzing around the carpool (unintelligible) (laugh).

MS: Were utilities like water supplies and waste and sewage disposal adequate (unintelligible)?

FP: Oh yeah. No problem whatsoever.

MS: Okay. Were there any campaigns to provide vaccinations to children or other health-related programs for construction workers?

FP: I'm not aware of that.

MS: How about the local schools? Was that ever an issue?

FP: Not with me. Of course, we adopted a daughter later on and she was an infant so we never— I don't know how the schools were. I assume they were adequate.

MS: Did you and your family become part of the community in which you resided or did you always consider it as sort of a temporary home?

FP: Well, as I say I associated with some of the merchants, but mainly it was with plant people, our social life, although I did have a neighbor who was with the ATF and we palled around with them, so—

MS: Were construction workers treated differently by local residents than the incoming operations staff?

FP: That's hard to say. I really can't comment on that because they—they were— You could tell they were a transient bunch. They— As they used to say, they'd run out of friends and go to another job. But— So I really— The only ones I had contact with on the job site, I had no problems with them.

MS: Construction occurred when the south was still segregated. How did this affect construction?

FP: Well I would think that a good many of the laborers were black, okay, the janitors, the laborers who would be digging holes and so forth. I would say that most of those were black.

MS: I know that they— I've had people tell me that they used to have segregated restrooms at Savannah River Plant and they got phased out at some point later on.

FP: I don't think I ever encountered that. Maybe in some of the outlying locales, little towns outside like Salley or places like that, you might encounter that, but I never— I will say this—I can recall seeing two truckloads of prisoners, the chain gang, one truckload of blacks and a second truck with a solitary white. (laughter) So that struck us all as funny.

MS: Was there much crime during construction?

FP: I— Well there might have been some, but I wasn't aware. There might have been some bookkeeping or pilfering. But I think there was enough of a—almost an intimidation that you didn't want to walk off that plant with anything. So I don't think there was much.

MS: What did DuPont, the AEC or any of the other subcontractors do to help with any problems that they may have had during the construction era? Is there any particular program to—

FP: Not that I'm aware of. Of course the community basically were—the community programs basically involved the (unintelligible) community—the—I'm trying to think of the—the fund. They used to call it the community chest, now it's whatever, okay. The plant would participate in that heavily.

MS: Okay. Had you had any previous experience with the construction of any industrial plants?

FP: No.

MS: What kind of construction work did you either do at SRP or were you familiar with?

FP: Well, as I said, I was in the department—the Power department, so I was involved in the construction of the water treatment facilities, the distribution of power facilities, the emergency power backup systems in the one hundred areas and back in the reactor areas, and somewhat, to some degree, with the Transmission department, and of course to generate we had— Four of the five one hundred areas had turbogenerators for generator powers, 100-C did not. So I was involved with the turbogenerators, to some degree the boilers but not a whole lot with the boilers, mainly from the electrical stand on the project.

MS: Okay. How was the work organized, construction work?

FP: It was pretty good. It was pretty well organized. I would have to say that

DuPont had a very good engineering department at the time and of course, they were the main contractor for a great many subcontractors, Gibbs and Hills and people like that, that would do certain aspects of the project, but I think our—the Du Pont construction company did an excellent job I would say.

MS: Okay. Was there anything good or bad that particularly impressed you about the construction effort?

FP: Just seemed to be pretty well running on schedule. We brought it— We brought the plant in on schedule and under—and under estimate. I shouldn't say we—I guess we did, all of us, but—

MS: Were you ever involved in any design work?

FP: Yeah, on some modifications. After the initial facility is in well then you try to smooth it out and change—make changes for the next area. And that was the thing that was good about it, we learned a lot of problems that occurred in the 105-R or 100-R area, I should say, and we tried to incorporate modifications so that by down the road— For instance, I'll give you an illustration. In 100-R, plans were made to treat all of the cooling water going to the reactors. This is not the heavy water, this is the river water. Now you're looking at 65,000 gallons a minute. We were going to treat every bit of that clarify it, get all the Savannah River mud out of it, you might say, which would include massive loads of chlorine and so forth. What we found that the mud, the silt, or whatever you want to call it, actually helped keep the exchanges cleaner. (laugh) So from then on in, we eliminated all of the clarification of the massive cooling water flows that went into the 100 area.

MS: Right.

FP: Pretty significant cost reduction. So therefore, the plans were made— Now a lot of this came out of Wilmington engineering.

MS: Right. But it required a lot of like field checks and things like that?

FP: Oh yes.

MS: What about— What was the design process like? Do you remember? What kind of feedback was there going on?

FP: They had a liaison for each—I guess for every— Well I don't know about the Reactor department, but the Power department, we had liaison directly with Wilmington engineering staff coming to visit the plan, talking about problems or changes. It was good communication.

MS: Okay. Did superiors ever solicit contributions and suggestions from employees?

FP: I would have to say on a limited basis because most of the— Are you talking about like say from the wage roll—the operators on up?

MS: Yeah I guess that'd be—

FP: Okay. Well most of those people were agriculturally oriented, okay, the ones that we had. We didn't transfer in wage roll people. We tried to hire from the local, so—the local pool, so most of those people were agriculturally oriented, but they made good operators.

MS: Right, okay. What was the construction schedule like?

FP: You mean for—realistic or when it was too heavy or—

MS: Yeah was it— I mean just—

FP: Unreasonable?

MS: Was it— Yeah or what was the daily schedule like?

FP: I didn't really get into the construction schedule so much. The had a timetable, they had a target date, naturally, AEC established target dates and we just had to see that every one of our projects, or portions, were on schedule. They came out pretty close, so I guess the scheduling was okay, reasonable.

MS: How many hours a day did you work in those early days?

FP: Well, eight hours generally, unless I would have to stand by sometimes for the checkout phases of a piece of construction, piece of apparatus, which would require me to stay overnight and stay with it for say thirty, thirty-four hours for a piece of equipment, to make certain that it met our specifications and the requirements.

MS: Right. What about, were construction materials generally there when you needed them or were there any shortages?

FP: You got to remember, I wasn't in construction now, okay? I was liaison, but I would—yes, I would say—

MS: What I'm doing is like these are just sort of like general questions about construction, but any time you want to answer them like just based on what you know or—

FP: All right.

MS: Either what you know about construction from what your personal experience or what you overheard.

FP: As far as I can tell you right now, I would say that there really wasn't any delay or lack of materials.

MS: Right. Okay. What about relations between labor and management? Again, you don't have to answer this specifically dealing with construction, but if you want, you can talk about the 100 areas.

FP: Okay, just talking about say employees in the Power department, wage roll versus supervision. I think Du Pont went overboard to some degree in trying to establish communications. You would have these meetings with your people as a shift supervisor, let's say, to find out if they had any gripes and sometimes when you ask people do you have any gripes, then they generate (laugh). But generally speaking, I think that we had a grievance procedure, we—I believe it was three—we successfully beat down three attempts to organize the plant. So apparently the people were satisfied, okay.

MS: Right. How often, if at all, did you see foremen and engineers using models instead of blueprints?

FP: I don't— I didn't see any of that. There might have been some, but I didn't see any.

MS: So you saw blueprints?

FP: Yeah.

MS: Did you ever do any work in construction after that initial period?

FP: No.

MS: Okay. What did you do in the off hours during those early years?

FP: Recreation time?

MS: Yeah.

FP: Well, there wasn't much to do in Aiken, per se, so we would—most times on the weekends, we'd take a trip down to Myrtle Beach. (laughter) Two couples, we'd get in the car. We just got a whim, eleven o'clock Friday night, let's go. (laugh)

MS: Yeah. Do you recall the big fire they had in Aiken? I think it was in early '53? It may have been explosion, in downtown Aiken.

FP: No.

MS: Oh okay.

FP: In 1953?

MS: I think that's right, yeah. It was like some kind of a propane gas leak or something that—

FP: I don't recall.

MS: Okay. The next set of questions are for plant employees, whether they're technical or general, so that's sort of like (unintelligible).

FP: Okay.

MS: And this will get into like exactly what you did at the plant, (unintelligible) record. I know we've already mentioned this, but I guess I'll ask it again. When did you first start working at Savannah River Plant?

FP: Well let's see, that would have been March of 1953. As I say, I was associated with the project, or assigned to the project, in the previous August. But we moved down there in March of '53.

MS: Okay. Right. Were there any reasons for not wanting to work at Savannah River Plant?

FP: From my standpoint?

MS: Yeah.

FP: No. (laugh)

MS: Okay. How much did you know about what Savannah River Plant produced when you first started working there?

FP: Very little. I had heard— Of course, President Truman had talked of it being the hydrogen bomb plant, but as far as nuclear physics is concerned, I'm pretty green on that subject.

MS: Right. Was the mission of the plant, military mission, a reason to want to work there or not to work there?

FP: I think that was one of the reasons, a pretty important reason.

MS: And you mentioned working on the NYX project?

FP: Yeah, yeah. That's right. You know that, okay. (laughter)

MS: New York Shipbuilding.

FP: Right.

MS: And was that your first job assignment at—

FP: At—with DuPont? Yes.

MS: Okay. And how long did you work there?

FP: At NYX?

MS: Yeah.

FP: Well from August to March would have been what, three, four—about four or five months. Let's see, January, February March that's three. December, November, October, September, August. At least seven months, I guess.

MS: Okay. Did they set up— How big a complex did they—did they construct there when they were doing that?

FP: At NYX?

MS: Um-hm.

FP: We were set up in the (unintelligible) shop of the shipyard, so that's the extent of the area, just a (unintelligible) shop. Pretty good size, okay.

MS: How big? I don't know, I'm just curious.

FP: Two structures there, they must have been maybe 1500 to 2000 feet long and a typical width, which would support three Gantry cranes, one in the center and two on either side probably four or five hundred feet wide. And these were excellent machinists, okay. They were good people.

MS: Right. Was it— When they were building that thing, was there any like scaling it down or how did they—

FP: Not that I saw. The reactors, I say, was built there and went to 100-R, okay. So that was full size reactor. We had one of the main electric motor drives, one (unintelligible), I believe it was 6000 horse. The others were all two motors, paralleled together, small pumps and so forth, one Byron Jackson heavy water pump and then the other ancillary materials. But basically we were trying to knock down the equipment to debug it if you will, and as far as Works Technical was concerned, I think their biggest objective in running that was hydraulic studies on the heavy water versus the cooling water around the foils and so forth, and the safety procedures.

MS: Right. Okay. If you would, sort of run down the different positions you had after you left the NYX program and then came to Aiken.

FP: Well NYX, as I say, I was in the maintenance crew (laugh) and I worked with shipyard employees, pull out a pump, replace it, line up the pump, test (unintelligible) so forth. And we worked weekends. We were on call on weekend, because they ran twenty-four hours a day naturally. It was a lot of pressure on to get that thing done. After NYX, when I went down to Savannah— Is that what you mean?

MS: Yeah.

FP: When I went down to Savannah, I was assigned to the Power Department there in the 100 areas. And I was assigned to the— Every— Even a sewer has a building number, if you (laugh) look at it. So my basic area (unintelligible) the 190 building, which was the big cooling water pumps and had the basins, the reservoirs associated with it. The 190 building, the 108 buildings which were attached, a (unintelligible) integral part of the 105 building. And there's where we had backup diesel power, AC, enough to supply the AC power. These units had to come online within ten seconds and assume full load. And then we had back-up diesel driven, especially (unintelligible) DC generators, motors on the tail end of the process water pump, so that if you had a power failure, they would take over, at lower speed, but sufficient to keep adequate cooling so you wouldn't have an incident.

MS: Right.

FP: So that's what I would check out basically and they'd get involved in the power houses as well and the substations.

MS: Yeah, right. How long did you work at—when did you retire in other words?

FP: I retired in '89, just about—'88, end of '88, January 1, 89.

MS: Okay so just about—just before Westinghouse took over.

FP: Right, right, right.

MS: Okay. What pressures were there to your job, if any? In other words, production quotas or strict adherence to procedures?

FP: Very much so. You had to make certain that things were right and done right. I guess you have to consider, we were probably working in a lot unknowns. (laugh) But as far as getting into the reactor area, I was—I had very little exposure there, definitely. And I say as a support group.

MS: What did you see as your most important responsibility?

FP: Get the job done on time.

MS: What did you think about Du Pont's management of the plant while you worked there?

FP: I don't know whether I should comment too much. I think I— I saw some people that were in supervisory positions that (laugh)— I had excellent chief supervisors. These were guys over the area super (unintelligible) great area superintendents that I had worked for. But there were some area supervisors that I don't—

MS: Was it too much overlap or—

FP: (exhale) No, it wasn't that it was overlap, it was—I would say some of them were unqualified, okay. I don't know whether to say that or not. A good many of them are dead anyhow.

MS: Yeah, right. What was the attitude towards safety at the plant among the employees and among managers?

FP: Of course, we managers had to push safety. The worst thing that could happen to you as a supervisor was to have a lost-time injury occur on your shift or whatever I think that a good many of the wage roll people thought that we overreacted to this, it was too much emphasis on safety. Whether that's realistic or not, I don't know. But we had a pretty good safety record there. But we might— The company might have gone overboard to some degree. But as I say, supervisors, you (unintelligible) or you were out, essentially. (laugh) Wage roll had to go along with the flow.

MS: Right. Did you or your group ever win any awards for safety or production suggestions or—

FP: No, I don't think my— I don't think in all the tenure that I was there that we ever got a full year of lost time injury—without a lost time injury, okay. So—there were crazy injuries, there were serious injuries, but not one year went by, while I was there, that we got the so-called department—an annual safety award or whatever, a year of production without an injury. And while I was there we never had one.

MS: Yeah. Was that kind of hard to get?

FP: No, we just— No, I don't think so. I— Well—

MS: It depended on how many accidents occurred.

FP: Yeah. I mean, we had a case where a superintendent—a supervisor was leaving the 100—the 700 area, the administration area, after a Friday morning meeting. He was hit—driving back. He must have had his mind on other things, hit by a trailer train and killed. (laugh) That's different, isn't it?

MS: Yeah that is— I hadn't heard about that.

FP: Yeah.

MS: How many people all total were killed during those—

FP: I have no idea. We had a couple of production—construction fatalities that I was aware of. They were— And that's the only ones, I guess, that I can recall. They were— They were spray painting this disassembly area basin with a very, very flammable vapor paint, Armourcoat, I think it was, to put on a high-density coat. And these guys were down in that well there, spray painting and somehow or other an extension cord got away and (unintelligible) blew them up.

MS: Wow. What were the most important measures that were in place to insure protection of your health?

FP: Of my health?

MS: Yeah.

FP: Oh we were monitored. We wore film badges. If you went into the one hundred—into the 105 building, each time you picked up a couple of pencils. You went through a hand and foot monitor. You stepped on the thing, put your hands in it, in and out. And you had a card there and the health physics people monitored it.

MS: Right. So—

FP: (unintelligible).

MS: Go ahead, I'm sorry.

FP: No, I'm sorry go ahead.

MS: What about attitude toward security at the plant, and how did that change over time?

FP: As long as I was there, it was tight.

MS: Somebody told me that there was an (unintelligible) story that somebody had put a monkey's face on their badge and were able to get in the plant a couple times. (laugh) Was that a

FP: Yeah. I don't recall— Every once in a while the auditors might do a check. And then they would visually look at your badge. But other than that, once you got on to the plant property itself, I was never inspected from that standpoint, other than they would count, get the guy's employee number and verify that it was he for financial, I guess security.

MS: What about— In the early days with security, did they check your badge at the beginning of federal property or— Like now you can go pretty deep into Savannah River Site before they—you have to go actually to— They don't check your badge until you go to really high-risk areas.

FP: Yeah sensitive area, yeah. No. It was different at New York Ship. At New York Ship we had a card and you turned that in at the end of the day. And it— Oh yeah it kept the card rather, and you got a badge in exchange for that when you went into it, into the facility. At Savannah, you didn't. You took your badge with you. And you didn't stop at the barricades other than there would be an occasional spot check on the way out, that's all.

MS: So they didn't actually— Unless you were going to a sensitive area, if you were going to like a—

FP: The 105 building let's say?

MS: Right, yeah.

FP: No. The only thing you would make sure there that you went into the hand and foot area, that sort of stuff. But no, you wore the same badge.

MS: Okay. What did the contractors like DuPont do to encourage safety and security as well as employee adherence to those guidelines?

FP: Well of course you tried to promote safety and maybe get some awards if you could, get certain periods of work-free time—maybe a dinner or something like that at a local restaurant. But other than that, that's about it. It was just— It was just understood that you will work safely, okay.

MS: Right. Did you do any work at the plant prior to getting a security clearance?

FP: No. No. I actually— I had my Q clearance at New York Ship and so I was already cleared. Because they did have a P clearance. Have you ever heard of that?

MS: No I never did.

FP: P clearance was like for vendors and so forth. They couldn't get into the 105 buildings or something like that. But Q was—

MS: The only ones I've heard of are like number 1, then L and then Q clearance.

FP: Okay. There was—I think there was also weapons clearance, weapons data clearance but I'm—

MS: Let me ask you about this while I'm thinking about it, they used to have a—some military units there at Savannah River Site, some anti-aircraft units. They weren't there very long and I think literally like maybe just a few months.

FP: This must have been after I was there.

MS: I think it was in like around 1955 or 1956.
FP: Oh yeah, I wasn't aware.

MS: Hmm, okay. I know they were just sort of out in the boonies.

FP: Well it could have been there.

MS: You don't run across that many people that know that or remember much about it, but, so I just wanted to ask.

FP: There could have been— might have been the result of some—some activity— (unintelligible) activity that might have spurred on this type of thing, but I'm not aware of it.

MS: Okay. Did any security issues or concerns impact your life off site?

FP: No.

MS: Did working at the plant affect social relations or travel or—

FP: Never travel or— We just didn't talk about the job site. You just—

MS: Even among yourselves or—

FP: Very rarely. It would be peripheral type stuff, like, Why'd this guy goof up or what you did here or— (laugh)

MS: Right. What major changes took place in the areas that you worked in during your time there?

FP: Well, let's see, one major change. We—we increased the power load, I guess, and that was a pretty significant venture, because we had to recalibrate orifice plates for flow sensitivity in the two headers that had (unintelligible) 105. So that was a pretty (unintelligible). We had a consultant from MIT that worked with us, advised us. If you can believe it, we drained the basins, the three, and had those walls—had them established accurately, okay, so that we could calibrate the drop in water level down, to calibrate the flow going through the orifice. That was a pretty significant— And I happened to be one of those guys that worked with the—another engineer and we shot-gunned that job. It was a—

MS: Tell me more about that, because I'm not that familiar with it.

FP: Well they wanted to increase the load, so they needed more water flow. I think we were running somewhere around 60,000 gallons per header or 35,000 gallons per header or 30,000. We wanted to go up about 10 percent or whatever, I can't recall. That was when they took the outflow of R and P. You ever hear of that? They built a cooling pond to collect the outflow because we couldn't get enough water up from Savannah River. But we had to establish the flow so that we could calibrate the orifice plates. So what we did—

MS: calibrate the—

FP: Orifice plates in the headers, the cooling water headers, okay. When water goes through an orifice plate it (unintelligible) drop with pressure, and that's what you use to determine the flow, okay. So what we had to do was—the test was to set up the level of the reservoirs, get them up to operating level, stop the water coming into it (unintelligible) period of time and then boom, everybody—then you measured the drawdown over a period of time. So it was a volumetric calibration you might say, loss of flow. Cut off the water coming from the river, let her drop down. And then we put new—bigger (unintelligible) in the pumps to increase the pressure, the flow. And I have to say I'm pretty proud of— I think we came within less than 5 percent accuracy (laugh) which was pretty significant when you think a 25 million gallon (unintelligible) what we had. So I thought Oh— Darryl Hornbeck was the guy's name. We— He's dead now. He's a tough—he was a good engineer, heck of a good engineer, Darryl Hornbeck. So Darryl and I were the Power department people who had project—the scope of the project in our (unintelligible).

MS: Right. Okay. Were there any major incidents in your area while you worked there? In other words, either reactor incidents or any—

FP: I don't know. All I know is that one Sunday afternoon, something happened and I don't know what. I got a call from— I was taking a shift in C area. And I got a call from the shift supervisor, production shift supervisor, run all your people through the hand and foot monitors, and we did and we went home in shoe covers and coveralls. (laugh) So I don't know. I'm still alive. (laugh)

MS: What year was that, do you remember?

FP: It must have been about '55, '56. I've got some clippings that I saw in the Charlotte paper of that, of something, and I don't know whether that was the time or not, but I don't think there was any serious fallout from it.

MS: Did you normally ride to work in a carpool?

FP: Yep.

MS: And what was— What was the reason for that?

FP: Economy. (laugh) I mean it was this 70- to 80-mile roundtrip a day. And of course a lot of the guys had families only had one vehicle. So—

MS: How did they work that out? Was it— Did everybody take a shift, like a day?

FP: Take a rotating day, yeah.

MS: Okay. And were those— Were the carpools organized by DuPont or was it just a private thing?

FP: No. It was a private thing. When I'd get out to an area, it'd be—it was hard to get a pool because there were not many people. When you're going out there there's— They're still grading the elevations, there's not many people to pool with. But it worked out fine. Sometimes you'd go into a different area, pick a company—a pool car to go over, a vehicle—company vehicle to go into the other areas where you were assigned. But it worked out fine.

MS: How did you find others to ride with? Was it just sort of like word of mouth?

FP: A lot of us moved from area to area too. So— But it was basically word of mouth.

MS: Okay right. Did people ever pay for rides?

FP: I don't know, they might have. People without vehicles, they might have.

MS: Okay. This you may or may not want to answer. How did plant operations and management change when Du Pont left and Westinghouse took over?

FP: Well like I said, I don't know. I was— I had left the plant several years before that occurred.

MS: Right. Did you want to venture anything on that or—

FP: For one, I was happy to see us get out of it.

MS: Yeah.

FP: Mainly from the standpoint that it was just a lot of— We're in the age of litigation and I just can't see how it could have done us any good, just the name Du Pont—chemicals—we're a bad name to begin with. I don't believe that, but nevertheless, that image is bad so— I'm just glad that we got out of it.

MS: Right. Did newer— Did the new environmental legislation change any operations or have any effect on the operation of the plant?

FP: I'm not aware of it. Of course, that was after I left when it—

MS: Right. The next series of questions deal with socioeconomic issues that are sort of general and— How has the plant location at CSRA impacted the impacted the economy of the area?

FP: Oh I think it did a lot for the economy. I think it—got a lot of businesses, car sales boom for instance, supermarkets restaurants. I think it did a lot for the economy.

MS: How did it impact lifestyles in the area?

FP: I don't think it impacted it very much. Naturally with more homes being built, people would feel like they were being infringed upon or their areas encroached upon. I'm sure there was that feeling, that they didn't want to see—that some people didn't want to see a lot of the growth.

MS: Right. Did the plant cause swings in the area's economy?

FP: Did the what?

MS: Plant cause any swings in the area economy when it would like go from certain level of—like from the construction era to the operation era for example?

FP: Oh yeah, yeah. I think when construction phased out, I think there was definitely a reduction in the level of the economy. Sure. Had to.

MS: Were there any housing shortages?

FP: I didn't encounter, but I'm sure there were some cases where there was (unintelligible).

MS: Okay. Did you hear about people renting out rooms in their houses or even spaces in their yards with trailers?

FP: No. These trailer parks were established— They were— They got these units—took the undercarriages off, put up water systems and sewage systems. They made a village out of those, okay. There might have been hundreds of trailers. It was a community.

MS: Do you remember some of the names of the major communities?

FP: Gee. They were down toward New Ellenton on the outskirts of New Ellenton, a good many of them, in that area. And then there were some in North Augusta area, some toward Barnwell places, and I guess even in Georgia, over in Augusta, in that area.

MS: Right. How did the economy and lifestyles change during periods of lesser activity at the plant?

FP: Well, I can't answer that because it was always (laugh)—always going when I was there.

MS: How about, how has education been impa—

END TAPE 1 OF 1, SIDE A
BEGIN TAPE 1 OF 1, SIDE B

MS: Okay. We were talking about education and—

FP: Well I think now that there's—there's an extension of the—University of South Carolina's there now, which wasn't there. I don't know of any junior colleges, but I do know that, that's about all.

MS: Okay. How have local politics been influenced by the plant being there?

FP: Boy that's hard for me to say. In those days it was—it was pretty much of a machine type operation (laugh) Edgar Brown and so forth.

MS: What about public participation in issues like nuclear power and the environment? Did that have any—

FP: There wasn't any then, when I was there, so I can't comment on that.

MS: Do you feel that the location of the plant increased or decreased the incidents of gambling, prostitution, drug use, that kind of stuff?

FP: Well of course when—at the heyday of construction, there was gambling and prostitution. There's no question about it.

MS: How does— How has entertainment changed? What did people normally do for entertainment in the early days?

FP: There wasn't much. It was mostly home entertainment, people going off, like I say, to Myrtle Beach or something.

MS: Right. What about the—I think they call it the ORA, Operations, Recreation

Association?

FP: Yeah, that was just getting off the ground when I left.

MS: And the next series of questions deal—more like cover broad topics for those who worked in the plant for a long period of time. Is there anything that stands out in your mind as the greatest accomplishment at the plant during its history?

FP: Oh we had our target date with AEC to go critical at R. I mean that was a contract date. We met it.

MS: Yeah. Does anything stand out as the greatest problem at the plant?

FP: Not in my mind.

MS: Do you feel the plant operated more effectively during some periods than other times?

FP: No, not really.

MS: And out of the work that you did, what aspect of the work did you identify most closely with—whether it was the plant itself, the contractor or the government or even the mission they had at SRP?

FP: I guess my job was to make sure the equipment was installed and train the operators, write operating procedures and so forth, and to make sure that the facility worked as it was designed to do, then move on to the next (unintelligible).

MS: Okay. The next series of questions deal with managerial materials. Why was Du Pont chosen over GE or some other potential contractor operator?

FP: I don't know. I guess I would have to say partially because of the capabilities of Du Pont engineering department, quite a staff.

MS: Okay. Why did Du Pont accept the project?

FP: I think it was— Well I can't really say. In my opinion, I think it was almost a reluctant acceptance, because they had built Hanford Works for General—and then General Electric took it over. And I don't think they wanted to get involved in it. I think they were—I wouldn't say pressured, but I think that the government wanted them to do it. So it was a good citizen relationship you might say.

MS: Right, right. How did the organization management of SRP differ from Dupont's regular commercial operations, or did it?

FP: Yeah, I think it was a little bit more free wheeling on the plant (unintelligible), maybe we'd encounter at a typical plant facility, a lot more degrees of freedom to operate, mainly because you didn't have production schedules to meet, so to speak, as you would on a (unintelligible) lead plant facility or something like that.

MS: Did the contract with the government offer Du Pont any advantages that were not available to in its commercial ventures?

FP: Not that I know of.

MS: What costs or impediments did the contract entail, the one that Du Pont had with AEC?

FP: The only thing I understood was a dollar-a-year basis, cost plus a dollar a year, and I think the benefit to us was the (unintelligible) people in training.

MS: Yeah. What were the most important organizational structure changes that took place at SRP?

FP: I can't recall any. I don't know of any.

MS: Okay. What were the strengths and weaknesses of the various management structures at the site?

FP: I can't recall any. I didn't encounter any. I didn't see it.

MS: Were there any like basic changes or trends in management philosophy during the history of the plant?

FP: No, I don't think so, other than company-wide, the institute of the savings thrift plans during that period of time.

MS: Oh really, when did they do that?

FP: I think '55 or thereabouts. And ironically it was very difficult to sell that to wage roll.

MS: Oh really?

FP: Oh yeah. I can recall talking to my shift people saying, Hey this is a good deal. You (unintelligible) this much money and this much— I don't trust you.

MS: So it was like a pension plan or something?

FP: Yeah, the start of a 401 you might say. I believe you bought a fifty dollar war bond, you got a share stock for a good price and so forth. It was a savings investment plan. It was difficult to sell that.

MS: Huh? Is that because people weren't used to doing that—the—

FP: Inherent mistrust, you might say, of management. What are you giving me something for nothing? I don't believe it.

MS: Right. Yeah.

FP: That was the only major change in the company plans and practices while I was there.

MS: How about any basic changes of trends in the management of specific areas?

FP: Areas of the plant?

MS: Yeah.

FP: No, I didn't (unintelligible).

MS: Okay. The next set of questions deal with reactors and the first question is, Why was heavy water chosen over graphite and natural water for the SRP production reactors?

FP: I really don't know. I don't know why that decision was made.

MS: Okay. Were you present when any of the reactors went critical for the first time?

FP: Oh yeah.

MS: What was it like when that happened?

FP: I wasn't in the control room but it's kind of nice to say, Hey we did it. We met AEC's target. I think we immediately shut it down. (laugh)

MS: Oh really? Talking about R-reactor here right? (laugh)

FP: (laugh) Yeah. Well we did go critical at the target date and that was an accomplishment.

MS: Yeah. What was it like in subsequent runs in the other reactors when they went critical for the first time?

FP: I don't know. I imagine it was quite a bit of enthusiasm and concern in the control rooms, but I wasn't there.

MS: What was it like when they shut the reactors down for the last time?

FP: For the last time?

MS: Um-hm.

FP: I wasn't there.

MS: How about for like R, for example, which was shut down in '64?

FP: I was gone.

MS: Oh okay. As far as reactors went, what did you look forward to in doing your job in the reactor areas and what did you dislike?

FP: Well I didn't work, per se, in the reactor area. As I say, I just supplied power (unintelligible) power. But it was just a job. We felt that things were going all right (unintelligible).

MS: Yeah, uh-huh, okay. The next series of questions deal with health protection. Can you describe, in general, the health protection measures taken at SRP to provide safe working conditions?

FP: Well I'm sure they monitored the areas. They had monitors on the ventilation systems in the reactor areas and then as I mentioned before you—when you went into the 105 building you went through a hand and foot monitor, and when you exited, you did that. And if for some—at certain times, you might have to wear both film badges and pencils. Well you always wore a film badge, but you might have to also wear pencils, which were—one would pick up one form of radiation the other another form, so— But it was pretty tight.

MS: Right. What were the most important measures taken to insure worker health and safety?

FP: I guess just personal monitoring like that.

MS: And how did those measures change over time?

FP: I don't know, if anything probably got stricter but I—

MS: Okay. What powers did health protection workers have to locate, stop and change unsafe conditions?

FP: Oh I think they called the shots. They determined how long a person could work in a radioactive area and so forth.

MS: Okay. Have management and organizational practices affected the ability to insure employee health and safety?

FP: What was that again?

MS: Let's see if I can reword that. How did management and organizational practices affect employee health and safety?

FP: I think the very fact that Du Pont's inherent belief in safety drove the—drove the processes to be the safest. I think that with the most available—best available technology to safeguard the health of the workers.

MS: Okay. That really pretty much covers the specific questions that I've got to ask. If there's anything that you want to bring up or enter on the record?

FP: No, I don't think so. I consider it a valuable experience. It's nice being able to go around and say that you were involved in one of the biggest construction projects in the world, when you think of it. A lot of us that were there brag about that to ourselves. We have a lot of pride in it and I think we did a good job.

MS: Right. Okay, well thank you very much for the interview. I appreciate it.

FP: Okay.

END OF INTERVIEW

Oral History Interview – Daniel Pellarin

Daniel Pellarin was born in New York.* He finished high school at 17 and enlisted in the Army Specialized Training Reserve Program, prior to being admitted to the Army. At the end of World War II, Pellarin was in the adjutant general's department, assigned to General MacArthur's headquarters in Tokyo. When he came out of the Army, in April of 1947, he went to Lafayette College in Easton, Pennsylvania, where he got a degree in physics.

In 1951, he hired on with Du Pont. His first assignment took him to Argonne National Laboratory. There he did some experimental work on the design for the Savannah River reactors. Later, at Savannah River, he worked on the test reactor in Building 305-M, adjacent to Building 777-M. Pellarin was in the control room when R reactor first went critical in December of 1953. Later he settled into a career in Reactor Technology, where worked throughout the different reactor areas.

*Personal information has been removed from the transcription

Interviewee: Daniel Pellarin

Interviewer: Mark Swanson

Dates of Interview: April 16, 2007 (Session 1) and April 18, 2007 (Session 2)

D. Pellarin: You're interested also in 777 building?

M. Swanson: Yeah, we have done a HAER interview or study of the 777 building.

DP: And as I understand, that's been torn down.

MS: That's has gone down, right, yeah, that's true.

DP: Everything I've been associated with has been torn down. I started out in Argonne National Lab as a Du Pont trainee over there, in the Physics group, in preparation for the 305-M reactor, the test reactor. And we were next door to the 777 building because the Lab (laugh) wanted to put reactors as far away from the rest of the business as they could. I guess maybe they always felt something might blow up. Well, the same thing was true at Argonne, that the reactors were at Palos Park, which was a state park that had been taken over by the government, and the very first reactor, CP-1, the one that went critical at Stagg Field, was dismantled and brought out to Palos Park, reassembled, by then they had some more uranium rather than uranium-oxide, and they rebuilt it and that's the one that was very similar to the test reactor in the 300 area.

And so George McManoway and I were involved in some experiments and we taught a— I thought it was so strange. I never had a course in nuclear physics. I graduated in January, just sort of off schedule for— And shortly after arriving at Argonne and getting assignment, someone thought, Gee, it'd be a good idea if we gave a course in nuclear, or reactor physics, doing simple experiments using CP-2. And George and I were involved in that thing, and I always felt uncomfortable, didn't know a damned thing. (laugh)

MS: Yeah, that was probably true for a lot of people, I think, especially in those early days where, considering the scale of what was built out there, it was kind of new territory for everybody. But let me go back to just to throw in a brief introduction here, this is an interview with Dan Pellarin, and it's the 16th of April, 2007. And Dan, if you would, just for the record, give your full name.

DP: Daniel J. (sounds like French pronunciation of "Jean") Pellarin.

MS: And what's your date of birth and place of birth?

DP: I was born in New York.*

MS: And what's your educational background?

DP: When I was seventeen, I finished high school and enlisted in the program that the army had, it was called ASTRP, Army Specialized Training Reserve Program. And they send us to college until we reached eighteen. And at that point, they extracted us from the program and fed us into the army, basic training. So I had one year of college in this program at Rutgers University as a general engineering background. Then I spent about a year-and-a-half in the service. The war ended and I was in the adjutant general's department assigned to MacArthur's headquarters, and sent to Tokyo, which was very interesting, to be there very shortly after the war. When I finished up, I came out in April of '47, and looked over a bunch of catalogs, with the help of my assistant principal, and identified Lafayette College in Easton, Pennsylvania, as a good school. They offered a degree in engineering physics, which was sort of a non-commitment in any one area. Anyway, I think I'm going into too much detail. I got a B.S. in physics.

And at that time, companies—this is 19– January 1951, the job market was pretty wide open, there were people interviewing with five and six different companies, shopping around (laugh) for the best offer. I very nearly committed with Eastman Kodak but didn't—wound up hiring on with Du Pont. In those days, they didn't pay your moving expenses and when I finished school I was in debt. So—and I didn't have clearance, and they also didn't take you on board—Du Pont didn't take you on board until you had your clearance. So we moved into my house in New Hampton, New York, which is—I guarantee you won't hardly find on a map—a little hamlet, really eery railroad passage into town. Well, anyway, I think I mentioned to your, what was her name, Mrs. Wood is it? The lady I spoke to, what's her

*Personal information has been removed from the transcription

name? It's right here somewhere.

MS: Mary Beth Reed?

DP: Reed, yeah. I may have mentioned to her that the very first day I was at Argonne I still didn't have my clearance but they finally, I guess felt sorry for me and at least put me on the payroll. I was in the reception area, spending the whole day just looking at textbooks and trying to educate myself (laugh) as much as I could, when on one occasion I hear this commotion and I look up and hear coming in to the reception area is Oppenheimer with an entourage of people, I guess it was a meeting. I was quite impressed. Well anyway, at Argonne, we did some experimental work that provided data for the people involved in the design of the Savannah River reactors.

MS: What were the major reactors at Argonne that were like precursors to the Savannah River reactors?

DP: Well they had a CP-3. CP stood for Control Pile, which– they didn't want an uncontrolled pile (laughter). But CP-1 was torn down; that was the one under Stagg Field. CP-2 was essentially abandoned except for what use we made of it to set up what they called danger coefficient measurements. It was a way of— It became a quality control instrument. Its use here at Savannah River was to take a certain fraction of the output of control rods, fuel, and run it into a stringer into the pile and compare it against a standard that was running periodically. And they weren't looking for absolute measures of what the reactivity of this fuel was, but how a batch compared to another batch and you could set up a statistical curve and say everything on the wings might be rejected. It was to test the fuel was okay, one of the tests. So that's what we were involved in. At Argonne there was a CP-3, which I never got to do anything with. It was a heavy water natural uranium reactor. That was pretty much the purview of the staff at Argonne in the Physics department. And there was an exponential reactor. Do you know what an exponential reactor—

MS: In general terms, yeah.

DP: There was one in 777. As a matter of fact, I worked on that reactor more than any other in the course of my twelve, thirteen years in 777 building. And there were a number of experiments done. They were trying to freeze on the design of the lattice for Savannah River, I guess. The initial one was to use quatrefoil. You probably—someone mentioned that to you. It was a fuel—extruded aluminum fuel tube that had four channels and a smaller central channel. It was like you took four circles and put them together.

MS: Right, and they just put them in a big tube.

DP: Yeah and there were twenty slugs of canned natural uranium. So there were a number of experiments we were doing in the exponential facility. You could extract useful information about characteristics of the lattice and how it was going to perform without making a whole reactor full of that particular lattice. You could just go into a region in the center and load in the study.

MS: Sorry, I was just trying to mess with the volume.

DP: So there was yet another reactor in—not at Palos Park, in which there were a number— I think they may have been doing work on the submarine reactor for Rickover's program. And there were a couple of Du Ponters, Du Pont trainees, like myself, who were assigned to that reactor. One of them was a guy that I subsequently worked for here, name is Pete Morris. Had you heard that name before?

MS: I've heard the name.

DP: Sadly, he was involved in a nuclear accident at Argonne. I guess—I'm sure someone before this time has mentioned how very fanatical Du Pont is about safety.

MS: Yeah, I've heard quite a lot about the safety culture of Du Pont.

DP: So of course at Argonne, Du Pont wasn't in control. We were their guests, so to speak. They were changing a lattice on this—I can't remember—it wasn't CP-4, I forget what they called that reactor. It wasn't an exponential; it was a critical reactor, in another building. Anyway, they were changing a lattice when one of the people involved in that work reached down and pulled out a control rod, and that was enough to make it go critical. And it fried— I think there were four people. Pete Morris was one of them that got an overdose. He didn't— He survived it. I never spoke to him about it. But he's dead now. I think he died, must have been a good ten years ago or more.

MS: Did he have any— Even though he survived, did he have bad repercussions from—

DP: They say—I never did— I worked for him. He's a very competent guy. Ph. D. from Rochester, University of Rochester, and a very nice person. It was a sad incident.

MS: Yeah. Just for the record, when did you begin working at Savannah River Site?

DP: April 1, 1952. And that was— At that time, I was following the construction of the 305-M and the subsequent start-up, calibration and training of the operators. Then I transferred to R-reactor before start-up. So actually at start-up I was in the control room. There were a couple, three of us, I think, that were taking data from the fission counters, the most sensitive detectors. They had travel, and they'd run them in as close to the wall of the tank as they could and we would be getting calibrate data as the control rods, safety rods first, were withdrawn and maintaining a plot of control rod position versus one over multiplication—1/M plot. That extrapolated would predict the location of the control rods at criticality. So as you got closer and closer, presumably the extrapolation got shorter and shorter and you could predict when you went critical—where you were going to go critical. I think there were a little politics in the game. I think Du Pont wanted to be able to tell the boss, I guess that was Harry Truman, then, that the reactors—the first reactor was critical in 1953, I guess.

MS: Yeah. I'd heard that. I'd heard that they had made a promise to—

DP: Did you see the film that they made? I say they—somebody on the fiftieth anniversary of the startup of R took a small group—a person representative of each of the various departments—one Health Physics, one electrical, one mechanical, one Reactor Tech, and took this group into R-reactor and made a videotape. Have you seen that?

MS: I've heard— I talked to somebody in Photography and apparently a— I think I know what you're talking about, and they did do a tape of it but they haven't put it together.

DP: Well, they handed a copy out to everyone.

MS: It must have been somebody else I was talking with then, because I've not seen that particular—

DP: Well I'll be glad to lend it to you if you like.

MS: Oh yeah, absolutely. Yeah, because I was told in Photography that somebody had took a lot of videotape of some kind of a tour in R-reactor, but they claimed that it wasn't ever put together in such a way that you could use it. But clearly that's wrong if they gave it out to people.

DP: May take me a few minutes to find it.

MS: Okay, we definitely would like to take a look at it.

DP: Yeah, that should be of interest. It was to me, you know. And I talked to one of the guys who went on that tour and he said it was creepy. I mean you go into this monstrous building. Have you been to the 105?

MS: Yeah, I've been inside it, yeah. They've got tile walls on the ground floor, like in the hallways? They didn't do that with the other reactor buildings.

DP: Yeah. Of course— I started out in R. I forget a couple— about six months before it went critical. And they were pushing hard just to get it critical, not to get it necessarily up to any power level. It could be a couple hundred watts maybe, (laugh) it's still critical but— They succeeded, and shut back down and then proceeded for the next two or three weeks really finishing up a lot of the detail that was really not absolutely necessary to go critical but part of the construction.

MS: Yeah I've heard they did that, that they had some—for political reasons they had to promise the AEC that they would get it started before the end of calendar year, 1953, and they just barely made it.

DP: By cutting a few corners.

MS: Right, just like at the site.

DP: So then we were put on shift, me, myself and three other guys were— We were in Reactor Tech and they wanted around-the-clock coverage. So for a period of about—I'm going to guess a little bit here, it's been so long—about six to eight months, I was on shift work. And I didn't much care for that. (laugh) Then I stayed in R-reactor as a part of the Physics group. And then at some point I was transferred to— The Reactor Tech had what they called a studies group, if you've heard of that.

MS: No—

DP: Okay. In each of the five 100-area reactors, the staffing— Well, I can show you. I do have some show-and-tell stuff that might be of interest to you. I'm trying to be as helpful as I can be. I found— I think it's in this folder. The trouble– I get things organized and then— What it was is a table of organization.

MS: It might be that thing right there.

DP: It was a single sheet. Yeah, there you are. This happened to be one—where is the date?

MS: Yeah that looks pretty early; looks from the fifties.

DP: Yeah, have you—

MS: I've seen stuff like that. Well it's actually— It would— It might be of some interest if it's from the fifties.

DP: The organization, like in P Area, had an area supervisor and then coming down from that a process supervisor in Physics with, in this case, four people—a process supervisor in engineering with, in this case, three people. Somebody else was on special assignment here.

MS: Yeah that's pretty good.

DP: I mean that's– They kept changing things a little bit. An awful lot of these people are no longer alive, it's sad, or have disappeared. You're certainly welcome to any of these. You probably got a list of people that they contacted for the fiftieth anniversary celebration.

MS: Yeah. I think we probably got that. Let me just take a look real quick. I'd say that we probably have that, but I've never seen this before so—

DP: You're welcome to—

MS: What we could do if you don't mind, we might take some of this stuff, we could xerox it and I could mail it back to you or give it back to you like before I leave this week, because I'm staying in Aiken so that wouldn't be any problem.

DP: Now here's the party in 1997, and these are the people who actually attended.

MS: Yeah maybe we'll make a copy of that one too.

DP: I helped a little bit. I didn't go to the reunion because by this time an awful lot of the people were people I didn't know because I left Reactor Tech and went to 777 building, which was technical part after—I can tell you—you may not be interested, after about eight years or nine years or so in Reactor Tech. And while I was in Reactor Tech, I went from R to C Area studies group. That's what I was going to say.

MS: Oh yeah that's–.

DP: There were five reactors and some engineers and physicists assigned to a group in each one of those 105 buildings, reactor buildings. Then over in C Area there was a building, stand-alone building, that was called the Studies group. And that consisted, again, of physicists and engineers who were doing special work for all– to expedite programs. Generally, they

were liaison between Reactor Tech and Tech division. I mean very shortly after, I don't know when it started after start-up, apparently the military had an insatiable appetite for (laugh) bombs. And I used to worry about this. I'd wonder, how long am I going to have a job here before they're going to have enough bombs to obliterate the world and they're going to shut the place down. That never happened, basically.
And after having spent about seven or eight years in Reactor Tech, I'd look ahead and see what the next job was and it looked to me like it was more distasteful than the one I had. And I was concerned also, if I was ever on the job market, in Reactor Tech, in the 100 areas, you pretty much have the role of a policeman. You're looking over somebody else's shoulder, seeing if they had an incident overnight and you come in the morning and you read about it, you investigate it, you write a reactor incident report and sometimes you had to be pretty diplomatic about these things because somebody asked–. Anyway, I got out of Reactor Tech into Tech division in 777 building, and I spent about thirteen years or so there doing experiments that in some cases were sort of bootleg. Savannah River was supposed to concentrate on problems of Savannah River reactors, not to do studies.

MS: It wasn't supposed to do like wholly theoretical work.

DP: Yeah. But there were— In the case— In my case, they assigned me to a guy who sadly died about six or eight months ago, who was extremely sharp. And they more or less catered to him. And he had interests everywhere. And he wanted— When there wasn't any work associated with plant activities, or if it was routine work associated with plant activities, he would go off and start a project of his own that he was interested in. And he needed a helper, somebody to do the dirty work for him, and that's where I came in. He was also—

MS: Who was that?

DP: It was Norm Baumann.

MS: Okay. He was part of our initial group, I think, that gave us our orientation into Savannah River Site many, many years ago when we were working on that fiftieth history volume ["Savannah River Site at Fifty"].

DP: So I worked for him for about thirteen years or so. We did a lot of publishable stuff, you know, published in Nuclear Science and Engineering or IAEA, stuff like that. I had a lot of respect for him.

MS: What were your other jobs at Savannah River Site? You worked in Reactor Tech in the various reactors and you worked for thirteen years at 777. Back then it 777-M, I guess. Did you work anywhere else?

DP: No, I don't think they gave it designation M.

MS: They did in the early, early years and later on they called it 777-10A, just because of its location. And they changed that designation at some point in the 1980s, but you're probably right, as far as people calling it, they probably just called it 777.

DP: Yeah, just happened to be located— And then the last four or five years, I got assigned to a group that was involved in design and safety of shipping containers. As a matter of fact, there was an interesting thing that was going on at this point. For the first twenty-five years or twenty years of plant operation, AEC, of course had—over there in 773-A building, administration building, that monitored what was going on and handled the purse strings, I think. And I had been told, I don't know this personally, that whenever there was an improvement or a project or something that should be looked into or perhaps done because it could improve or increase production of tritium and/or plutonium, that someone in Du Pont would ghostwrite the letter that would initiate this project or suggest this project, that the people in AEC, and later DOE, that were here, were not really technical people. There were a lot of accountants and people who handled money and so forth, that it was really— I don't know, I can only guess how they interacted together.

(interruption)

DP: The last— You're really not interested in this so much. I fought like hell to get out of that group because, again, it was a little bit like Reactor Tech, had somebody else to do the work and we were the individuals assigned to it to push for completion, but not involved in the technical aspects of it. I had gone to Tech division because I had felt that, on the job markets when the Department of Defense (unintelligible, interruption) shut down Savannah River and I'm on the job longer, I would be better qualified to get a job if I could show a background in experimental physics than in reactor physics, Reactor Tech. [Interruption] And so I fought like hell to get out of there and eventually did and then the last about three years of my employment, I was in the group at TNX that was involved in the design of the glass melter.

MS: That would have been, what, roughly in the late seventies, early eighties?

DP: It would be twenty years ago.

MS: And that was the last thing you did at Savannah River Site? When did you retire?

DP: I retired twenty years ago—twenty years ago this past January, that'd be eighty-seven (1987).

MS: So you retired before Westinghouse took over?

DP: Yes. And—

(interruption)

DP: Yeah, I was fifty-eight when I retired. It was the best thing I ever did. The work with Norm Bauman was very interesting because we—

(interruption)

DP: I'm sure as others have told you, after R-reactor became critical and problems were worked out and changes were implemented in P-reactor, which had the same—pretty much the same features as R. And then the next one to come on-line was L, which was a little smaller built, and K which was like L. And then C, which had the slightly bigger tank because by then they had produced an adequate inventory of heavy water to fill the bigger tank.

Everything was beautifully come together. The first area was M Area because they had to produce the control rods and the fuel to go into the—and along with it, the 200 Area, which had to produce the D_2O that was going to go into R. And so—

MS: Oh you mean the 400 Area?

DP: Yeah, I'm sorry, 400 Area. I'm sorry.

MS: And then I guess the last thing would be the 200 Area, because that was where they'd take the stuff from the reactors and have to separate it.

DP: Yeah. And basically there were two kinds of lattices. I'm afraid I'm repeating stuff you already—

MS: Oh that's all right.

DP: The natural uranium, which contained 238 that captures neutrons eventually and forms the plutonium. And the lithium target lattice, tritium lattice, which had spikes or enriched uranium and had lithium targets, because they wanted that to produce tritium. Of course that's what's been missing now. There hasn't been a reactor operating out there for what, thirty years.

MS: Yeah, they closed the last ones in '88 I think, except for they had that K-reactor Restart, which barely was a restart, the one that Westinghouse did in the early nineties, and I think somebody said it went critical for twenty-four hours and they shut it down again. Obviously they didn't produce anything. But as I understand it, tritium is made in some commercialreactor now, but they still process it at Savannah River Site. But of course that's the thing that—because it's got a half-life of eleven or twelve years. They just have to keep making that.

DP: Yeah, little over twelve years.

MS: And plutonium, they've probably got enough to last forever, as long as this country lives anyway. (laugh)

DP: And the lattice that was used— I mean there was continuous evolution of the fuel element. It started out with that quatrefoil and then evolved for plutonium production into concentric cylinder-type pieces. And the control rods themselves were lithium, so that they were producing tritium in the control rods. There were a couple novel features of reactors that were incorporated. I'm sure someone has mentioned the use of half rods to shape the flux in order to obtain the maximum power from the reactor. The water entered the fuel tube through a water plenum, six circulating systems. The water is introduced into the top water plenum and then with the proper orifacing you have different flow zones where you take advantage of the center— radially, the center of the reactor is the highest flux and highest generation. The natural shape of that radial flux is a cosine. If you can flatten it down by shaping it, then you run into some control rods in the center and you change this into something like this, you'd get more effective tubes running at full power, given let's say that you have a central metal temperature limit that you don't want to exceed from the fear you'd have a meltdown. Same thing is true if you looked axially in the reactor. As a matter of fact, no I think then radial flux shape is J-0 and the vertical distribution is a cosine, for a cylinder.

MS: You know more about that than I do. (laughter) I'll take your word for it.

DP: So the use of half rods, I mean just as the name implies, they were half—a regular control rod, only half of it was loaded with lithium-aluminum. And by positioning that in the reactor, they can take the vertical cosine shape flux and by putting a control rod here, flatten it out and shape it so they could run at higher power. So there was a continuous evolution, interaction. When I was in R-area I would get involved in some of these tests. And they were people from Tech division who were developing new and improved fuel rods. And there would always be a couple of new things in the reactor here or there that were followed very closely and if they were successful there'd be a turnover.

Of course— So there was that, the development and improvement of fuel assembly. Then, of course, there was the one that they probably had in mind from the beginning because they provided the capability to add another heat exchanger in each of the six systems. When we started up there were just six heat exchangers—one in each system. They added another one, and they were big and expensive. And then they—to take advantage of the bigger heat exchanger, they had to go to bigger piping and bigger pumps. And so by increasing the capability to carry away the heat that was generated, they could run to higher power levels for the same temperature (unintelligible).

MS: As I understand it, the buildings were always designed to hold like twelve heat exchangers per reactor, but in the beginning they just installed six because, again, they didn't have enough heavy water or whatever to run all that through there.

DP: But whoever coordinated that did a wonderful job, you know, bringing everything together.

MS: Actually it is pretty amazing considering that the size of the project and the fact that it was coordinated so well. It's really a remarkable engineering feat that they could put all this together in such a way that they did and it—I know when you read about it, it is pretty impressive, from design to construction. And it seemed to be there was a constant feedback flow where you had—you've got—

DP: Field change requests.

MS: Right. And while they were building R, they found out something they didn't need at subsequent reactors, they would change that, as they would go along.

DP: I was in R-reactor after having been in L. I never was in K or P. While I was— I guess I was a process supervisor at the time in R-reactor is when they had the nozzle leak. They found water where it didn't—shouldn't be and when things were inspected, they discovered a crack, stress corrosion, I guess crack. Someone talk— Did you talk to Ed Holgate? He would actually— He was very much involved. Sadly, you know, there are an awful lot of people that are dead, you know, even in this neighborhood, all Du Ponters, their ranks are being decimated. So this is a good time, I think.

MS: Well, it's like there were so many people that worked at Savannah River Site, that even in doing something like this, we had to sort of set an arbitrary number, we'll just interview this many because that's all we've got time for, but good thing about these subsequent projects, is you get an opportunity to talk to more people as–.

DP: It's an interesting job you have.

MS: Yeah it is pretty interesting. It's kind of fun to do the interview part, but that's where you really feel—

DP: What kind of background do you have?

MS: Well we can get into that a little bit later, just because—so it won't be on this. But I was actually— I have a degree in history and in anthropology. But I went to grad school and I studied Mesoamerican archaeology. I don't do that, but that's okay. (laughter)

DP: That's a big interest of mine. Archaeology. And we've done a lot of traveling since I've retired, probably getting away from—

MS: Yeah we'll deal with that later. But— So what— So I guess for your jobs and everything, you probably had to have a Q clearance, right?

DP: Yeah.

MS: And that was probably pretty standard for anybody in Reactor Tech, I would guess.

DP: Yeah.

MS: Who were your supervisors back when you worked in the reactor?

DP: Okay. Let's see— Let's restrict it to Reactor Tech. I worked for Phil Hayward. No one seems to know where he is. I mean, for the purpose of informing about the anniversary get-together. He was very competent, Ph.D., I don't know where he's from. I worked for Bob Axtmann, who is head of the department of engineering, reactor engineering at Princeton. I worked for Pete Morris, the fellow who died. He was a Ph.D. from Rochester, University of Rochester. Let's see— When I was in various 100 areas, I worked for Oscar Cranvule. You can find his name spelled on that under reunion list. He was an engineer. I worked for a fellow that used to live up here, Gene Kiger. He's dead. Let's see, what else? The very early days.

MS: Who were some of your more memorable co-workers?

DP: Well, (laugh) certainly the most colorful would be Bob Axtmann. Now, (laugh) you know what a helmet liner is, a hard hat, has a little hooks that go in, fasten in. It's like a sweatband, goes around your head. Bob Axtmann would have one of those hanging on the coat tree in his office, and not—without the metal thing. And he would very solemnly pick it up on occasions when he had to talk to Production department, who were running the buildings. Production department was the superintendent and assistant superintendent and area supervisor and senior supervisors and so forth. But Axtmann interacted generally with the superintendent or the assistant superintendent. He would put this thing on. Of course it looked ridiculous. With a great degree of solemness, he would walk down the hall from where his office was, maybe twenty feet to where the production superintendent's office was. And he would call that thing his "talk-to-Osterdal hat." Osterdal, was at one time or another, assistant— And he'd go—(laugh) he'd walk in there. And he could do this without cracking a smile, you know, sit down and relate whatever his business was to Osterdal.

On one occasion I remember going into his office. I had found something that was amiss, I don't remember the detail. And I was quite excited about it, I guess. And Bob Axtmann was sitting at his desk. He has one foot up. DuPont safety rules would probably frown even on one foot, but he had it, and he had his shoe off. And there was a hole in his stocking, and he had a toe that was protruding. He was— All the while, you know, I'm all out of breath, I'm talking about what's going on, it's not right and we got to do something about it. And he's just looking and wiggling the toe. And then all of a sudden with no other forewarning, he reaches down, puts his finger in the hole and tears the sock, you know, just rips it off his foot, balls it up and throws it into the wastepaper basket. And he turns to me and he says, That'll teach my wife not to darn my sock. But he—I knew him. He was at Argonne. I knew him from Argonne. And he was in Reactor Tech. He was a great guy to work for. He had a running feud with another guy, a Ph.D., in Physical Chemistry. His name was Sid Katz, very confident, he was from Johns Hopkins.

Du Pont had some very, very good, very high-caliber employees that they had pulled together or even out of their commercial plants to feed in. As a matter of fact, I think there were five plant managers at Savannah River. Only one could be a plant manager and the others were extremely knowledgeable. But anyway, he and Sid Katz were sort of forever bantering back and forth, making bets. And I remember one time (laugh) when Bob Axtmann lost a bet. He made a dollar bet with Sid Katz and lost. So he paid him off with a hundred pennies that were taped down, I mean really taped on a piece of cardboard (laughter), so he had to work at it. It was funny. The time at Argonne was quite interesting of course.

MS: Now you mentioned Argonne earlier, but how long were you at Argonne?

DP: I was—exactly a year. It was a very relaxed place. As I say, the reactors were in the former state park, called Palos Park, and they had a bus system, and so forth, dropped us off there. They had Argonne employees, some of them, names that harken back to the Manhattan Project, Lewis Turner, for example, was head of the Physics group. But they had picnic benches outside and people would go out and conduct some of their business. You'd see them arguing and scribbling and we'd go out there and eat and crank up a softball game, and chess became a big fad.

There'd be chess games that would go on through half the afternoon. Supposed to be, I forget, a half hour or an hour lunch period. There'd still be chess games going on two hours later. (laughter) There was a fellow by the name of Mort Hammermesh, who was very competent, physicist at Argonne. He was a great chess player. As a matter of fact, he'd get five or six games going at the same time. He had the capability of stopping in front of the board, particularly if it was someone who wasn't a real good player, and almost just glance at the thing. He wouldn't even bother to sit down. He'd make his move and pass on to the next one. Well he'd get Sid involved in some of these things and Sid Katz would just try his utmost to win just one game. And it's so funny, Mort would come up to Sid's board, glance at it. He'd recognize what Sid's last move had been. And I remember on one occasion, in a loud voice—and there were a lot of spectators—in a loud voice he'd announce to Sid, "You can't do that, man, and live." He was from Brooklyn and he had the Brooklyn accent. And poor Sid was just—just make Mort more resolved to beat him. There were a lot of good people, and an awful lot who've left, I mean they were transferred or quit. My first officemate was a guy by the name of Dan St. John. And—

MS: This was at Argonne or—

DP: Argonne. Beyond a doubt— I mean space was at a premium, so they had two people in many offices. Dan St. John, I think— I don't know whether (unintelligible) yet, but he achieved, I think the highest professional ranking that Du Pont can give. I don't know exactly what they call them but some sort of research associate, something like that. The guy was just amazing. Because here I am trying to pick up the dregs of what I should have had in college if I'd stayed for that full year. And there's a steady stream of people that are coming in to talk to St. John. Didn't bother him at all. He seemed to be able to be doing—working away on his work. Somebody'd come in and he'd swivel around and accommodate them, very nice disposition. Often it was Sid. Sid would work on a problem and he would be stuck and it'd be some complicated math thing that he had never heard of before. And St. John—it just amazed me. He could stand up to the board with a piece of chalk and talk to Sid in equations, I mean just write them down like we would write a letter. He— I've never seen anything like it before and I've never seen anything like it since, but he was just an amazing person.

MS: Now did he stay at Argonne or had he come to Savannah River Site?

DP: He was at Du Pont.

MS: Oh he was at Du Pont.

DP: But he had—he was a physical chemist. And he had come from commercial Du Pont. He wasn't a new hire. And he came down here, I think, only a couple of years. And then last I heard of him— Du Pont has always has had a policy of buying and selling companies. And they bought up some small company in the Midwest and was looking into the commercial application of holography and St. John went in as the lead man in this small group—Du Pont group, that was looking at that. I don't think anything ever came of it, it was one of the—probably many (laugh) that didn't work out. But I did see that he was—had the highest professional ranking in terms of technical accomplishment.

MS: Just out of curiosity, when you were working in the reactors, how often did you have to get tested for radiation levels?

DP: Well whenever you entered the building like, let's say you got to where you parked your car and you went through the gatehouse, which was still away from the building, you still—and then you entered the building and picked up a radiation pencil. And you wore that until you left at the end of the day when you put it back in the rack, as well as a film badge. And your own identification badge, you wore that. So if you were going to be— I'll relay an incident that happened that I was involved in. One of the things that was developed, and I was involved in providing the liaison between the people who did this development— There was a group called Instrument Development group that, in some respects, overlapped similar work that was done in the laboratory, in Tech division. Anyway, what this was, this device, was a—we called it a "traveling wire monitor." It would take— You'd load it with a spool of piano wire. You'd do this in the disassembly area, where there is a path under a wall that permits you to discharge fuel elements. They get picked up. I'm sure you had heard about the charge-discharge machine.

MS: Right.

DP: Well it would pick the element up in the air, move it across the reactor to a channel and go under water. It would be placed in a cradle, and then this machine would be activated. It would go under the wall in the water and come up on the other side. Well, this offered a path to the reactor while it was operating, with no one in the room. So over here in the disassembly area, where the radiation level was not the problem, we installed a traveling wire monitor, which— I think there were about four different positions through which a wire could be pushed across the reactor floor underneath a generous bend, across the reactor floor, up to the water plenum and then down into a one-inch instrument rod position. There it would cook for, I forget, five, ten minutes. Then you could call it back out and it would run through a scanner that would look at maybe a one-inch section of the wire as it came through, past the scanner, and it would draw a picture of its activation profile, which was a measure of what the axial flux shape looked like, and then you could use the half rods to improve it. Later there were schedules that people calculated that showed where the half rods should be as a function of where the full control rod was, to achieve this optimum flux shape to minimize maybe central metal temperature, whatever was the limiting item on power.

I remember things we had some problems with. And I remember on one occasion where I stayed over. There was another fellow who was working with me, and the thing had jammed. And we finally decided the only we could get out of this mess we were in was to topple the shielding away. That would give us access to the spool on which the wire was wound and we would, with long-handled tools, pull the spool off, let it drop into the disassembly basin. Well, we did it but we exceeded our weekly dosage. And I remember getting contacted by the head of the Reactor Tech department calling and chewing me out for (laugh) getting overexposed.

MS: Well, it sounds like they were pretty conscientious about that kind of stuff, the health physics aspect of it all.

DP: Yeah. Tritium was a problem. I didn't get much involved with that, but in the -20 foot [level] and -40 foot [level]— I'm assuming that you know the—pretty much the layout of the building.

MS: Right, yeah. The -20 and the -40 would have been where they had the heat exchangers and the pumps—the water elements would all be down there.

DP: Yeah. And that's where if there were water leakage, there would be tritium, so people who went in there would have to be in full suits with breathing air. I never did have much occasion to go in there.

MS: Yeah I heard that once the reactors really started getting operating, that they had a problem in those levels with just general radiation levels were kind of high, that they had to—if you wanted to go down in there a lot of times you had to suit up and stuff like that. They didn't have that similar problem at the upper levels just because of, like you said, leaks and just the water being there and all that stuff.

DP: Well one of the questions on your questionnaire that I got to thinking about—

MS: Let me just double check this thing. Unfortunately, it has a time limit. Let me see where we're at here. I'm afraid this thing may be just about ready to— Let's see— It's roughly about an hour-and-a-half and I think we're approaching that. I may have to go back and change this setting so— Supposedly it's very—fine, so it'll only last about an hour-and-a-half. There's another setting that's a little bit lower but it'll give you an extra hour.

DP: You asked what time periods in the operation are the most significant and is it different for each reactor?

MS: Um-hm.

DP: And I had trouble with that question because I mean, there weren't really— I mean the objective was to operate the reactor at the highest inage at full power. And—

MS: Well a lot of those questions are pretty subjective and so you can answer it any way you want.

DP: The period that would be significant like would be the installation of the heat exchangers and the piping. I mean that was a major, major, major improvement that permitted higher power levels.

MS: Right. And that would have all happened in the fifties.

DP: Yeah.

MS: And pretty much the rest of it is just improving on a process that has already demonstrated that it did work and it's just a matter of like making improvements to it where you add safety features to it and as the power level goes up and that kind of stuff, but I mean basically the thing operated in the fifties.

DP: And there was—apparently a lot of the equipment was contracted out, like the charge-discharge machines.

MS: I think that was made by American Machine and Foundry.

DP: Yeah, AM&F, who were, I guess, ideally— You see some of the machines they use in industrial processes, things are flying down and— They were quite unique, I think.

MS: Yeah, I don't think they had anything that— There's nothing that was built like that. It's a unique kind of a— They just hadn't built any kind of–.

DP: Yeah and I guess they used another adjective in front of it, called it a telescoping actuator system. In fact, you could lift the whole thing up and—

MS: It would go up in the ceiling, yeah.

DP: Where it would permit the charge—

MS: The discharge machine to go underneath it and then do what it's got to do. And I've seen diagrams of that. It would go all the way up to like a recessed area in the ceiling. And then the charge-discharge machines would move, then they would go back then this thing would come back, yeah.

DP: And that tower, or top hat, I think, was 120-foot elevation. It was the highest point in the reactor.

MS: I know we've been up to elevation +66, which is where—

DP: Where the amplifiers.

MS: Where the T-amps are—

DP: (unintelligible).

MS: Right, and a lot of which I don't quite understand, but I know the principle of it, so it's— When you take a tour of the reactors, what always throws me is that even now, even most of them are just like shells of what they used to be, there's just so much going on, there's and so much noise. Even now, there's like with fans blowing and stuff like that, that when you see these things, you don't really quite get the big picture until you look at the engineering plans, because you get overwhelmed by the detail, when you go to different levels and you're not really—you're just kind of going—

DP: There were some systems that were developed, like one I think of in either Newark—that's where I think the experimental facilities were, not in Wilmington where the corporate headquarters is, but it was developed by Du Pont engineering and in particular a guy by the name of Cathie, Con Cathie (?), which was a cooling water monitor. It looked at the effluent from the heat exchanger, and it was designed to pick up any radioactivity that would be caused by a leak in the heat exchanger. I mean the only way— You've got cooling water from the river in the shell part and you've got D_2O from the circulating system in the reactor, going through the tubes. And it was designed so the pressure in the tube was higher than the pressure in the shell. So if a leak developed, it would leak D_2O into H_2O, not screw up your moderator purity by going the other way.
And that system, there was quite a bit of trouble with. I don't know why. The idea was to search and find the—I call it a "window"—energy window through which you would get the best signal-to-noise ratio for detection of radiation from the reactor. I mean there were problems, a lot of people coming down from Wilmington. The guy who designed that came and worked them out. I know George McManaway, probably the most knowledgeable guy on the actuator system. Sadly, he's got Alzheimer's. I don't know how much he can remember. But there were activities, like I say, during the time the building's getting put together, instrumentation checked out and all. It was a pretty busy place, everybody doing his little share, procedure writing. Paul Hoffman is a procedure writer or at least (unintelligible).

MS: Yeah, I've always heard that procedure writing was a big thing at Du Pont.

DP: It was, yeah. Everything was done by procedure. And then after I left Reactor Tech, there was a great deal of work done on the safety system—

automatic safety, computerized–.

MS: In the sixties, they had the first safety computers that were put in. Was it GE-412 or something?

DP: Yeah, see I don't know anything at all about that.

MS: That was the first one. I'm sure they replaced it later, but –.

DP: Strangely, there was a crude automatic pilot system that was included in the initial design and installed. I worked for Pete Morris at this time and I was given the assignment of looking into the feasibility of using it. There was a great deal of, I think, reluctance to turn over the operation of the control rods to a machine. Just—I think it made people nervous. And I remember looking into it, writing a report, and then the thing pretty much died there. We may have even tried it out; I think we did. Anything that was done in the experimental nature was done under what we call the SP, Special Program, I guess it stood for. So you wrote a detailed procedure that someone could take and follow step by step by step, like building a Heath kit. And that had to be approved by both Production and Reactor Tech, and then scheduled that to take place. Some of them were done during shut-downs or if it required reactor operation, it was done at that time. And there could never be any deviation from what was written without authorization.
So all things considered, they operated those reactors very successfully, satisfied the— And I guess it wasn't until the Reactor Tech anniversary get-together, when I heard— I don't know was it E. J. Holgate or somebody who was master or ceremonies comment that we should look upon this, or our involvement in this project, with pride because in a sense we helped win the Cold War. And you know, I had never considered it that way before and it's true to some extent.

MS: Yeah, I think that certainly was a factor, there's no doubt about that.

DP: Now they did have an incident in the L reactor where— One of the projects I had at one time was implementing a use of a source rod. This was—antimony-beryllium has the characteristics that once the antimony is activated, it'll kick neutrons. I think it's a gamma end reaction, kick neutrons out.

And it was useful in that it's always nice when you're starting up a reactor cold, like you've discharged everything in the previous cycle, and there's no—nothing radiated there. You've got your fission counters, which are the most sensitive detectors, two of them, all the way in as close as they can get to the reactor wall. And your count rate is very low. Your statistics are not very good. And you're starting up your reactor. Of course you keep a sharp eye out, looking for a response from these instruments.
Well with the source rod, something in the middle of the reactor or anywhere in the reactor, emitting neutrons, it doesn't change the reactivity, but it does change the flux level. You get more neutrons, better statistics earlier, confidence in these fission counters are working. Sometime in L Area, they pulled out a source rod, it was just one. They pulled out a source rod and I don't know what— I don't know the details. I wasn't in Reactor Tech anymore. I just heard—

MS: Is that the one that I heard they pulled it out and it dissolved in the air or something?

DP: Yeah, it melted.

MS: It melted? Yeah.

DP: They did not— We used to— One of the chores that Reactor Tech had was to generate what we call "cooling curves." And they were maximum permitted time that an element could reside in the air during discharge before it was necessary to initiate cooling, which was done from the crane control room by the guy who was operating the discharge machine, discharge crane. And that was a pan under there, that would slide out. And after the element was pulled up out of the reactor into this machine, the pan swung under and they went traveling off to the discharge canal that I described. And I guess—I don't know what happened. They didn't (laugh) initiate cooling when it should have been, whether the curve was incorrect and it didn't give them—tell them to initiate it or what— But it did sort of melt down and created a clean-up problem.

MS: Right, because I remember they—that's where they enlisted volunteers from all over the plant. Was that the one where they had to go in there for a few seconds and mop it up a little bit and then run out—

DP: It may have been but one that was the leak in R reactor. As I say, I was in R Area at the time. We used to have to write a morning report that we would phone via the superintendent's secretary so that it went to him and went to Wilmington. Gosh, during that time I was writing morning reports that were twenty pages long, just describing the events of the previous twenty-four hours. Well, not twenty-four but since I— Yeah, well, what transcribed up to that point in time. And I do know I stayed away from that place, that's down -20, and construction was actually breaking into the reactor wall to get to the—trying to find where the leak was in the discharge.

MS: Oh yeah I remember hearing about that. That would have been difficult.

DP: And there, I think, the working times were quite short, I think twenty minutes or so or something like that.

MS: I'm afraid—I think our— Oh this thing's still going on so I guess it's all right.

DP: Boy that is really compact, the tape.

MS: That is compact, yeah that's true. Well let me just run—see if some of these questions if they were—

DP: Let me look at my list too.

MS: Out of curiosity, since—what was the main impact of the reactors in 777 to the start-up of the main Savannah River production reactors? What was the main thing that y'all learned in 777 that you applied to the operation of the reactors?

DP: Okay. The main thing is that during this period, when there was a real concerted push to develop new and improved fuel elements for the two types of missions, to produce plutonium, to produce tritium, during that time, the physics of these lattices were measured in a full-scale mockup of the 100-area reactor. I mean that— Consider there are six hundred positions. They loaded the fuel and mocked up the reactor— Now, this was a critical facility; it wasn't like the exponential. And— So they were doing tests and measurements related to that.

Also, interestingly, the Canadians in their Pickering stations on the Great Lakes, they were interested in D_2O-natural uranium. See, these [reactors at SRP] were the only D_2O-natural uranium reactors in the United States. The Japanese were interested and the Swedes where they had (unintelligible) site, but I think said that they weren't going to generate any more or build any more. So we did— They would send—on a couple of occasions, send delegations down here, and they would contract with the Savannah River to do measurements in the 777 reactor that they were interested in. Now there was a Canadian co-op program, in which DOE, or AEC before that, had given the Canadians a grant with the only specification that the money be spent in the U.S. (laugh) And since we were the only place that had D_2O-natural uranium [reactors], they spent the money at Savannah River and we had—and they would come down. There were meetings to decide on what they would like to have done and how it would be done and what we would— And we'd always write a report. I got involved in some of those because a lot of what I did was foil activation, getting plots of what the flux looked like in a cell.

And we had the Japanese come and stay for about three weeks, and one of the foreman of the machine shop in 777 had been a marine in the South Pacific and he still absolutely hated the Japanese. So they had to be very careful that he didn't get too close. And I think he had been injured himself. He always walked with sort of a limp, but never talked about it. So that was interesting because at the end of this period when we did these experiments, the Japanese invited us to a party in Augusta and then to the hotels and they had some sake— And I don't know where they bought it, they bought it with— I remember they— There was one long weekend that fell over a period when these measurements were scheduled. We asked, What do you—we could give them ideas or maybe get together with them or whatever. But they had it fixed in their mind, I guess, before they ever left Japan, that they wanted to go to Key West. And from here, to go to Key West—

MS: Yeah, that's not exactly close.

DP: Not only that, but it's sort of boring, but they did. And I remember a couple of occasions I went up one time to Ottawa in the wintertime and coming back, we were scheduled to be on a train. We were going to come back from, I forget, Ottawa to Toronto or some place. And we were really at Chalk River. And we were in touch with their traffic and transportation department. I guess a couple days before we were to leave, the train was on time. Then they had a snowstorm out in western Canada and each time we called them, the train got further and further and further late, to the point where it was over a day before the train would arrive. We finally bummed a ride with the employees going our way.

MS: I can imagine that would be pretty difficult to have to mess with. Well we could— Unfortunately— I've got other questions I could ask, but I'm afraid it might be running out of time.

DP: Time is not a problem to me.

MS: Well I was just thinking, if you want— I'd probably have to break this right now just because I've got to go over to Evans and interview Bill Bebbington this afternoon, and I've got to be sure and pull this off of this machine and put it on the little laptop computer I've got. But we could, if you want— If you want to talk some more, we can do it maybe on Wednesday morning.

DP: How's that to you? I don't know, I sort of babbled on a mixture of—

MS: I'm going to go ahead and shut this off then just so I don't run the risk of—

(end of Session 1)
(beginning of Session 2)

DP: The guy I worked for, for some strange reason, going to work, he decided that he was going to go over the fence. And it's sort of out of character. And sure enough, he climbed over the fence. Of course, there were guards around and they nailed him and he got his ass chewed out for that. Let me turn on the light here, maybe see a little more.

MS: Yeah, the eyesight— I've got reading glasses now to get me through my day.

DP: This thing has a time delay in it. I've got it pushed down so it— Then the question is whether I have this switch in the off-position or the on-position.

MS: That's not—I can see well enough.

DP: With a little patience it'll come on. If it doesn't come on, I'll switch in the—

MS: Yeah, this is good enough. We talked about a whole host of things, I guess— So this is sort of like the continuation of what we did.

DP: Another thing I can offer you that may or may not be of help was when they had the reunion, the first one, I was interacting with Stan Goodman. Does that name mean anything to you? He was in the Production department. Anyway, he recruited me to help get in touch with people from Reactor Tech. And so here're some names, addresses, phone numbers. I don't know whether it's of any help—you can—certainly borrow it.

MS: Yeah if you don't mind, we might xerox this and I can mail these back to you.

DP: Yeah, be fine. Let me see if I've got–. I knew McKibben.

MS: Oh, Mal McKibben?

DP: Not very well. It's funny, you could work in the 100 areas, say you're in L Area and somebody else is in the studies group in C Area and your paths may interact for a brief period of time, maybe at a meeting or so you recognize them. But you don't get to really get to know him, and that's McKibben.

MS: Yeah, we interviewed Mal McKibben I guess it's been a couple years ago. He's sort of in charge of that Citizens for Nuclear Technology Awareness.

DP: Yeah, he's very active in that group.

MS: And interviewed Larry Heinrich yesterday.

DP: Yes, I know Larry very well.

MS: He had some good information. Then I talked to Fred Christensen yesterday over at the Houndslake Country Club, and he had to take off after lunch for some real estate emergency or something like that, but it was interesting.

DP: Is he in real estate?

MS: Apparently, pretty seriously.

DP: Oh. Because I know another fellow, Dick Harrell, who's been in real estate for a long time. He retired from the plant.

MS: He forgot to tell me and it didn't even dawn on me this would be a problem, that you can't wear jeans in the dining room at the Houndslake Country Club and I had these pants on right here.

DP: Yeah, a special dispensation?.

MS: No I just got a special pair of sweat pants. (laughter) So he came out and apologized and said, I'm sorry I forgot to tell you about the no blue jeans rule. He said his son was the one that implemented the rule. I said, Oh well.

DP: I don't know what all this is, to tell you the truth. This is the workers present at R Area start-up [Pellarin is showing the interviewer some materials].

MS: Yeah we might want to take that.

DP: Okay this—

MS: Was this was something that was worked up at the time, that was actually done, or reconstructed later?

DP: It has a cover letter. I'll give you the whole thing.

MS: Oh okay.

DP: Yeah, I would say after the fact, we're enclosing a copy of the list that was developed using past records and some good detective work by Stan Goodman and others, and I was one of the others, I guess. We regret there may be some employees that we were unable to locate, though the best attempt was made. So that's probably the best list, it's typed already and—

MS: Right, it's ready to go.

DP: The other one's— So why don't you just take that?

MS: Okay. In fact, let me just put this inside here–. One thing that Larry [Heinrich] talked about yesterday which I've never heard before, he was talking about the real reason that Savannah River Site decided to go with the mixed lattices in the sixties and seventies is because they had— He said there were like three things going on—the navy had something they wanted to get rid of or they had too much of and they worked up a mixed lattice thing to still produce some plutonium and tritium, but they also did other things that were— It's on the tape and everything from his interview, but I can't recall exactly now, it was too complicated.

DP: I guess I never heard that addressed specifically.

MS: Yeah, I've never read that before, I've never heard that before.

DP: Again, I guess that falls, to some extent, into his rule of compartmentalization, although it wasn't information that I was privileged to—

MS: Right. I've never heard that before and I've never read it before.

DP: I guess I thought it was a lattice designed specifically for tritium production.

MS: Yeah, I assumed it was just sort of for—

DP: In R-reactor more so than in some of the others, but to some extent in all of them, there was always some auxiliary program that was being satisfied. I mean there were—like californium project that would have certain assemblies that were in the reactor, sort of test assemblies, or ones that they needed isotopes for the power sources for the satellites, so there were a couple of rods in to satisfy that program. Then there were always—for a long time, I mean while I was at Reactor Tech anyway, there were the test assemblies, the ones that were being evaluated for—because they improved the production, they operated at higher power.

MS: Right, they were just experimenting with different things because it came about at the same time they were doing the other, the special products anyway, so I figured they were just doing—just testing out different stuff because they wanted to. There was that element too, I'm sure, but I didn't realize they were actually addressing specific production needs that were more complicated than just producing plutonium and tritium. It was the—something about neptunium, they had a bunch of and they wanted to turn it into something else and the navy had something. There were three things, he rattled them off, and fortunately the tape got it, but I couldn't write fast enough.

DP: I think Larry was involved in those study group projects.

MS: Right. That was something he just volunteered because I didn't know enough about it to even ask. And so he just said, Oh we should talk about mixed lattices. Okay. That's fine. But yeah, I think you're right. There was so much going on out there, that everybody knows a little bit—

DP: Knows what's going on in his area—

MS: In their particular area.

DP: Well every Friday, we'd have a meeting in C Area. There was a studies group. It was quite a large group at one time and people were coming—going from that group, being assigned to the areas for a year or so, coming back or going to another— I mean there was some mixing going on. Every Friday at the C-reactor, C Area studies group location, there was a meeting, and each of the supervisors would present what transpired over the course of the week in his area, so you heard that and then that was just the supervisors that were involved, plus the people from the studies group who wanted to attend it, but not the people from the areas.

MS: If you don't mind, I'm going to put this on pause for a minute. I'm going to go out and get my notepad, I forgot that.

DP: (unintelligible) usually work through me, but because there was a studies group in the five 100 areas and this movement around—

MS: Well it's true. It's like— And there was a lot of movement around—

DP: Excuse me. Unless one was in the Power department or Health Physics or something like that, at least as far as Reactor Tech was concerned. We got out of our carpool in the morning (laugh) and went right to the 105 building, shut the door and didn't see the sun again for another eight-and-a-half hours or so. And you know how bright and glaring the sun can get when you're in South Carolina. You come out in the morning like moles coming out of the ground, I mean that sun blasted.

MS: Yeah it's so bright out there because there are no trees. It's just like–.

DP: And the cars were parked out in the open in the parking lot, the sun beating down. You had to put the window up because you could have a thunderstorm or something. And we'd get in the car, and as I say carpooling was a standard practice. Generally, there were five in a carpool, some with six. Cars had front seats that went all the way across, and it was hot for the first several miles (laugh) down the road.

MS: But of course the cars didn't have air conditioning, I'm sure.

DP: No. It was just the norm.

MS: That'd be kind of rough.

DP: For a period of about five years or so, in about mid-fifties, there was an awful lot of companies in America that seemed to be climbing on board the bandwagon, that nuclear was going to do everything—run locomotives, fly airplanes, provide power sources for the North Pole. I mean, it had just a bright future. I must say that influenced me in accepting a job with Du Pont because it was specific to this—eventually we were going to come down here. But there was an awful lot of movement. There were people that would stay about three years and then move on. General Electric, American Machine and Foundry, I mean there were just a whole host—General Atomics—host of companies that enticed people. I even got on board, I began looking at the prospects of going with Westinghouse in Pittsburgh because they had a program with the University of Pittsburgh where you could go to school in the evening, and I started to look into that until I ran into a requirement that the prime contractors with AEC, at the time, were obligated to notify the employer if there was someone looking for employment. And well what that meant was that your boss knew that you may not be happy or satisfied and you were looking elsewhere. So it was like dropped at that point.

MS: Right, that might not be a good thing to advertise.

DP: In the meantime, University of South Carolina developed a program here in Aiken that they were sending the instructors down for classes in the evening. But you could only—they would only accept, I think—I think it was twelve credit hours off campus and beyond that you had to go up there. Well, I got twelve hours pretty easy and then after that, it was Saturday getting in the car. This is before I-20 was there, running through the back woods to Columbia and taking courses. And this went on—I think I was five credits short. I had arranged a thesis to be done on a non-classified topic at the plant, so it brought school people and plant people together, at least to that extent that they formally approved that I could do this, and I had the thesis completed.

Five credits left, and I was involved in taking another three credits. I was in R-Area at the time. And I was to go up on Saturday and I think it was a Thursday at the plant I got a telegram, saying that the head of the department, the guy who was breaking all kinds of rules about— Well, it was almost in some cases a correspondence course. And most of the teachers, professors at the university on Saturday, which was the only time I could go up there, wanted to not to be bothered with classes, they wanted to start their weekend. But this fellow that they had recently hired and had put in charge of the Physics department, was willing to teach classes on Saturday, he accommodated me. At first there were enough people that we could get a carpool going up. Then pretty soon this guy was interested in electrical engineering and this one was interested in something else and pretty soon I was by myself going up there. And then I received this telegraph—the poor man died of a heart attack. And with it, they lost the department head, all of these unwritten understandings and agreement that he had, we had—

MS: They just went away.

DP: Disappeared. And it got to be a chore. I had a whole bunch of little kids here in the house that were banging on the door, I had homework to do. And I got so discouraged I just dropped it. And then many years later, about ten years later, they started another program out of the University of Columbia, they called that the GPA Program of Engineering Education. I think that was it. And I guess I'm talking about myself. (laugh) You're not interested in this. I started over. They did give me credit for quite a bit of work that I had done previously. And I wrote another thesis, and again had an agreement. I think Norm Baumann was my advisor here. The university had a couple people who had worked at the plant. One of them, Colgate Darden, had worked in 777 building where I was, so he became—he was present at the time I had to defend the thesis. So I finally finished, very late in life, and after a lot of struggle. But that program, I think, is still going on.

MS: I guess this is before they had the University of South Carolina at Aiken, right?

DP: No, they had it here in Aiken but it started out as a two-year school in (unintelligible). Have you been through the museum here in Aiken?

MS: I don't think I have. Oh the one that's right there by—in a hollow and coming from Richland Avenue you go right—sort of make a right, I mean a left turn, a 90-degree turn to go to the stoplight there? And you go right past it and it's sort of on your right?

DP: Yes.

MS: I've never actually been in there.

DP: They feature an exhibit that focuses on this era that we're talking about. I think they moved intact an old drugstore from Ellenton or one of the other towns. If you've got a couple—an hour or so to spare sometime, you might walk through there.

MS: I always— I've seen it before, maybe because I see it all the time I don't think too much about it, but I'm pretty sure I've never been in there.

DP: But it does cover that era that we're talking about, sort of a traumatic one for Aiken. (laugh)

MS: Yeah, I can imagine so. So I guess the whole question about which reactors did you work in and in your particular case, you were probably in a lot of different ones.

DP: All except two. I never was in P or K. There were people, I guess, who were in the studies group, which was located in the C Area, but not in the reactor building. Well, anyway, that school eventually grew after they got started and Bill Casper was very instrumental getting that going. And then they developed— Have you seen the four-year campus? The college eventually moved out on University Parkway.

MS: Yeah, in the place where it is now? Yeah, I've seen that. And they've got the—like in the back they've got the Ruth Patrick Science Building, I think. We had some kind of Savannah River Site Heritage Day there last fall, I think it was.

DP: They've just completed the auditorium, I think, that can accommodate four thousand, which is going to be used for activities, sadly mostly rock-and-roll or whatever groups that come through Aiken.

MS: They got to make some money I guess.

DP: The last seven years of my employment, I taught out at the University in the math and engineering department. I had always wanted to do that and I was able to. I got a lot of satisfaction out of it, because—that I wasn't getting at work. Because I don't know if anyone else had mentioned it, I think most of the people my age went in and went through the period of power increase and–. It was a very busy time. I always say the American taxpayer really got his money's worth, because we worked hard. And then any further improvements, I think, weren't justified on the basis of the cost. Suddenly, they were getting close to the point where they had enough bombs, I guess, to blow up the world many times over. And during that period of time, I think Du Pont pretty much ran the place in its entirety, even though there was an AEC group there. I think Du Pont was writing letters to itself that would originate out of AEC, DOE—you make this kind of study and this kind of study. They were carrying the ball. But then when they reached this point where they could see the end, it turned sort of to what seems to be characteristic of all government installations, turned political.

MS: Yeah, that's probably true.

DP: And it was less interesting.

MS: Right. That's kind of one of the things that Fred Christensen was talking about yesterday at lunch. He was saying that— He was talking about the relatively small number of people that they used to run the production reactors, and in fact the entire plant. He said when they were producing stuff out there, they only had about 6500 people working out there on a permanent basis and maybe a thousand in the Lab but that was included in the 6500 people.

DP: And that included security and even the janitors. Much of that has been contracted out.

MS: Right. And then he said after Westinghouse got in, that especially like in the early nineties when the population ballooned out there to almost 30,000. And he said, apparently— And there was some reason why— There was political reasons why they did it because apparently Westinghouse got paid on the basis of the number of people it had employed out there and also the fact that it was in Strom Thurmond's home district and everything that—at that point he was like pro temp leader of the Senate or something, so I think he was behind it but he certainly didn't object to his district being padded. So by that point, there's all kinds of politics involved and they're not really concerned with production at all, they're just making sure everybody's happy and whatever.

DP: I left before Westinghouse came in. As a matter of fact, Du Pont had always (unintelligible) pertinent— Du Pont had always said that we would be treated here exactly as if we were in commercial Du Pont—the same benefits, the same policies. So that's the way we—what we believed in. There was a period of time, over twenty years ago now, when the company and a lot of other big companies were offering early retirement incentives, like they would perhaps add three years to your service or whatever and calculate your pension on the basis of that service. Anyways, it sweetened the deal throughout the company, except for several plants that were involved with contracts with the government, that meant this one—although people in the Engineering department in Newark and Delaware, if more than half of their work was involved with Savannah River Project.

(interruption)

DP: If a person in Engineering department was working and more than half of his work was related to Savannah River Projects, he was not offered an early retirement sweep, no one at Savannah River here. Well a bunch of us got together, tried to get a lawsuit going. No one told you about this?

MS: No. I hadn't heard about that.

DP: Well, we got a lawyer from Columbia .

MS: When was this roughly?

DP: This was about twenty-two years ago. It was a pretty sizeable group that were involved, but— I was interested in— I'm not going to get off the subject.

MS: That's okay, you said you got a lawyer from Columbia?

DP: Yeah. We carried it on for about a year, but eventually some district court got it dumped in their lap and in the interim from when we started the suit to this point that they got it, apparently a similar case had arisen and judicial made a ruling that they considered we fell into (unintelligible) by this ruling and so they—and it was not favorable for us, so the thing died. But anyway, there were some people who were unhappy about that, myself included. I mean we'd been told from the outset that we were Du Pont employees.

MS: Right, and there was no distinction between you and commercial Du Pont.

DP: But yet when it came to this issue, we were left out of it–. But I worked about two more years and then retired early.

MS: Now when did you retire again?

DP: I retired when I was fifty-eight.

MS: What year was that, do you remember?

DP: Yeah. It's complicated by the fact that I had vacation coming. I think I ran over into '86.

MS: 1986 maybe or so?

DP: Yeah, I think it was '86, '87 or '86. My anniversary would have been in March. (unintelligible) a couple more years, it would be thirty five years that I worked for Du Pont.

MS: Let me ask you this, talking about the—like as far as preservation issues, dealing with the reactor buildings, what would you say were the most significant parts of the reactor buildings, worthy of preservation?

DP: Yeah, I have thought about that a little bit. Certainly the control room—the main control room, which was sort of divided into two sections. One side was the—there was a console that was sort of in the middle of that section where the reactor operators sat and they operated this little knob they would diddle every once in a while. And in front of them, there were panels that depicted the lattice. You've probably been in there—the temperature monitor, the flow monitor.

MS: Right and you got the nuclear half of the control room and then sort of what they—they called the graphics half, but it's like the water and electricity—

DP: Hydraulics.

MS: —the hydraulics and stuff on the other side.

DP: Right. And that too was depicted to circulating groups.

MS: Right, it's kind of like a graphic like where you see the reactor and you saw the pumps and the heat exchangers, those little black silhouetted things that the lines go into. And all the lines are color coordinated. It's really pretty nice.

DP: Yeah, it makes a lot of sense to show it that way. Then there was sort of on the borderline between those two areas was a big panel with enunciators, enunciator panel, which monitored all kinds of variables and was set to go off. Some of them were reactor shut-down. If that level that enunciator was set for was reached, it was something so bad wrong that you wanted to shut the reactor down automatically, safety rods would plunge in, all the control rods would be driven in sequentially. Of course, there's a third safety system that was rare earth inks, elements, that had very high absorption cross-section for neutrons.

MS: Was that that gadolinium stuff?

DP: Yeah– whole bunch of—a mixture of things.

MS: But as far as like— In addition to the control room—

DP: Okay, what other thing I think would be of interest. Since it is a reactor, you should show the reactor room. As I mentioned, a novel feature of this reactor was not only could you control radial flux shape, but with the use of half rods, you controlled the axial flux shape, as well. I don't think that was done anywhere else. The telescoping actuator system, except it's very difficult (laugh) to see it. You'd like to saw the building in half, get a cross-sectional view of it. It's hard, go up at 66 level and all you see are racks and racks of amplifiers.

MS: Yeah it's kind of hard to— When you tour the reactor nowadays— Of course, you're not seeing it in operation; you're just having people describe it to you and like I said, you've got to get at so many different levels to see what's what. You don't really get a clear picture of exactly how it all works together. Sometimes it's easier just to look at the plans and look at it than it is to actually take the tour of the building, have people point out different things, because you have so much stuff there, that after a while it's just like—it didn't make sense.

DP: Yeah the thing that has always impressed me also if I go visit like a big dam with it generating electricity. It's always amazing to me you enter this vast area and you look in the control room and there are two people there. Now it's just a handful of people and on shift in the 100 areas, there were just a handful of people running that whole building. And even those people were—like control room operator, he was sitting in the chair, he had a hard job staying awake. I've seen a couple occasions when they've fallen asleep.

MS: Yeah because it's— As long as everything's working well, there's not that much to do. And that's kind of hard to understand. And you're right, when you go to someplace where they do have a lot of—an awful lot of machinery and stuff, it's like, kind of amazing.

DP: Let me continue–.

MS: Absolutely.

DP: The assembly area where they received the fuel and put it in the order in which it was to be presented to the charge machine, which was the same thing as discharge machine. It's called a charge/discharge machine. You pick it up at a station.

MS: Yeah I've seen that, what do they call it, presentation point, the little narrow slit in the wall.

DP: A big slab of shielding here so the thing had to go around and didn't have a direct beam from the— It was presented to the— It had to be inserted in the correct position. They had to get everything in its proper sequence. There's nothing, to me anyway, that's particularly unique about that area. The disassembly area, which is the big basin— If you had visited at a time shortly after the fuel had been discharged, it was sort of pretty. You looked down in there and you see this bluish glow around— It was Sid Katz who worked in Tech division, I guess I've mentioned his name, used to carry on a study program of some sort. The thing I do remember about it is he irradiated vials of whatever it was that was in it, down in the basin. He would lower it adjacent to the fuel assembly where it would be irradiated from the very high gamma. It would change the color of the glass to a pretty red color and then when it came out I guess after a period of time it gradually changed back. Did anyone ever mention to you the food irradiation program?

MS: I've read something about it, but nothing in detail.

DP: Okay, I was in L Area, where this took place, and it was supported by—it was the quartermaster corps in the army. I'm sure that's not the correct— it was the army. And they were investigating the use of food irradiation to prolong the shelf life and also offer, I guess, the troops fresh meat, like they were canning chicken and other things as well. And they took some of the discharged fuel and put it in an array and passed the food through the center of this assembly, and really what they were doing at Savannah River was just a service for this program, much like the people who are studying the neutrino. That was done in P-reactor.

MS: Going back to the food irradiation program, was that—that was done for the army. Was that something the army asked y'all to do, or was that something that you said, We have this potential service, would you be interested, and the army said yes?

DP: I can't answer that one because I wasn't— But I can only tell you, and I guess it was just an assumption on my part, that it was something that had been probably asked–.

MS: Well let me ask you this, how successful was the food irradiation program?

DP: Well the building production area superintendent, Gil McMillan, became a—he retired and he became a senator and represented this area, very, very nice guy. He had Hanford experience. There were quite a few people in higher management that came here with Hanford experience. But anyway, he was telling me he had attended some meeting somewhere in the country. The meeting pertained to this program and they served the meat that had been through the food irradiation machine that I guess he told me it tasted fine; it tasted just—it hadn't changed the flavor. Well, one thing of concern, I think was the—that you would get some neutron production in gamma end reactions. It would be quite low, but it was there. And for some reason, the program just ended. I don't know that it went anywhere else.

MS: Yeah, I haven't heard much about it lately, so I didn't know whether— Also, what was the actual purpose of it? I mean if you irradiate the food, does that just kill all the bacteria? Is that it?

DP: Right. Kill bacteria.

MS: So you're doing it that way, rather than like putting it through steam or something? Is that—

DP: Yeah, rather than— You would— The idea was, I guess, some GI on X station somewhere in the Arctic could get fresh chicken rather than canned chicken. Maybe there wasn't that much (laugh) incentive, that's why it's— And you did hear about it some more, in the sense that it was mentioned as a way of retarding the sprouting of potatoes–, it increased the shelf life in fish, which is always a great concern on ships, where fish filled the hold—.

MS: It can go bad pretty quickly. Yeah I was just always wondered. I've heard about the food irradiation program—

DP: There may be some countries like Canada, maybe France, that are using it for potatoes or—I don't know.

MS: I just assumed that they stopped doing it after a while because maybe it wasn't unsuccessful, but maybe it just wasn't that economical to preserve food that way.

DP: Yeah, or maybe the general public would—

MS: Later on, wouldn't accept it.

DP: Wouldn't accept it.

MS: Right, yeah.

DP: And that's why the army got involved. The poor GIs didn't have—

MS: Yeah you don't have any choice, yeah.

DP: —any choice.

MS: Well considering some of the things they made them do in the forties. Some people had to look—I mean they were given special glasses which you had to look at atomic blast and I don't—and like that Bikini blast they did in '46, I mean they irradiated animals that were left onboard ships and stuff like that, see what happen to them. And some of the soldiers weren't too far behind on other ships. Some of the stuff was like—not good. I remember I saw a film about that, about the animal thing.

DP: As a matter of fact, I may have mentioned with CP-3 at Argonne— I'm a little vague about that. It could have been CP-5. Anyway, the thing I do remember about it is in the side shielding, they had portholes or places where they could remove the shielding for the purpose of extracting a beam for an external experiment that would be set up on a site reactor. But there were also some locations around that reactor– that was a D_2O-natural uranium– that they called the goat holes, and they were putting goats in there and blasting them. It was a great deal of interest in the medical aspects of radiation. I sort of remember the goat holes.

MS: Okay. And that was like at CP-3 or something like that?

DP: I think it may have been CP-5, I'm not real sure where— I never did any experimental work around there. There was one other program— You spoke to Tom Gorrell and he told you about the reactors that they constructed?

MS: I remember I interviewed Tom Gorrell—

DP: A test reactor that was designed— What was its purpose? To— I never had anything to do with it, but I knew what it was for. And I've forgotten now, but I know that Tom Gorrell was involved with—

MS: I know that Tom Gorrell was involved in, of course, 777, a lot of the work in 777. It wasn't the smaller reactor that's right beside that PDP, was it?

DP: No. You know where construction had its star-shaped—

MS: Oh you're not talking about HWCTR, are you?

DP: (unintelligible) somebody. Oh that's it.

MS: You're not talking about HWCTR, are you?

DP: Yeah, HWCTR, Heavy Water Components Test Reactor, yeah.

MS: That was in the old star-shaped temporary construction headquarters.

DP: Have they torn that down too?

MS: The last time I went by there, it's just a shell. I think it's pretty much gutted or whatever, but the part that's above ground that was a bullet-looking shell. Kind of rusty but it's still there.

DP: Containment vessel, that's the—

MS: Right. Yeah they did that in the late fifties, early sixties, I think.

DP: Yeah. And I don't know, I think that was done probably was run by the Lab Tech division.

MS: Yeah I think that's probably right.

DP: Not Reactor Tech.

MS: Yeah I don't think it was— Because it was kind of like a big—

DP: It wasn't a production—

MS: Right, wasn't a production thing. Solely to do some testing for potential of using a heavy water power reactor. And they did it at Savannah River Site because they had plenty of heavy water. And yeah, it didn't seem to go anywhere as far as that went, but they say, the Canadians used heavy water in power reactors, but we didn't go that direction so I guess they stopped doing that.

DP: And the Japanese and the Swedes also, because they contracted with us. Tom and I were in Reactor Tech together at the same time for a period of time.

MS: Yeah, we interviewed him maybe last year. Seems to be doing fine, looks good. But yeah I think he worked at 777 for a long time.

DP: Although, he wasn't there when I went to 777.

MS: Well it's like everybody, nobody's at one place forever– . There for a while, maybe that's their place they like more than anywhere else, but they always end up somewhere else too.

DP: The nice thing about it, is that there were so many different activities going on out there, that you can live in the same house, you just jumped into another carpool and went to work.

MS: Yeah, I guess that's true.

DP: Of course, there were some transfers off-plant to commercial. Dick Baxter was one that—

MS: What do you know, if anything, about that Barnwell Industrial Complex that they were messing with back in the early seventies? It didn't pan out or Jimmy Carter killed it or something?

DP: Yeah. They're talking about using that building for a program that—I'm not sure what it was. Yeah, I don't really know much. I tell you, the only contact I had with it was one of my students—since I taught in the evening, I mostly had almost entirely people who worked in the daytime. A lot of them fall in the category of: they could have gone on to college when they finished high school, but they were too interested in the car and the girl, and then they got—then they got started in the work-a-day world.

MS: And then they thought, years later, I'd like to go back, yeah.

DP: They went back. And there was one student who came from Barnwell. I guess I never really knew— As far as I know, they never really got—started it up.

MS: Yeah, you don't hear too much about it. And it's possible they never quite finished it, I don't know.

DP: But very recently I— Tell you the truth, just within the last week or two, I saw a small article in the paper where it was being considered for use and I can't remember what the program was.

MS: And that was something that— Was that on land that belonged to Savannah River Site and Savannah River Site donated that land to this—some entity or something, Allied Chemical or whatever it was–?

DP: It could well be.

MS: This is course is kind of a loaded question, but if you had to guess or had to venture a comment, which Savannah River Site reactors do you think would be the most significant?

DP: Well I'd say R because it was the first. It was the first production D_2O-moderated reactor. Unless the Russians had one, I don't know. I don't think so.

MS: What about, out of all the installed equipment in the reactor, what would you say would be the most significant pieces of equipment?

DP: Pieces of equipment.

MS: You can also mention the tank, too, if you want to.

DP: I'm sorry?

MS: You can mention the reactor tank, too, if you want to. I guess that's sort of a piece of equipment—integral piece.

DP: It's—that's a question that left me a little puzzled. If you approached it from the point of view of what was essential, you'd have to identify almost everything. You couldn't run without pumps and heat exchangers and the control rod system and servo system and instrumentation. There were a lot of novel things that caused problems—flow monitors which measured essentially the delta-P across the monitor pin. And on the bottom of the reactor was— Did anyone could talk about the monitor pin?

MS: No, go ahead.

DP: If you went all the way down to -40 and entered the reactor room, you could go underneath the reactor itself. They take you under there?

MS: No, we couldn't do that because it's still too contaminated, but they called it the pin room.

DP: Yeah, the pin room.

MS: I've seen pictures of it.

DP: They call it the pin room because for each of the 606 holes, if you like, for fuel elements, of which only 600 were used; the other six were gas ports. I think there was a monitor pin that the fuel element was positioned over.

And because—

MS: And that just measured temperature, right?

DP: The monitor pin was more or less designed for the first fuel assembly, this quatrefoil that I mentioned, that had sort of four channels, and where the water exited at the monitor pin– holes in the side of the fuel housing— The fuel itself was in slugs, eight-inch long, something like that, one-inch diameter. They would load them into the four channels. Water— Cooling water entered from the top, went down each of the four channels and exited at the bottom, impinging on the four thermocouples that were in the monitor pins. They could be replaced, when necessary, from the pin room, monitor pin room. From underneath the reactor, they could withdraw— Of course, they would only do that at a shut-down.

MS: I've seen that where you've got these—you're looking at the underneath of the tank, I guess, and the bottom shield and then you got these little knobby looking things all in there and then you've got wires— I guess that's to go back to the control room so you can take the readings on all those things.

DP: As a matter of fact, that's a paddle that the operator sitting at the console were running the reactor. If you look straight ahead in front of him, he's sees that depiction of the reactor with the—your little lights there. And they can set the— Also they can plug and read the temperature.

MS: What do they call that, a jack plug or something or—

DP: Yeah, jack plug. One of the chores that the reactor operator would have, would be to measure every one of those temperatures, go through that panel, plug in, essentially transfer the data to a piece of paper, then color it in and get a picture of—maybe they used red for the highest temperatures. And then they take some action, with moving the rods. They can move them individually or by gangs of three—three gangs. And the fuel was— the fuel in the element that they charged to the reactor was orificed so as to make best use of the water. At the edge of the reactor where the flux falls off, the power generation would be lower than in the center. So they would take that into account by changing the orificing, wouldn't put as much flow through those elements. As a matter of fact, now that I think about it, that was one of the tests, I believe, they did in the assembly area, was to check the flow.

MS: Yeah I guess that's true if you're talking about like equipment and stuff like that, I guess all of it is required. What was the most— In your opinion, what would be the most unique pieces to the reactor buildings?

DP: Well, I think the concept of using the half rods to shape the axial flux. Since I had a hand in it, maybe I'm prejudiced a little bit, but I think the traveling wire monitor was an interesting thing, even though I got burned on it. But that's not anything that was essential to the operation in the reactor– could do without it.

MS: Yeah, just one of those things that—extra little—

DP: Yeah, it's one of the things that came to mind when you asked the question, you know of—something concrete that we interacted with another group. It turned out that that was not a Tech division or Lab tie in. It was with the Instrument Development group, which was part of the Plant, not the Lab. The Lab was mostly involved in the fuel element—very heavily involved, entirely involved in the fuel element design. Also, they were interested in— You know, Norm Baumann's wife, Elizabeth or Liz Baumann, she— When I was in R Area she was doing some experimental work in the distillation area. Actually most of her work was in—oh what do they call it, where they—ion exchange filtration. They had a small side stream that they pulled off from the main pipe. They'd send off to distillation. And it would go there by way of a couple of cells when they'd pass through ion exchange and filtration–. Like the fuel pump in the car.

MS: Right, so you're talking about the purification wing or something?

DP: Yeah, the purification wing.

MS: Yeah, that was a pretty big operation at each of the reactor buildings.

DP: But if purification ever got— If the D_2O purity got down below a certain level, they could always pump it out and replace it, bring it back up. There were two—there was one individual, still alive. Bruce– Gosh. He made a career out of the moderator. He was concerned about things like turbidity, how cloudy it was, purity. I could get it off the list. I don't know if you've spoken with him or whether you want to. He's getting quite old.

MS: What's his name?

DP: Bruce— May I see the list of names?

MS: This one here?

DP: Any one.

MS: If you want, I'll put this on pause and let me get the restroom too and I'll be right back.

(pause)

DP: Yeah, (unintelligible).

MS: Okay.

DP: He's very much an intellectual and he— I think he came to Du Pont from academia. He was a typical sort of absent-minded college professor, a description of him, very mild person–. But he made a career— He was, I think, assigned that job from day one and worked at it—moderator chemistry. He could just as well have been in the Tech division as Reactor Tech. He had his little cubicle (laughter).

MS: And that's what he did all day. I guess, it sounds like the most critical part of the reactor, the part that people probably want to see, is the reactor—

DP: And the console.

MS: And the console and all the control room stuff, and then the actuator, tower elements and then if they can get down there, reactor room and then below, where they've got the pumps and the heat exchangers. I mean just everything that's right at that central core. Assembly/disassembly. It's not the core of a reactor.

DP: Yeah and I'm not real sure whether distillation system— I mean, if you included that, I think you would, at that point—

MS: You've done everything else.

DP: Have all of the major components.

MS: Right, that's true, yeah.

DP: Other than the offices. (laugh)

MS: Yeah that's true.

DP: Which are not of interest.

MS: (unintelligible) nobody's going to want to see those because they're stripped now anyway so—

DP: It was sort of a cavernous building, wasn't it?

MS: Yeah, it is still. You're right there. Each of the control rooms looks different too, depending on how—some of them just like stripped out, others have— Where was I, at C-reactor fairly recently, reactor room? And they've got wood panels all over—in front of all the different panels, the actual control panels, because Wackenhut goes in there and they have paintball exercises in the control room. That's to protect the panels—by having wood panels in front of them.

DP: Why in the world—

MS: They're on rollers. You roll them back if you want to see the panels, otherwise, they're always in position.

DP: This is for a terrorist who's penetrated—gotten into the heart of the—because paintball, I think more in terms (laugh) of assembly area. Oh that is great. Play cops and robbers.

MS: They've gotten that far in there, we're in trouble.

DP: Yeah I guess when R Area went down, it was pretty natural conclusion that it was the oldest, had a leak and that was the fundamental reason. And— So that one went down first. And we began leeching parts out of it. The heat exchangers were natural to come out (laugh), you know, whenever they needed one. There were quite a few heat exchanger failures. The other type of failure that was of concern would be a fuel element failure. So they monitored temperatures and flows because the fuel failure would cause generally some swelling, reduction in flow, change the temperature and the flow rate to that column. But they had no way of identifying the actual channel in the quatrefoil, except by temperature. Temperature they could measure. Interesting thing, too, the channels were not completely separated, isolated from one another. So there was some mixing as the water exited, but there was a weighting– you could tell which of the four thermocouples was influenced largest or the greatest by the failure.

MS: What equipment was not original to the reactor operation, but was installed later?

DP: Of course the pumps. I guess I hinted that some of the cooling water activity monitors—they had some problems, but this wasn't unusual I guess– modifications require traveling wire monitor or something like this, not in the original design. The source rod, that antimony-beryllium, source rod whose purpose was to raise the flux level in the reactor and get better statistics for start-up. Has someone talked to you about xenon and samarium?

MS: I know about xenon, it's sort of a xenon oscillation problem and—but not a— I know more about xenon—the problem they had with xenon at Hanford than I know about— I mean, I know they had some xenon issues later on at Savannah River Site, but I don't know any details.

DP: Well that was one of the jobs that Reactor Tech had, that was to keep current information for the Operating Production department. When a reactor, let's say had an unscheduled shutdown– running along and then all of a sudden all hell breaks loose, bells and whistles go off and you look at the enunciator panel, which was—each enunciator was about that high and that wide and the writing on it and the bulb behind it and there were probably something I would guess on the order of thirty of those things to warn you of conditions that were out of spec, that would light up like a Christmas tree (laugh) on a reactor like that. Then xenon would build in and let's say—

If I could depict just graphically. Let's say with all of the rods out of the reactor, that there would be a certain amount of reactivity in the reactor. Let's say it's at this level here, okay. You've got— Some of that reactivity is tied up, let's say, or counterbalanced in the control rod system while you're running. Let's say that's down here. What I'm saying is if you pulled all the rods out of the reactor, your reactivity would be here, but you're controlling the reactor and so the reactivity is held in rods and it's here. At this point in time, (unintelligible), you have an unscheduled shutdown. The reactivity starts climbing, because of xenon and samarium poisoning. That's— I won't go into the details of that, necessarily. But at some point here, let's say, just arbitrarily as it climbs, it reaches this level and which, if you pulled all of your rods out of the reactor, you could not go critical, because you just don't have the reactivity. It's been chewed by Mr. Xenon. There's a period of time between when the shut-down occurred and when the xenon poisoning reached that level, that's that time interval here, that you have a shot at getting the reactor up and critical before you use it, so to speak. But you have to be—you have to go after it aggressively, well not too aggressively.

But in many, many, many cases—and it depends on how far you are along in your fuel cycle before you shut down to discharge. This time interval changes. And at some point in the cycle, sometimes it's only like an hour-and-a-half and just say, Forget it, you're not going to get the reactor up in an hour-and-a-half. And not only that, you've got to get it up and you've got to get it high enough that the burnout of the xenon is going to be larger to burn out from the neutron flux that you're—in the reactor, to get to a high enough— Got to get the power level up high enough—flux level, power level the same—that you counterbalance the build-in of xenon, xenon being fission product from the decay that's taking place, its half-life. If you don't make it here, you've lost it. You can get it critical but not, as I say, high enough power level that the burnout exceeds the build-in and you can lose it. But most of the time, from a practical point of view, Mr. Xenon has control and they won't even necessarily try. One number we would supply to them, that is how much time they had to make it—to get it up, in order to make a successful re-start-up after "scram." The other number is the xenon goes through the transient build up to its maximum value and then begins to die off. And it wasn't until you got over here, that you had the reactivity—enough reactivity to get back up.

MS: How long was that period of time?

DP: That period of time could be twelve, sixteen hours. So that too, is a function of (unintelligible). And we would supply them with that number as well.

MS: So they had like a window of opportunity to get started up before the xenon really crested, and then you had to wait until it went down the other side before you could start it up otherwise.

DP: Right.

MS: See, I kind of had heard that, but I didn't know exactly how they dealt with that.

DP: Well that's a very simple language view of it. I guess they weren't aware of—at Hanford—how significant xenon poisoning effect was. So hurrah, we were critical (laugh) and then all of a sudden it dies off. I might say—this, you might be interested in this. Something similar to this happened in 305-M reactor, test reactor, having— The way that thing was handled, we loaded it manually, shoved chunks of—slugs of uranium into it, with the control rods and everything, then very slowly pulled the control rods out until a critical was reached, then decided if that was enough reactivity. Because it operated at 20 watts, like a 20-watt bulb (laugh). There wasn't any cooling system other than AC. It was maintained in a helium envelope. This was because nitrogen in the air is enough of a significant poison, captures neutrons, then as the atmosphere pressure changed, it would change the reactivity in the reactor and in the test reactor, 305-M, if you're interested in comparing these 20 slugs against a standard set of 20 slugs, you're not making absolute measurement, just—you want to make comparison between these two sets and if they're close enough together then these 20 slugs are then fabricated properly and they're okay—they're fueled and not some—some spy didn't load them with something else and send them out to the 100 Area to be loaded into the quatrefoil. So that's the measurement. But if in making— Sometimes there's a very small difference in reactivity between this set and the standard. If the atmospheric pressure is changing fast, like a front is coming through, you're trying to make a measurement, a comparison of the reactivity, when the reactivity in the reactor is floating around and clouds and wind blow by— This was true in CP-2, the reactor at Argonne that George and I worked on quite a bit. There were some days where we'd say, We just can't measure today because– the reactivity– due to atmospheric pressure change. So to avoid that in Savannah River, they put a shell around the block of graphite and uranium, which was (unintelligible).

MS: Yeah– so I guess it's gone now, but I remember the last time I saw the 305 reactor, part of the wall was still there.

DP: You couldn't see the—

MS: You could see part of it, yeah.

DP: A big block.

MS: Right, exactly.

DP: Well the interesting thing is the construction, as they reached the end of the job, at 305, someone, I don't know who, suggested that they wash down the interior of the steel casing before they started loading in the graphite and uranium—actually it was the graphite and then uranium went in, sealed it up. And what they did was to have buckets of triclene, trichloroethylene.

MS: Yeah I think I heard about something like that.

DP: And the construction people didn't worry about anything. They were told to do this– sloshing it on. And it's streaming down the sides on the inside. And into the base, which was a grout—and the grout was (makes noise) sucking this stuff up. (laughter) And they were ignorant—we were ignorant. I was at the building. I didn't know this was going on, they were working around the clock. Anyway, so they stack in the graphite, put in the slugs until we get critical, put in a couple more until we have the rods in the right place, (unintelligible) everything is fine. First thing we did every morning was to pull the rods—control rods—out to a certain position and check the pile period, the time it takes to E-fold, a factor of E, and note down these things, just— And we maintained a plot, ch-ch-ch-ch-ch-ch-ch-ch—the reactivity was going down. Everyone was scratching their head, and they finally were able to reconstruct what happened. And it was necessary now to put a clean-up system in the recirculating atmosphere that was maintained on the reactor. That was designed. But that's the 305, but it was an interesting—the very first reactor that went critical at SRP, was dying. (laughter)

MS: Yeah that would not be a good sign for the future.

DP: What else did they do that— Of course, the evolution of the fuel assembly—

MS: Right, that changed over time. And of course later on, they got computers in there too–.

DP: Yeah, that I know nothing about.

MS: Yeah, I just know pretty much they had computers. I don't know any details.

DP: They had that crude thing that I described and I wrote a TA, which is "test authorization," which permitted an evaluation of it, and then followed it up with SP, "standard procedure," to tell them exactly what the test would consist of, step by step. We did a very abbreviated, just—and then nothing more was done. And I think everyone was really content with 1) putting very many control rods on this system so that should it malfunction in some fashion it told all the rods (laugh) to go out, capable of doing it. And then 2) on the other hand, you can't just take a few control rods out of– all of the rods that were in the reactor and have them control the reactor without getting the radial flux screwed up. So— It was (unintelligible).

MS: One other question. This may be the last one that's on my list here is, what equipment was specifically designed by SRL for the reactors?

DP: Okay. The fuel element. There was an Instrument group in SRL as well as an Instrument group in Works Technical. Do you know the distinction between Works Technical and the Reactor Tech?

MS: I think so, but go ahead and tell me anyway, just so we can have it on the record.

DP: Tom Evans, I think was department superintendent of a group that was on the same par as the Operations group, Powerhouse group, you know, this was Works Technical. And under him—directly under him– were a group of Reactor Tech on the same level, Separations Tech. There was a technical group associated with the 400 Area. There was a technical group associated with the M Area, fuel fabrication. They were all at the same level, so when we talk about Reactor Tech we're talking about just a small piece off of Works Tech.
One of these groups that are all at the same level was Instrument Tech, Instrument Technology. And they supplied support for instrumentation to all of their brothers in the same level who are in the 100 areas, 200 areas, 400 areas. Over here, separate, is the Laboratory and somewhere in there— I don't know, sometimes these charts—organization charts—change. But there was an instrument group, very impressive, very competent, instrument group in Tech division. And sometimes it was never clear to me which one was working on what, except when the guy showed up, you got to know him in the Tech division. So you're asking me specifically what did Tech division do in the 100 areas.

MS: Yeah and I guess— Or, for that matter, if it's even more specific, if you know of anything that was designed actually in SRL for the reactors, but— Reactor Tech didn't really have— Reactor Tech was sort of a liaison with SRL, wasn't it?

DP: Yes.

MS: It was kind of like, sort of—

DP: They worked with them, but a lot of what they were doing in developing

improvements in the equipment, was done in their laboratory rather than in the field. Now if it were in the field, it was almost always the Instrument Technology. You'd see them working on the flow monitor or equipment that was in place, they were working on it. They did more of that sort of thing, working on problems with existing equipment, rather than development of new equipment. It seemed to me, as I think back on it, that Technical Instrument group were working on the more difficult problems than developing new approaches. I'm trying to think specifically— They had one guy who was—pretty much worked on the nuclear instruments. Maybe this is an example. I'm not sure (unintelligible). There were a lot of shutdowns– spurious, unscheduled shutdowns, that originated out of the pile, the reactor period meters. I mean it was a device that measured the reactor period as you change power. And sometimes (laugh) it had a mind of its own. You're at full power, everybody's happy, and then all of a sudden, (makes noise) all hell breaks loose. The reactor is shut down and you look around, you don't see any abnormalities in flow or temperature. And you look at the nuclear instruments, of course they're all—they're all driving charts, so you can unroll it and look. Then here you see a spike on the period meter, just got some sort of a transient. They tried to work on it.
But one idea was that it just— I think— I think it was called the "impossibility principle." And essentially what they did was to, by using filters, or God knows what, fixed the period meters so that they were only sensitive in a range of periods that were practical, I mean that the reactor could experience, almost like you were tuning a radio and you're trying to get an FM station in your—and you're getting interference from AM and you just disconnect the AM so that you're only looking at a band in which your stations exist. So that was one thing I think they did to cut down on those spikes that might originate, that were ridiculous, the reactor couldn't achieve that kind of a signal system. But— I'm trying to think. There were probably, I'm sure, many other examples. I'm trying to think of the people who'd be best to talk to. (unintelligible) guy who had come from Virginia Tech.

MS: (unintelligible).

DP: Another guy who quit here, went to work as a professor (laugh) at a university (unintelligible). I'm trying to think, who else. Oh I know– Dick Herold He's the guy who's into real estate. He was very active in that group.

MS: Well, that covers all the questions I can think to ask right now, but there may be some other things you want to mention that I haven't thought to bring up.

DP: You're heading back to (unintelligible).

MS: It'll be later this afternoon. I've got to go to meet some people at Savannah River Site at Carolina Barbeque and I—

DP: Oh yeah that—

MS: Got to go to Carolina Barbeque.

DP: Have a good appetite when you get there.

MS: Yeah, I purposely did not eat much for breakfast so I'll be starving when I get there.

DP: That is really good.

MS: That's good when these things come together like that and the price is reasonable. You're right about that.

DP: It's a real bargain.

MS: It's cheaper than Duke's barbeque.

DP: Well they don't offer the vegetables.

MS: No, they don't offer the range of vegetables you have at Dukes, but the barbeque at Carolina is head and shoulders above Duke's barbeque.

DP: And their hushpuppies.

MS: Hushpuppies are very good. You're right, hushpuppies are good.

DP: The wife will claim that they were better a number of years ago. I don't know whether they changed the chef. I still find them pretty good.

MS: Yeah, they're pretty good.

DP: I think our son may hold—he's very close to the record, number of hushpuppies. I think he ate twenty-four one time.

MS: Wow, that is a record. You're right, that is a record. So that's pretty good. But they are pretty good.

DP: So which reactors are most— in one sentence for each, which of the SRP reactors is historically significant? I would say R-reactor for historical point of view. (unintelligible) consider ranking reactors for the report. Well, the only other thing I can think of here is C-reactor may rank a little ahead, only because it's got a bigger reflector, runs at a higher power, but unless there are political ramifications, I can't think of—a time period when your operation was significant. It's different for each. Again, the only thing I can think of is thatperiod probably something on the order of eight years long– and piping, heat exchangers. What equipment was not original but was later installed? Oh, one would have to say there was a time when they decided to put the reactors together very fast because of the rush to have the hydrogen weapon. Of course, the reactors would never meet Nuclear Regulatory Commission standards for commercial reactors, so I think they put a Band-Aid, a patch on it to—

MS: Yeah, to make it— I mean that's— The way they designed it in the fifties was—that's what they did. And then later on as commercial reactors got more safeguards and they were more concerned about the—what was it, confinement or something like that?

DP: Containment.

MS: Containment, confinement issue, and they decided it just wasn't worth building a whole envelope over each reactor. That would have been too costly. So they just implemented lots of measures to try and alleviate—

DP: And I ran into this in the shipping—for the short time I was in the shipping container business. The discrepancy between what the government was requiring from commercial reactors and what they were doing in operating their own reactor, (laugh) was an embarrassment.

MS: And probably one of the reasons why they decided to do all this extra work at Savannah River Site was to try to alleviate some of that.

DP: And some time, like twenty years later, that problem still persisted, I'm sure, with respect to containment. But also with respect to shipping. It's a sore problem today, to find a place to dispose of used fuel– in Nevada, Yucca Mountain.

MS: Yeah, Yucca Mountain in Nevada.

DP: I got involved a little bit with that. Turns out that the DOE, NRC, DOE, after DOE was AEC and then Department—

MS: Oh yeah, ERDA. That intervening group that was between—

DP: Yeah. Well anyway, the NRC had very strict requirements on inspection and design of commercial reactors, in part, I think has caused—has stifled that industry. But I was told that the Nuclear Regulatory Commission individual was not welcome to come to Savannah River. If they requested it, it would be denied. Because for the longest time, I think, the government was claiming exemption for their requirements on the basis of national security, that's what it boiled down to. And they lived off of that excuse for a long time. We were shipping plutonium by airplanes, by other rail in containers. And then later we had to sort of retrofit what we had been doing, to try and show that it met the NRC requirements. They had a standard accident, train hit smack into it, rolled into the river, catch fire—

MS: Worst case scenario, yeah. Do everything possible to—

DP: (unintelligible).

MS: Yeah a lot of the other questions I think we've already addressed those.

DP: Yeah, or talked around them.

MS: Or talked around them, well, kind of addressed it and then went on from there.

DP: I never did witness photography in the 777. There was a system set up. I can see the guy now, I knew him. I don't know his name. He was the official plant photographer. You could call him up, tell him what you wanted photographed, and he would have to get a permit. Everything was sort of classified. So it had to be run past the people responsible for classification. But I'm trying to think— I'm sure he probably went out there and at one time or another we took a picture of the traveling wire monitor–.

MS: Yeah that's— There don't seem to be too many— There are shots of like the reactors before they went online and then you get some—whenever they had like a long shutdown or they have workers inside there, you might get somebody in there that would take some pictures of that, but most of the photography is like shots of individual instruments, if something blew up or whatever, or if they had a problem with it, they took a picture of it.

DP: Or there were pictures if Crawford Greenewalt came down.

MS: Yeah, stuff like that. For all the VIP tours, they had lots of shots of that. Otherwise, there were shots of like some, God-knows-what instrument blow up or get corroded, they would take a picture of that spot and that was probably for somebody local who wanted to document that. But now you have twenty, thirty years later when you look at it, you don't know what it is. They may have it labeled on the sleeve but maybe not. So now it's kind of like— So that's why this will be pretty helpful, to actually–.

DP: One possibility comes to mind. You're familiar with the DP reports?

MS: Um-hm.

DP: They are sort of formal. They are documents. They get quite a serious review because they are for external distribution. Of course, many of them were classified. I wrote a DP report for my thesis and it's not classified (laugh), but there were a lot of them that were. And a lot of them cover the sort of thing that you're asking about now. If, particularly in the Lab, Technical division, Instrument, they developed something different, I'm sure they wrote a DP report for it and it might include a picture, but it would more often not be a picture—not taken out in the 100 areas but on the workbench. I don't know who has a library of DP reports.

MS: That would probably still all be over in what they're calling Savannah River Site archival records. It's in that building that's right across the way from the 773 building. It's right across—

DP: As you face 773 to the right or left?

MS: As you face 773, you're pretty much right— I mean, if you're facing the entrance— If you step out from this building, you face the entrance of 773. It's right there across the street from the—

DP: There didn't used to be any building there at all.

MS: Yeah, I don't know how old that building is. It wasn't built very well because it leaks pretty bad, but that's where all formal records are kept, like all the DP, SBF, all the reports with all the—

DP: You might just page through, you may come across something you can use.

MS: Yeah, that's true. We have used a lot of the stuff in those records, but they're kind of a mess since it—sometimes you don't know what to ask for. Sometimes it's easier just to flip through it and see what they've got. They've got different things in different spots.

DP: They'll let you do that.

MS: Yeah, I've got a Q clearance, so I can do that. In fact that was the—

DP: Most of stuff I would think now has been declassified.

MS: It could be, but probably not because they just don't have anybody to do it. It's still— That's solely the reason they gave us Q clearances, so that we can look at that stuff. It's cheaper for us to get a Q clearance, then we could look at that stuff, than to get somebody in there to declassify that stuff and then present it to us. So that's the reason we got that. But it could be declassified. There's not that much stuff in it. So, that'll be something for—we'll worry about that at a later date.

DP: Of course there are an awful lot of documents that were written, a lot of them were not DP recorded, were just internal.

MS: Oh yeah, there's all kinds of stuff.

DP: Could probably fill up a—at least 50:1 ratio.

MS: That building is full of documents of various kinds. I mean, there's— Du Pont had abbreviations for all these different types of things and it was like a report that came out of the Lab, that was something, if it's something that was generated by Reactor Technology, if it's reactor area history it's something else. It's like a monthly report, it's this, a weekly report, an annual report.

DP: And you have a year to finish your task?

MS: Yeah, probably a little bit less than that, but there's a lot that can be done. (laughter) There's no doubt about that. No end to the research that can be done.

DP: Well that book there is just worth its weight in gold, as far as I'm concerned. It contains a lot of photographs. That reminds me, I'm sure Walt Joseph probably mentioned it, but I guess I commented I sat opposite him at one of our 50+ meetings. But the speaker at this meeting had something like eighty or ninety postcards of old Aiken. And he just, one after another through—identified the building and where the shot was taken. So, I don't know. But yours is not historical from that point of view?

MS: No, not from that point of view. I mean there's a little bit of that in there but not much. It's pretty much related to just what went on at Savannah River Plant and— But there's enough there to document as it is. And I think that's one of the big historic treasures, I think, at Savannah River Site, is just all the photographs. I mean they have a lot of photography at Savannah River Site. And really at this stage, it really ought to be considered an artifact, and preserved. But we— I think that's—we probably hit all the main points here. Let me turn this thing off.

END OF INTERVIEW

Oral History Interview – Linda Perry

Linda Perry was born in Georgia.* She now lives in North Augusta. She first took a position at Savannah River Plant in 1981, and still works there today. She was present for the transition from Du Pont to Westinghouse that took place in the 1980s and 1990s.

Perry's first job was as a stenographer in the Reactor Technology office in C area. On a dare, she took a test for employment in the Production department, and was soon enrolled in a program to be trained as a reactor operator. Her initial training was in C reactor, and she was later transferred to K. In 1984, she went to L area as part of the L Reactor Restart program. She later ran training courses in the Reactor Simulator building in C area, and was also involved in the K reactor restart program done by Westinghouse in the early 1990s.

*Personal information has been removed from the transcription

Interviewee: Linda Perry

Interviewer: Mark Swanson

Date of Interview: March 20, 2007

M. Swanson: Okay, this thing should be on and hopefully it will work. It took me a while to figure out what was wrong with all that but—

L. Perry: I'm sure it's working, or we just think it's working.

MS: Yeah, it's doing, yeah.

LP: Okay, because it's ticking.

MS: It's ticking so it should be okay. If you would, just for the record, state your name and affiliation with Savannah River Site?

LP: Okay, Linda Perry. I work for Washington Group International, Westinghouse and I've been here twenty-six years.

MS: Also too if you would, just for the record, where were you born and when?

LP: I was born in Georgia* and lived my life—childhood, in Aiken, South Carolina, until I married in 1975, at which time I moved to North Augusta, South Carolina.

MS: When did you first start working at the plant?

LP: My hire date is February 21, 1981.

MS: And which reactors did you work at?

LP: The C-reactor is where I did—I began my initial training, then from there I went to K-reactor. I also worked some in P-reactor, not as a permanent staff but as an augmented staff for the reactor control room crew and I then, after finishing my training and working some period in K Area, I then went to L Area in 1984 as part of the LSPT L Area start-up crew.

*Personal information has been removed from the transcription

MS: Once that got going, what was your typical day like?

LP: At that time, I was a—what you call a senior control room operator in the LSPT group, L Area, start-up group. And a typical day during that period of time in L Area, was we would follow jobs within construction jobs or testing jobs within the reactor in the refurbishing of the L Area.

MS: How long did that take?

LP: It took— To start L Area up, of course it had been— The reconstruction process had been going, I believe, since 1981 or 1982, prior to me going over there in 1984. But the startup of L Area actually came maybe in late '85 or '86, the first of '86, I can't really remember. But I was there during the startup of the night that we—the afternoon that we started L Area up and we took it to the power level that we were allowed to take it to. We were limited by the L Area lake temperatures, so we couldn't take it to full power like we had been used to doing in the other reactor areas.

MS: When did they construct L Lake?

LP: They were constructing— Well we went through a series of lawsuits by the states—South Carolina state– while we were in the process of refurbishing L Area, as we—especially as we got nearer to the start-up period, which was in the '85 and the early '86 timeframe. And that's when—during that time we were given direction by the state that in order to start up, that we had to begin construction of L Lake. So I believe it started probably some time in '85.

MS: Once L got started, what was a typical reactor operating cycle like?

LP: Okay, for a senior control room operator, a typical day was to where, say the dayshift, we would report—we'd have to be in the control room by ten of eight, and which time we would take our shift turnover based on the various positions that we were going to relieve in the control room. That could either be the graphic panel operator or the data operator or the nuclear console operator. So depending on where we were in that rotation, we would get our turnover as to anything other than routine operation that was going on—if there were any procedures that were being run or any particular pieces of equipment that were out of order or had broken down that we were on any kind of limiting time, to where we only had a certain amount of time to get it fixed so we either had to reduce power or shut the reactor down.

So a typical day would be starting on dayshift, starting at about ten of eight and then going in, and if you were the data operator or the graphic panel operator, you would begin taking your hourly readings, which would be several clipboards of readings that you would take. You would learn the status of the plant, so to speak, by going around the panels and doing the various readings. So that really started your day as to where you began familiarizing yourself with the control room and the indications that you had in the control room and any abnormalities. During the day, you would again continue those data-taking rounds periodically. Some of them were every fifteen minutes, some of them were every hour, some of them were once a shift, could be every four hours, twice a shift or whatever. But you would be constantly taking data, monitoring the panels, responding to any alarms that went off in the control room, and just making sure that all aspects of reactor operation was covered.

MS: What kind of special clothes had to be worn when you were in different reactor areas?

LP: Well there really were— You dressed for the comfort of the job and a lot of times for the position. If you were out for the—as a building operator, the type of clothes typically worn up until about probably 1987 or '88 were blue jeans and knit shirts, T-shirts—very comfortable loose-fitting clothing. Of course, during that time and depending on what was going on at the reactor, you would change out into what we called SWP [Special Work Permit) the radiation zone, RZ areas is what we called them back then. That type of work would only be done during reactor shutdown, usually. But there were some areas of the reactor that during operation you would have to dress out into SWP clothing, which consisted of the white coveralls, the white cotton gloves with the rubber gloves over them, and the white cotton booties with the rubber shoe covers over those. So you would have to dress out to periodically go in certain areas during reactor operation and take samples or do monitoring or things like that. But typically it was just street clothes as far as comfortable clothes that you could do physical work if you were out in the building. Now often if you were assigned to the control room job, you may wear blue jeans also or dress pants and maybe a nicer shirt, whatever.

Back in 1987, '88 timeframe, we instituted what we called reactor operator uniforms, or reactor uniforms, which that was during the reactor restart period to where we were trying to adapt to commercial standards and improve our conduct of operations, which included the overall appearance of our reactor staff. During that time, we would have various colors, all of them within the white, blue and gray family of coolers. For a reactor senior supervisor, it would usually be gray pants and a white shirt. For a control room supervisor, it would be gray pants or skirt and a gray shirt, which would be a dress shirt. For a reactor operator out in the building, it was usually gray pants and a blue shirt, a dress shirt. Again, we had coveralls, maintenance coveralls, we could dress into if it was particularly dirty work and of course the protective SWP clothing that we could dress into if we needed to go into a radiation zone. So we gravitated toward uniforms and of course on the dayshift most of the time with the senior control room supervisors who wore the gray pants and the white shirt, they would also wear a tie with that. So we polished ourselves up, so to speak.

MS: How often did you have to work the nightshift? Was that very often?

LP: Yeah. I worked what they call the—I guess the southern swing shift, which was horrible, from 1982 until 1987. So I got to work the nightshift, seven midnights straight, once a month for all those years. And the southern swing— I believe that's what you call that shift schedule, but it's where you would have seven days on days, which would be 8 to 4, you get one day off during the week. Or six days 8 to 4, one day off during the week, then you get a day off on Friday, so to speak, but then you would go into work Friday night, which would be for Saturday morning, so really that was no day off. So then you'd work seven midnights and then you'd get what you called a long weekend, you'd get one of those a month. And you'd come off Friday morning and you would not go back to work until— And that was your only weekend off during the month. You wouldn't go back to work until Wednesday, four-to-twelve shift, and you would have to report at ten to four on that Wednesday, at which time you would work seven four-to-twelve shifts and then you'd be off two days before you started your day-shift over again. So really once a month you had a long weekend, the rest of the time you were working on the weekends.

MS: What about—talking about clothing and everything, there was some mention of visors that were worn at assembly—in the assembly areas? Or is there— Somebody mentioned that—in old photographs I saw lots of people wearing visors, like a hat with a bill on it and they just got some kind of like a visor.

LP: Okay, now I didn't work in the assembly area, so I'm not real sure as to what type of headgear they wore in there.

MS: Yeah, I wasn't sure if that was just something that people wore just because they wanted to, or if it was required.

LP: Well as far as I know, I never remember any visors being required in reactors, as far as anybody to wear visors. So I— That may have just been something they wore in that particular area for some reason, but it wasn't a requirement, I do know that.

MS: What about— Now you were one of the first women to be trained as a reactor control room operator, am I not mistaken?

LP: Well, I came in at what you call on the ground floor. I worked first— When I first came out to work here in February of 1981, I went to work as a stenographer in Reactor Technology in C Area. And that was the brain building for all of the reactors, where all of the engineering and procedures were based. And I showed an interest in what I was reading and doing and typing at the time, and I really took a production operator test, which was— Reactors was part of what we call the production unit. And in the production unit, you could go into Reactors or you could go into separations. Well I chose to go into reactors because I just had an interest in that, being in Reactor Technology. And I went into— It was on a—I stayed as a stenographer for about four months from February to about June/July timeframe and then I took the Production test on a dare at lunch. And after lunch I was in Reactors.

And so it was— I went in on the ground floor as an auxiliary operator, which we called at that time was a Grade 6 operator and that's as was low as you could—that was your entry level. And that was the building operator that did all the building work. Usually on each shift in Reactor there were two auxiliary operators or Grade 6's. So I went in and began shift work immediately, went through a period of training and—which was not that strenuous as far as classroom training at that time. Most of it was on-the-job training. And it was prior to the real influence at that point, that Three-Mile Island had had on the nuclear world as far as procedure uses and things like that. So a lot of the things that I was trained to do was just by watch and do, not necessarily procedures. We knew there were procedures, we saw the procedures, we read them, but it wasn't to where we actually had the procedure at that time in our hands step-by-step. Of course, all that changed.

And so then I stayed as an auxiliary operator for about a year, which time I—an opening came for what you call a reactor operator, which was a Grade 7, which was a step up, and that was additional education and training in Reactors to where you not only knew how to work the building, but you knew how to work as a purification operator in the purification control room, and you started fitting more into the actual nuclear process at that time.

So that was a period of training there and I stayed there really only about six months and was promoted on to a Grade 8 operator, which was a senior control room operator. And that training period at that point became very, very extensive, to where it had to do with lots of classroom training, about six, seven modules that you had to complete, be tested on, a final examination, time spent on the job training within the control room. It took about a period of a year or two, fifteen months, to train as a senior control room operator and to go through all of the testing evaluations, walkthroughs and certification processes that you had to do. After that, you were required to re-certify every two years.

So I stayed at that probably for about a year-and-a-half and then at that point I was asked to become part of the simulator testing group, because we were building a simulator, a reactor simulator, that was to be assembled in 707-C, which was the reactor training building. And this simulator was being built up in Silver Spring, Maryland, at Singer Link Corporation. So I spent some time, about six months, up there testing out the new simulator before it was brought down. And after it was brought down, I then was—worked in the simulator as a lead control room supervisor of training. I trained supervisors, I trained shifts, which at that point were required to come over and train in the simulator. And during all that time, of course, we had to keep our certification up and work out in the field also. And then of course the restart efforts started and I entered into that part of it also, into the training for all operators and supervision for reactor restart in '89, 90 timeframe.

MS: What about— While you were in L-reactor, for example, what products were produced in L-reactor at that time? Just the usual plutonium, tritium?

LP: I'm not sure as to what the charges were at that time. And L-reactor never really even— It was probably— Well it was a state-of-the-art reactor. It was just totally redone, beautiful reactor, but we never were able to realize our full potential. The runs were longer because it took longer to produce our product because we were not allowed to run at the higher megawatt, the higher temperatures, because of the problem with L Lake and the buoys and the temperature and the agreement to do all of that with the state. We had to shut down as warmer months came along because just the natural temperature of the air outside exceeded the buoy limits. So our—most of our time was spent shut down in reactors in L Area, which was unfortunate, all of that work. And again, during the time that we were running in the winter months, it was at low power levels and we ran by the temperatures of the buoy—our power was limited by the temperatures of L Lake.

MS: What was security like in L-reactor? Was it—

LP: Well in L-reactor, security at that time, Wackenhut had established themselves onsite by that period and it was of course very different from the Du Pont patrol. As they were refurbishing L Area, of course, they refurbished the L Area patrol gate points, that gatehouse, you might say, badge houses into more secure, totally remodeled the badge houses. It used to be that the very first security that we go through in reactor was basically just walking in through the building with a little countertop there and you'd have old Du Pont patrol sitting there. But then, of course, as we came in, the security was redone in L Area. We got into where we had metal detectors and we had cypher locks to get through and we had hand geometry, and all of the nouveau security fads that came out, we seemed to get it. And then of course, after 9/11, it's just ridiculous. And I don't really— I'm not that familiar with how the security is in the areas now. But again, it went from just an easygoing, hey how are you counter to just very futuristic type gadgets that you had to walk through—metal detectors. You would be frisked down with the security wand. Anything that came along, we seemed to try it.

MS: Right. How did the safety devices—were they installed like in the L Reactor Restart? How were they upgraded from what had gone on earlier in the reactors? Was there a whole slew of new safety devices?

LP: Well there were— Well we did a lot of upgrades, but again, most of what we did was, I guess, refurbish to where we just fixed what there was. Again, we had—that were in the new—that were in the other reactors, of course, they had gone to brand new fission counter systems, and we went to that in L Area. We went to the Remax [Remote Monitoring Access] system—that was installed in L Area, which was a system that you could evacuate L Area and still have control of L area from a central point onsite or any of the other reactor areas. We got all of the other upgrades that had been put in the currently operating reactors of—well at that time of K and P, because C was not running at that time. I believe that's when it started to shut down because of the crack in the tank. We got seismic—of course we put in all of the seismic bracing which had not been in the L Area prior to that during the early first run of L Area.

So we had— Again we reconstructed or, I guess that's the word, and we also upgraded L Area into what they were. We still had the automatic instant panel in L Area, which that was also new—automatic instant action, which was located in front of the graphic panel, that's where if cooling is not available and assembly is dropped—or there's radiation or an assembly is failing, to where automatic action will be taken, so we had that. We had new what we call CCTV [closed circuit TV], which enabled us to remotely look inside the RZ areas from a television and toggle switches from the graphic panel. That was a particular new section there. The stack tritium monitors—they were upgraded to what we call the BTM monitors. And the "B" stands for the name of the man that invented these things, and it's about a foot long; I can't think of it right now. But it was— The-name-of-the-man tritium monitors. And again we began taking readings from that particular system based on just the recorders from the stack tritium monitors. So everything that was upgraded in the C-, P- and K-reactors when we were redoing the L Area was—the upgrades were put there to where that would be a state-of-the-art reactor.

MS: How many people worked in L Area during that restart program?

LP: Restart—

MS: They may have been a complication, too, with the construction workers there and I guess the construction was first and then they came back with the operation.

LP: Well we were all there together because the construction crews and operations were there because we were all really intermingled in the projects that we had because we had good operations project managers that were over systems—particular systems to get those up and going in L Area. And of course they—in order to get their project completed, they interacted with the construction crews, because they're the people that did the work. And so it was like one giant construction project, only you had operations folks really leading the effort, or serving as the project management leads, is what you had. Like I said, you had very little actual real operating time of L Area. As far as how many people were there, I have no idea, because you had such a diversity of people. That's probably the second most diverse undertaking on this site, besides that initial building of the site—because you had all kind of construction workers from every discipline—pipefitters, electricians, everything from laborers on up to chief construction superintendents. You had—gosh, engineering.

MS: You have to have a lot of engineers for L Lake.

LP: You had engineerings that—well engineers that were assigned to every project, like a team of engineers. Then you had operators who really ran with the project to make sure it was going on okay. And I really don't know—that'd be interesting to know. Then of course you had a tremendous amount of supervision there, of good, old Du Pont supervision, who knew how and had the knowledge of what—of the building and construction of the other reactor areas. So they bought— I don't think— It would not have even succeeded if we hadn't have had that old-time knowledge there.

MS: All right. Okay. You've covered already an awful lot of the things that we wanted to discuss. A lot of these questions here were really designed for people that were starting out in Reactor Technology from the very beginning, so that's like the fifties. So we don't have to worry about that. Out of curiosity, what did most people do for food out there? I know there was a lunchroom and all that.

LP: Well that was— The L—as far as— In all the reactor areas, it was common— Well it was part of the shift that everybody cooked and ate meals together. And especially— Not so much on dayshift except for dayshift on the weekends, but always on the four-to-twelve shift and the midnight shift. And most shifts had a grocery rotation cycle to where everybody had a turn to bring in groceries for a particular night. And so usually the shift would talk about what they wanted to eat the night before or any special occasion or— Sometimes they grilled steaks. It wasn't uncommon to grill—to actually have grills outside the 105 and grill steaks, that wasn't an uncommon thing. The patrol folks always were cooking something. The powerhouse people, some big— Some of the best food was out here. I mean, everybody had their favorites of who could cook the chicken the best or who could make the best biscuits, or patrol was always good on deer stews, I can remember. Then you'd go to the powerhouse and they were always— It seemed like they were good on the salmon stew and the catfish stew and somebody's frying fish. You always knew— And the areas, especially on shift, including the patrol, the powerhouse people or whatever, we ate together. And then you'd have different food preferences, sometimes from area to area. P Area, which a lot of people from the Low Country down the Barnwell, Allendale, Hampton area, preferred to work in P Area because it was closer to their home. And you would have a different type of cooking from those people a lot of times. And so it was always interesting to know what they were cooking. I know I had possum out there one time and never had that before, had an alligator tail, which was delicious, never had that. Someone cooked rattlesnake, couldn't eat that. But you'd have a different type of cooking based on what everybody's experiences were that worked in any particular area.

MS: That's pretty interesting.

LP: It was interesting.

MS: What about— So you're talking about like different areas having different food and stuff like that. Was that true for separations? I mean did everybody sort of have their own— Back in those days, did everybody cook together or was that primarily L, because that was a special situation?

LP: Well all the reactors, I know, P, L, K, C—everyone on the off-shifts or on weekends on days, probably 95 percent of the shifts cooked, yeah. That was a thing, a really big part of the camaraderie of the shifts and everybody— Even back then in reactors on—within other shifts or other areas or whatever, we all knew each other and we all knew who could cook what good and every—back then everybody mostly knew how many kids everybody had, who was married to who, what their hobbies were, what they did, what their name was, their little idiosyncrasies. And it was a magical camaraderie and an esprit de corps that has never been seen since. And I really feel like that was—that had thrusted on and had survived all the years until we shut these reactors down. And it was gone after that. When Du Pont left, it was gone. It went with it. It took that magic with it. And of course Westinghouse came in and that's one of the first things they did was rip out all the kitchens.

MS: Oh really? Is that true with like the reactor area?

LP: In the reactor areas, that is—they did not do it in C-reactor because C-reactor was not up and operating. But as soon as they came in and of course we operated a short while after that before the P Area incident that shut us down forever. One of the first things they did was rip out the kitchens.

MS: Why was that?

LP: I feel like it was a difference between Du Pont's understanding of people and the importance and the cruciality of the esprit de corps and that camaraderie and the total ignorance of the other company that came over and took over the contract.

MS: What other changes occurred that made it different during that same period?

LP: Well, during that period, we again were opened up to the world and had no defense to it. Prior to that, we had been in our own little world and had operated safely and with impeccable conduct, although we didn't know to call it that at that time, but we had the commercial industry, the nuclear navy industry which was starting to lag and looking for a place to hide out, infiltrate, or squat at that time, and we were a prime target for it. And of course we sucked them all in. And as one group would get in, they would bring in their other group. And we became a holding pond for the sagging commercial industry. And unfortunately, a lot of—

MS: Commercial nuclear industry—

LP: Commercial nuclear industry and the navy nukes. And unfortunately, a lot of—well, the majority of high-management positions, we were removed if you were in a high management position, and those people, through no experience, were given those positions. And of course, we had—it set us immediately down to a different level, and we've never gotten back up to that level and it's been downhill every since. And that was the major change. And of course when you have such a major change in leadership, it trickles down and domino effects to where the morale is affected and when the morale is affected of course that affects behavior and of course that affects performance. And there was a—the safety program became more of something you got to do for fun, rather than something that you truly believed and lived and did everyday. And so I think safety suffered a tremendous amount. I think, of course, the morale, the camaraderie did.
And when you have all of those things that are affected with people that spend ten and twelve hours a day together, shut off from the rest of the world, you're going to have performance problems. So I think at that point,

immediately the standards were lowered, both in morale and camaraderie, in safety and in the potentiality of what this site could have done. And I think it still is that way today to where we've never gone back up to even 80 percent of what we could have reached or done, and I think that's one reason why we haven't gotten new missions, primarily, because the good is just not there any more.

MS: I hadn't thought of that, but that's really true. I mean it does seem like this place is underutilized, being for the size it is—the investment in it and the—

LP: Well there was a different management of attitude or culture at that time, because at that time with Du Pont, Du Pont fostered their employees. They promoted— I meant not promoted, but they encouraged their employees. They looked for potentiality. If you didn't have potential, they gave you potential. And they weren't there to use you to further their potential. And the management we have today is, of course, 360 degrees from that, to where they don't have the knowledge, do not have the leadership skills, so what they do is they take from you the potential or the talent or the progress you make and claim it for themselves, because that's the only way they can survive. And that was different. Back then we had a very secure, confident management that was—that could do everything that their subordinates could do. But when you had the switchover—
And it's still true today. We have leader—we don't have leadership. We have management that has no clue as to what it takes, and has never been out there in the trenches or has never been out there with their hands on the tools. And they say, Well we're not operating anything, but there's still a lot of tools to get your hands on—have not been out there. They don't appreciate or they don't try to interact with the employee or the skilled worker unless it's to take something from them for their own use or their own benefit. They do not promote their people. And that's the big difference. And I'm sure that you look at any company that's progressive, that stays in business is that's the primary factor of their success is that they do that. And it doesn't take—anybody that would come in here halfway blind off the street to see that that's not here. And so why give you new missions?

MS: I hadn't thought of it that way but that's really—

LP: You've got to lead new missions here. Just like back then we were lead or we had leadership. We had self-leadership, to where we led this company, this culture, into a very progressive, very successful existence. And that air was cut off. And until— So there's no coming back and reconnecting for any new mission here.

MS: Yeah it does sound like that's a major type of problem.

LP: It's sad. After my group leaves, there will be no— My group that hired in with me that's in the operations, both in separations and any area of the site—separations, spent fuels, even—well any area, SRNL, whatever, when my group leaves, that will be the last group that every saw anything run or have any experience with the Du Pont culture. So we will be it.

MS: Well when did you leave the reactor for the last time?

LP: I left the reactor after the K restart in 1992. At that time I was personnel manager for reactors. And my position was taken over by the human resource organization and I then went into human resource management supervisory skill training.

MS: So you were at K-reactor as well, during the—

LP: Yes. I was— My office was in the C Area, 706-C Building, Reactor Technology building, when I became personnel manager. And then I supported the K Area into where I made sure that the operator supervision was trained, qualified, certified, all the shifts were staffed, even did some training to the people—to the operations at that time and readying them for K restart training. And at that time, as soon as K Area started, I moved out. My last assignment after K restart was to excess the reactor people into the site.

MS: Why did they elect to restart K and not continue on with L?

LP: Well—

MS: I'm assuming by the time K started up, L was already closed again.

LP: All of the reactors were closed again, yes. I'm not really sure. I'm really not sure why the decision was made for that.

MS: What were the differences? You've talked about that to some degree, the difference between like the Du Pont corporate culture and Westinghouse's culture. Could you see that in like the L restart versus the K restart?

LP: Oh yes, definitely. Yes, in the K restart we had the nuclear navy influence, we had the commercial influence, we had the Three Mile Island influence, we had— We had basically people that were strangers out here directing us, and including DOE. We didn't have— DOE had not been active participant in any of the reactor operations during the Du Pont years or really any of the plant operations. And you know, we had—you might as well have gone out and got a busload of strangers that knew nothing about what was going on, and put them in that nuclear control room and told them, you're in charge. And if it had not been for those of us that were in there with the reactor restart crew that were the last to have been certified and the last to have had our hands on the indications or last to had our hands on the toggle switches or any of the instruments, it would not have restarted, because the restart crew had never operated a reactor. That's why we were there. And then we had, like I say, a roomful of strangers in charge—supposed to be the safest restart ever.

MS: That didn't last long either?

LP: No, about twenty-four hours (laughter), they shut it down. And you know, they faked it for that long.

MS: Why in the end did they shut down K-reactor? Was it just they decided they didn't need the material? It was—

LP: I really don't know. I turned my back on it. You think all these millions that they pour into L Area, millions that they poured into the K restart, and I really don't know, unless it was just to say, Hey we can start back up and we can make nuclear material—that just to show whoever. And I don't know why they shut it— I don't know why they started it up or why they shut it down. I don't know really— And I don't think anyone that was working in Reactors the night that the P Area blip occurred on the high-level flux monitor, when they shut the whole world down and essentially we never started up. I don't know why they ever shut it down over that; that was a common thing. But it was evident that when the new company that took over the contract came in— And it was told to people in Du Pont and out here from other DOE sites, that this place—this group will come in and shut you down, because they shut everything down. And it wasn't long to where they were looking for something and they shut it down.

And I guess it's hard to bring in—because the workforce blew up to about, gosh, close to high 20,000 then when the world came in to help us restart correctly. So I think that may have had something to do with it, that they had this glut of what they considered valuable nuclear experience out there that they needed somewhere to stuff them. And so what's a better place than to say this nuclear complex had a problem and we need to come in and fix it. Because it wasn't long after that that we had the P Area incident, which shut down all the reactors and immediately DOE headquarters came down and it was just a big mess and the next thing you know, every Tom, Dick and Harry that had ever been on a ship or boat or had sailboats on their pants or anything came down here to show us how to do it. And then everybody from any nuclear commercial reactor—NRC, the (unintelligible) all of a sudden they all showed up. So I honestly think it had to do with looking for somewhere to keep those type of people busy at the government expense.

MS: Well out of curiosity, you mentioned the P Area incident, but what exactly was that?

LP: That was on a startup. It was a routine startup to where we— Again, it hadn't been long after Westinghouse had taken over, and of course DOE started being any way at all active, and they showed up in a control room, P Area, for the first time. And again, it's like getting a group of tourists out there and bringing them in to oversee what trained people are doing. And if they saw something that—they saw an instrument on a nuclear startup react as it should have reacted and they didn't understand it, so like a lot of things though history, ignorance breeds fear, and immediately it became, Oh gosh something horrible happened in P Area, and the only difference is they could scream louder than we could explain. And so it became a mass hysteria and the next thing you know we're all shut down and we're the most in need of help place in the world. And it all played into what it was supposed to play into.

MS: Yeah. Well I wonder if by that point maybe they had just simply made enough plutonium and they just didn't need to make anymore?

LP: I don't know.

MS: Of course that doesn't answer the question about the tritium stuff but—

LP: Yeah well, I don't know. Again, at that point is when we started—the workforce bloomed to upper twenty-thousand people and we had everybody in the world—nuclear navy, commercial industry, out here working and we weren't running a darned thing. Whereas, we used to be running two separations, a vibrant administration area, a full medical, an SRNL, which was SRTC at the time, five, four reactors and two canyons with around eight thousand people.

MS: Talking about the nuclear navy stuff, was that MOX or have I got that wrong?

LP: No nuclear navy, they hired—said we needed to become—adopt more of the naval standards and the naval this and naval that. And that's simply because at that time there were a lot of excess naval—nuclear naval folks hanging around. They just weren't building that many nuclear subs and the Charleston shipyards were laying off and it just wasn't a whole lot of nuclear sub activity, and these folks needed places to go and their buds were in here, put in high-management positions, so they sucked them in. Put them on the payroll. Reactor restart had a blank check.

MS: That's pretty good. Well that pretty much covers all the questions I can think to ask right now, but if there's anything else you want to add, feel free to do so.

LP: Thank you.

MS: Well thank you. Appreciate it very much.

END OF INTERVIEW

Oral History Interview – Al Peters

Al H. Peters, Jr., was born in 1929.* After earning a B.S. in Chemical Engineering at Clemson College in 1950, he served in the Air Force during the Korean War. In 1953, Mr. Peters began a 36-year stint with the Du Pont Company. The majority of this time was spent at the Savannah River Plant.

Peters began his work at Savannah River at the CMX pilot plant, working within the Savannah River Laboratory. He was transferred to the plant's reactor Technology Department in 1969 as a plant supervisor, and continued to play a strong role in plant management. By 1977, he was appointed assistant plant manager. After two years at another Du Pont facility, he returned to Savannah River to serve as manager of the Savannah River Laboratory, a post he held until 1981. During the 1980s, Peters served as manager of Plant Facilities and Services. He stayed on at Savannah River for one year after Du Pont left, to help with the transition to Westinghouse. He retired in 1990 and currently lives in Aiken, South Carolina.

*Personal information has been removed from the transcription

Interviewee: Al Peters

Interviewer: Mark Swanson

Date of Interview: December 13, 2004

M. Swanson: This is an interview with Mr. Al Peters and the date is 13 December 2004. We're going to be talking about … well anything you want to talk about basically, but we kind of want to put the focus on the CMX/TNX area.

A. Peters: Right, right.

MS: So if you would, just state your name and when you were born and any bio information you want to give.

AP: My full name is Albert H. Peters, Jr. I'm 75-years-old.* BS Chemical Engineer in Clemson in 1950 and worked approximately thirty-six (36) years with the Du Pont Company after getting out of the Air Force and the Korean War and all but one (1) year of that service was at the Savannah River Laboratory in the Savannah River Plant and one (1) year after Du Pont left I managed the transition activities of Westinghouse and that's about it.

MS: Okay, great. Our particular project is to work on CMX and what was done there from the early days and how that might have changed over time until it closed down.

AP: Okay.

MS: Uh, when was the first time that you worked at CMX?

AP: I started my career with Du Pont at CMX, I think, January 23, 1953. So I was in the very early stages of CMX but it had been operating since 1951 and was the first operating site at the plant at that time.

MS: Uh-huh, okay. Which came first, CMX or TNX?

*Personal information has been removed from the transcription

AP: CMX. CMX was the very first either research or plant facility that was operating on that plant. That doesn't count the construction forces and the construction buildings, which started in 1950 I guess.

MS: Uh-huh. Okay, why did they put TNX and CMX together?

AP: Well, they were experimental facilities to support the … CMX to support the nuclear reactor complexes; TNX was built to support experimentally the chemical separations facilities and the primary reason for putting CMX there was it was on a bluff, overlooking a swamp area next to the Savannah River, and the primary purpose of that facility initially was to test the fouling characteristics of the Savannah River water, which was used for cooling the heat generated and nuclear reactors. So, we set up an experimental, fairly large, it really was what Du Pont called the semi-works. It wasn't a small scale, it was a very large scale semi-works and the initial tests were on prototype heat exchanges, which we measured the fouling characteristics of the Savannah River water. The concern was that the water had a lot of silt in it at that time because initially, this was before the construction of the Strom Thurmond Dam and Lake, which was earlier called Clark's Hill. At any rate, that water was very silty and the concern was is that would foul the heat exchanges and limit the thermal capacity of the reactors. As it turned up, the silt actually kept the heat exchanger tubes clean so this facility had … CMX had a very large water clarification plant to remove all of that silt and turbidity and so we ran side by side comparisons with clarified water and … which we called treated water and with just raw water, right out of the river, and it turned out that as a result of that work, which ended about 1954 is as near as my memory serves me. At that time, our reactor was already built and these water clarification facilities were installed in our reactor. Subsequently the next year, P reactor was completed; they couldn't wait on this work to determine that.

MS: Uh-huh.

AP: The work saved about twenty-five million dollars ($25,000,000) in equipment costs in each of the three (3) remaining reactor areas. So it paid for itself in spades. That was just one (1) small part of the whole CMX complex work at that time. The CMX facilities had the equipment and all for pumping water from the Savannah River to this experimental complex. So it was only natural, I think, to answer your other question; that TNX was also built at that place. It made sense to do that because it was an experimental complex under the Savannah River Laboratory and so we could share common like steam, water, electric, all of the utilities …

MS: Okay.

AP: … plus the resources of the technical manpower.

MS: So both facilities were managed by the lab right?

AP: That's right, we reported to the laboratory. The Director at that time was Milt Wahl.

MS: Hmmm.

AP: Now let me ask you one question.

MS: Certainly.

AP: I don't who all you are interviewing but in terms of that work on the heat exchanger program, I came late in January 1953 because it was well underway. At first, if my memory serves me right, the very first head of the CMX, was Paul Dahlen.

MS: Hmmm

AP: Okay, I'm going to say you definitely ought to interview Paul Dahlen.

MS: Yeah, uh-hum, yeah.

AP: And then Paul Dahlen; just a little bit of history, was transferred from CMX to the plant in Reactor Technology, and succeeding him was a gentleman named Ray Hood; he's deceased – well, that's not going to help you any. Ray wasn't there too long before he was transferred, and he was succeeded by Earl Nelson; he is deceased.

MS: Okay.

AP: Uh Earl …

MS: I'm going to write their names anyway.

AP: Okay. Uh, Earl was transferred, again, to Reactor Technology because these two (2) facilities, CMX and TNX provided hands-on with much smaller scale and comparable equipment, both in CMX and TNX to support the plant. So while the plant was being built, they didn't need a lot of technologists following construction, so that's another purpose of the CMX facilities, was to utilize these technical people or to get them familiar with the nuclear technology and then transfer them into the plant. They all went into either Reactor Technology or Separations Technology. Subsequently, like myself, we ended up in production in the plant …

MS: Okay, all right.

AP: … in management but after Earl Nelson was transferred from the plant; actually he was transferred back and became head of the Pile Engineering Division in the laboratory. CMX was a division of Pile Engineering Division, and Pile comes from the first nuclear pile of reactors that they called piles at Hanford but it really was in Chicago.

MS: Oh, okay.

AP: And then Pile came from the standpoint to use blocks of graphite to moderate the new drawings, but …

MS: Right.

AP: Earl subsequently was transferred to commercial but after Earl left, Fred Welty replaced him at CMX, as head of CMX, and then I replaced Fred Welty as Head of CMX. That's … I'm trying to think, when I left and transferred into Reactor Technology, the … I believe that Vascoe Watley replaced me as head of CMX. I was moved up to the main lab and I had CMX as a sub-group.

MS: Uh-huh, right.

AP: And that's where Dave Muhlbaier was working at the time for me.

MS: Oh okay, right.

AP: Uh, Vascoe Whatley, do you have his name?

MS: Uh-uh, no.

AP: Vascoe and Dave are both a little bit younger than I am, but Vascoe would be older than Dave and he lives in Allendale. B-A-S-C-O-E Watley W-H-A-T-L-E-Y; and Vascoe, I haven't seen in years.

MS: Uh-huh.

AP: I assume he's still alive.

MS: Okay, uh-huh.

AP: Subsequently a few years later; this would have been I think in the seventies (70s) but uh, Bill Durante do you have his name?

MS: Uh-huh. Bill Durante, right?

AP: Durante, he lives in North Augusta and I haven't seen him in a long time and I assume he's still alive. He was also at CMX uh though he started his career up in Pile Engineering Division up in the main laboratory and was transferred down at CMX. So those are the people that you might want to put on your list. Right around in the seventies (70s) sometime most of that operation, I'd say late seventies (70s) had ceased at CMX and we had a minimum amount of work and they built public facilities and consolidated them all up in 773 up in the main laboratory.

MS: Oh, okay. Is that when they had the heat transfer lab or something?

AP: Yeah there was a heat transfer lab in 773 that did most of the heat transfer work, originally under Sam Mirshak in the laboratory. Sam got promoted and that all came under me when I was transferred up there. But some heat transfer work was done at CMX by the same individual, Sam Mirshak. It never was assigned to CMX but there in the early stages we had the utilities and the facilities to do this work and this was work … heat transfer work done to determine the … from the safety standpoint what we call the limitation of flow down the fuel element due to excessive heat generated by the fuel, in this case there was an electrical tube, and our concept was to have what they call, boiling disease protection.

MS: Hmmm.

AP: And that was really the only heat transfer work that Sam did at CMX.

MS: This was the 1970s right?

AP: No, this was the 1950s, the 1950s, now I'm going to go back to the fifties (50s) in a minute so you … I want to be sure that the total broad aspects you will gather.
CMX's primary purpose; if it became a fluid transfer operation, most of the work done at these initial works were done fluid dynamics for both liquid, water, in our case; and air and I'll explain those in a moment. Plus, we did work on the erosion and corrosion of two (2) element surfaces. Example, my very first assignment coming out of R&D in the Air Force was to determine the corrosion characteristics of the aluminum clad slugs, which when they discharge from the reactors are put in buckets in these huge underwater cooling bases. They stayed there three (3) months or so before they were shipped, dissolved in the separation facilities. Well it turns out there was a coupling electronic … electrical coupling between the stainless steel and the aluminum cladding. It caused the aluminum cladding, called galvanic corrosion, to corrode and if it corroded too much during storage it could penetrate the cladding into the uranium cores [inaudible – someone clearing throat] for that basin. So my work was to characterize that corrosion and prevent it and the way we prevented it was to put an aluminum liner in the buckets.

MS: Oh okay.

AP: And there is a DP report by me on that. Then the next phase of work and equally important, much more important than that corrosion work was the fluid dynamics around the fuel and target elements so we had facilities built initially to flow test a fuel and target elements and what we call a converter. A converter was just a misnomer, it was really a hydraulic facility for subjecting these fuel and target elements full length, full length-full mock ups to the fluid conditions they would experience in the reactors. We used heavy water for all these experiments.

MS: So there's no heavy water …

AP: No heavy water at CMX.

MS: Okay. When was this?

AP: Sixties (60s).

MS: Excuse me? In the sixties (60s) this was or late fifties (50s) early (60s) what?

AP: No, no, that started in the fifties (50s) also. I had that, I was doing work on fuel elements from the hydraulic casting in fifty-four ('54).

MS: Okay.

AP: These were the slugs, the very first Mark 1 slugs.

MS: Right, right.

AP: What we did is we subjected these targets and fuel elements to the same hydraulic conditions they would experience in the reactor. So we wanted to be sure that we didn't have excessive vibration that would cause again the damage to the cladding and expose the fuel and the vision products to the moderator and the reactor.

MS: Uh-huh.

AP: That became very significant. Particularly, what we did at the upper … the very top of the elements because early on we had heavy water pumps and the reactors that didn't pump as much heavy water coolant over the fuel elements, so we had to put restrictors. These pumps generated a fair amount of pressure and so our total flow capacity was limited by the pumping capacity.

MS: Uh-huh.

AP: Which ultimately we changed and we put in much bigger pumps that almost doubled that capacity. At any rate, for this boiling disease protection, we had restricting orifices at the top of these fuel elements. So if the flow decreased a little bit and decreased pressure dropped across the orifices and let more flow come back in. Now why would the flow decrease? Because of a blister on the cladding or boiling; so that was to prevent boiling disease.

MS: Uh-huh.

AP: And at the bottom of these fuel elements, we had a monitoring configuration we put over the monitor pins in the reactors and they had a pressure tab for monitoring and a pressure differential as fuel elements and full thermocouples; so even before our reactor achieved their initial design power, which was a few hundred megawatts, a drop in the bucket compared to what we ultimately achieved …

MS: Uh-huh.

AP: Our reactor was sitting there idling at just beyond critical station, very low power, because we had a problem in the monitoring efficiency. In other words, we wanted to be able to detect that if we had a pluggage in the sub-channel that the monitor pin would show you that and you could shut the reactor down and take that element out. It turns out the very first initial experimental work on our monitoring was done on our Engineering Research Laboratories in Wilmington, Delaware.

MS: Uh-huh.

AP: And then the Wheatstone Bridge complex for the thermocouples to properly measure, they made a mistake in the hookup.

MS: Hmmm.

AP: And they subsequently found that, but in the meantime, we're working with, you know, full scale elements and full scale hardware. So all of that work we took over at CMX and there again, that's in the early fifties (50s) late fifty-four ('54) and fifty-five ('55) we started this extensive program on that and Fred Welty was the initial guy in CMX doing that work.
So in fairly short order, we configured changes in the bottom fitting that would improve the mixing so that we could pick this up; made those changes in the reactors, also gave them calibration [inaudible] so they know what they were looking for and allowed them to proceed to full power at that time. So that was all done, it was lots and lots of work done in the fifties (50s) and the sixties (60s).

MS: Uh-huh.

AP: Okay, the other thing we did that led the very pioneering work layer; there's another gentlemen that worked for me down there that did work in the early fifties (50s) on the mechanical seals of the pumps and his name is Fred Apple, A-P-P-L-E. Fred left us after completing all that work on the mechanical seals and other work that I will tell you in a minute that he did for me and went to work for Georgia Tech in their test reactor. As far as I know that where he is, if he's still alive that's where Fred is. You might want to talk to him.

MS: Oh, okay.

AP: That … except a few … if you dig up detail laboratory reports, not too much is mentioned about that pretty pioneer work that Fred did on the mechanical seals. What we were concerned with there is we wanted mechanical seals with a long life and with very low leakage of heavy water. So right to begin with, the whole complex for the nuclear reactors was very sensitive about the safety in a very broad sense of the word. In other words, we didn't want a lot of heavy water leaking out.

MS: Uh-huh, right.

AP: That would have been costly; uh, you had to contain it and of course, if there were any fission products in the moderator why that was another source of leakage of fission products. Okay …

MS: Now how did you do that work if you didn't have any heavy water at the …

AP: The characteristics are the same as far as mechanical … heavy water is … has a higher density and the reason you use it in nuclear reactors is because it's much more efficient in moderating the neutrons to the desired level and captured by the uranium and breeding plutonium.

MS: Uh-huh, uh-huh.

AP: And if you …

MS: But for other characteristics, it was close enough to regular water so …

AP: That's right, as far as … a little difference in the density and a little difference in the boiling point but that's about it. A little … insignificant difference in viscosity, which is an important characteristic for determining pressure drop across surfaces.

MS: Right, right.

AP: But factor all of that in and like the monitoring. We didn't rely just strictly on the work I've done at CMX. Example, I did work on the mixing in the sub-tanks; are you familiar with the geometric shape of some of these fuel elements?

MS: Yeah.

AP: Do you know what we call a sub-channel is where between two (2) ribs, usually on the tubal elements you have four (4) ribs to support the thing laterally. We wanted to know what was the degree of mixing in a sub-channel. Was there any mixing from one sub-channel to the other? I did work on a small scale for that to determine that to help us know what that monitor pin was telling us down there, but to characterize what we did with monitor pin and that sub-channel work, what Sam Mirshak did was heat transfer lab with what we characterized is another limit called BOSF, are you familiar with that?

MS: Uh, no.

AP: Burn-Off Safety Factor. We wanted to have a Burn-Off Safety Factor on the heat transfer of the fuel elements, which Sam characterized in small scales by heating electrical strips or electrical tubes with the same fluid dynamics they would have in a reactor. They keep putting the power in that until it actually, physically burned up and that's where the burn-off safety factor comes in. When you back away from that in the reactors; well now to be sure we knew what was happening in there, we had a mechanical counterpart in the old Pile Engineering Division, which later the Dave [???] headed up.

Developed full-scale, took a full scale fuel element, instrumented with thermocouples in these sub-channels and bring all of those leads up to the top of the reactor and in an actually experimental condition measure in the reactor what the temperatures were in those sub-channels. That told us from a fuel element design standpoint we had, with all these sub-channels, we had to balance as best we could. So, our initial fuel design, we would test these in the reactor and we would make subsequent changes in the geometrical shape of the fuel so we could get a better balance as far as the distribution of coolant in those channel. Anyway, that's a pretty long story but it was very important from a safety standpoint that whole business. So we tested all of the fuel elements at CMX for vibration damage or erosion damage and that subject of erosion became important to us for two (2) aspects.

As we for the nuclear reactors … as we evolved with the technology and changed … put in more heat exchanges, put in more … bigger pumps to utilize all of that. Are you familiar with that book there?

MS: Yeah.

AP: Okay, so we've got a term in that book. I managed that by the way, we show the power increase that occurred. The production which is directly proportional … in those reactors and a lot of that came about because of this work that was done at CMX. Erosion, the question was, we originally designed these fuel elements based on heat transfer and experience that handled it. Also, at Columbia University if we had experiments at Columbia University going on parallel this whole project. So a lot of heat transfer work was done up there also. The question was, if we increase the flow so that the coolant velocity increased twenty-five (25) feet per second to fifty (50) feet per second, would that cause serious erosion of that aluminum cladding? So Brad Apple, again, we did pioneering research or you could say development on the erosion characteristics of aluminum, magnesium, stainless steel and titanium. If velocity that we were currently experiencing was twenty-five (25) feet per second; double that to fifty (50) feet per second, ultimately went to one hundred (100) per second. Now what's important about that one hundred (100) feet per second is that paved the way to show that the aluminum would stand those velocities in the production reactors.

That plus the heat transfer work done at those, plus the mechanical design and all was very important to the success of the high flux operation. Now that is referenced in this book. I don't know whether you were interested in that or not but we said so much of that was done a CMX that we could set world from a heat transfer standpoint and an engineering standpoint; we could have success if cooling velocities of ninety (90) to one hundred (100) feet per second.

MS: Right. When was this … when was this done?

AP: That was done in the late fifties (50s), early sixties (60s).

MS: Uh-huh.

AP: Now also in that time, just to tie it together a little bit. We were also interested in supporting the commercial nuclear technology business.

MS: Right.

AP: And we had that big tester/reactor built on site and we had a …

MS: What are you talking about … "Hector" [Heavy Water Component Test Reactor, or HWCTR]?

AP: Hector, right.
We had … we built a facility again to test the fluid dynamics, corrosion/erosion and things like that at the conditions that they expected at Hector; that was done at CMX in what was called a power test facility, which Brad and I designed, built and operated.

MS: Now this wasn't at … this power test facility was it CMX? Where was this?

AP: All right, if you, you know, you walk … I don't know is the building still standing? Are you familiar with the building at all?

MS: No. I've got uh … I was talking to Dave this morning and I had him just draw out an outline of the building plus the other two (2) buildings that were there that were part of the CMX/TNX complex.

AP: Alright, if you look out at the back of the building, there was a wing of offices from out there … see, here is the main complex where we had all the heat exchangers, the full test facilities, the corrosion/erosion and all the monitoring work on the bottom end fittings and all was in this complex. You walk into the building like this; there was an office complex here where major CMX engineers were sited and then there was a wing, and down this wing they had supporting ordinary water laboratory and offices for some CMX people and the TNX staff.

MS: Uh-huh.

AP: This way, over there, is the river and the swamp. And by the way, we referred to ourselves as "swamp rats" at TNX.

MS: Oh, okay, uh-huh, uh-huh.

AP: Right over here was this power test facility then operated at two hundred sixty degrees (2600) centigrade and about one thousand (1000) pounds of pressure. There again, because of the … of Hector, there was interest from a neutron economy standpoint in looking at magnesium.

MS: Uh-huh.

AP: So we did flow tests on fuel elements in that facility with magnesium and it eroded substantially. It was not a suitable cladding at those conditions for power reactor fuel. It's about that time when Fred was offered this job and we had finished most of the work that he had an offer to go to work for Georgia Tech and their test facility. We ultimately shut that down and the timing on that would be about the time that John Walker and I did a piece on the filters. I can calibrate you on that time. Interesting thought about that facility … you know for an engineer. I was a Chemical Engineer and John Walker, let's see, John Walker came after Fred Welty. So it was John Walker between Fred Welty and myself as Head of CMX.

MS: Okay.

AP: Okay and John … John was a brilliant mechanical engineer. That would have been 1963-ish. In the design of that facility you had to be extremely concerned about the thermo-stresses on the piping as well as the facility and all. I had never done any 3-dimensional stress, being a chemical engineer, and John Walker was an expert and he said I don't have time to do this. This is before he became head of CMX and he said, "Here is a book." So I did that and Fred Apple, who was a mechanical engineer, and Dave Palmer, I think Dave was mechanical, I'm not sure whether Dave was mechanical or chemical. I would guess mechanical.

MS: Okay.

AP: There was another one that worked for me in that period, by the way, Dave Ward.

MS: Uh-huh.

AP: Okay, so you got him on your list; he worked … he started his career at CMX also.

MS: Uh, yep, I got him on the list.

AP: Okay, Dave did work … Dave did work on a piece I haven't covered yet. But at any rate that was very interesting a design of that piping system for that power test facility; because with those conditions you had big changes and length of piping and things like that you know, could fail if they weren't properly designed and properly supported for the stresses, but anyway. So that was a big learning experience for sure for me.
Over in the TNX facility they ended up with quite a few buildings because, you know, most of the semi-works are done for the defense waste processing facility, which was done at TNX.

MS: Hmmm, right.

AP: Okay, in a building where a fair amount of tritium work was done … here again is CMX, there's CMX, right next to that was the original TNX building. Then it was another building over here and this doesn't count any of the defense waste processing facilities which added more buildings to that complex.

MS: Oh, okay.

AP: But this building over here was built to do some basic work on tritium and we needed a facility space to build a one sixth-scale model of the reactors from a hydraulic standpoint. This was when we were increasing the pumps and the nuclear reactors, and the question was in the moderator space part of this increased flow, would there be severe damage due to vibration of the fuel elements because we were talking about doubling the flow. So we wanted this facility and we called that the cross-flow tank and Dave Ward and I did all of the original basic work in that. Prior to that Dave did work on a smaller scale, where we subjected the fuel elements to a cross-flow. The work cross-flow comes out because the water generally goes up in the middle of the reactor, then down but there's also some going straight out this way into those open nozzles and the question was when that flow, going across those cause severe vibration and damage to the fuel elements? And as it turns out, it didn't, but we weren't sure with that smaller scale model it would uh, Dave built right in the main building. We built a one sixth-scale model and that was successful.

MS: When was that done?

AP: That would have been in the late sixties (60s), mid-sixties (60s) to late sixties (60s); before the pumps were put in whenever that was.

MS: Oh the new … the reactor pumps, the Binghamton pumps?

AP: Yeah, the Binghamton.

AP: Okay, after they … the other thing that was monitored carefully in the reactors was the bulk moderator temperatures outside the fuel elements but within the tank, okay? As we increased power and … like increasing the heat transfer capability in the system. More heat exchanges and more pumps, okay? Uh, and careful design of the fuel and elements; the moderator temperature, which was at the atmospheric pressure at that time; later, we put in vacuum breakers and increased the pressure slightly six (6) or seven (7) pounds, something like that. But the moderator began limiting power because it was getting close to the boiling point of D_2O. So the question is and this was near the center of the reactor … so we did work, Dave Ward did work for me in that tank, that big cross [inaudible] tank, to characterize the flow and also the … mainly the flow because we could not … the only way we could assimilate local heat generation is, we just heated the water up to one hundred (100) degrees and ran our test, was to put in a fuel element and hit it with steam so we could get local(?). We didn't have the capacity to get more than one fuel elements worth of heat. That took a huge steam accumulator outside that tank. I think that building may be gone now too, I really don't know. I haven't been out there since …

MS: I haven't been out there but I've been told that pretty much all of that stuff's gone.

AP: … yeah, well at any rate, we found out that by putting jet tools in the reactor the jet would flow up … a fairly high velocity, uh, then we could eliminate those hot spots that occurred in the middle of the rack improving the flow up and over and down and that work was done at CMX by Dave. And ultimately, since we had this capability now of ejecting steam in the reactor, we did safety analysis in that tank.

MS: Uh-huh.

AP: By injecting steam and things like that to determine the pressure characteristics of the system and Dave did that work also.

MS: Hmmm, okay.

AP: I know that all that work was completed before I was transferred to reactor technology, which was in sixty-nine ('69) and Dave had long since been transferred to reactor technology also. So that's like mid … I'm guessing, mid … early 60s, mid 60s something like that.

MS: Uh-huh.

AP: All right. Then the other major work that we did was the development of the filtration system or the containment system of the reactors.
That was done under me at CMX and the principles were Dave Muhlbaier, a fellow named George Priggy, who did most of the original work on the effectiveness of activated carbon for removing [inaudible] and … let's see Dave Muhlbaier. Dave did work on full-scale and he might have done some of the bench-scale, we did bench-scale works on filter samples, three (3") or four (4") inches in diameter. It was very important, because it was wet conditions, in an accident in which you lost coolant capability to reactors. You generated a lot of steam, and the question was would Hepa filters withstand that; and ninety-five percent (95%) of them wouldn't. We did experiments on all kinds, quoted them all and found one (1) particular filter that would withstand most of the conditions, but not all of them.

MS: Uh-huh.

AP: These were high strength water repellant Hepa filters. So we developed de-misters to put in front of these filters. This was all done on full-scale models, where we had that accumulator out there that could generate lots of steam?

MS: Uh-huh.

AP: And we actually could simulate steam flows ten (10) times the normal flow of [inaudible]. The activated carbon beds were the last thing in this chain to remove the [inaudible] fission box(?).

MS: Uh-huh.

AP: So we had a full-scale facility where we could test de-misters, filters and the activated carbon filters; all … those activated carbon filters, by the way, were designed by us at CMX.

MS: Hmmm.

AP: So we not only did the technical work on the effectiveness of them but then subsequently we found out by work that I had done in the main laboratory in Pile Engineering, where we had a little test pile?

MS: Uh-huh.

AP: We subjected the carbon to high radiation fields and that work was done my Bob Miller; he's dead now.

MS: Uh-huh.

AP: But Bob was a co-author by this big confinement report that Bill Milant and Muhlbaier and myself wrote.

MS: Okay, uh-huh.

AP: Subsequent to me …

MS: Phyllis can find the report?

AP: Yes. They found that the activated carbon acted like a catalyst and created methyliodine on the band itself and the carbon wouldn't retain that. So that work was done subsequent to CMX, it was done in the main laboratory and I can't remember the gentleman that replaced Miller up there, who did that work and he's still alive too; Muhlbaier would remember him I'm pretty sure.

MS: Hmmm, okay.

AP: Now Vascoe Watley did a lot of the work … hydraulic work on the fuel elements and also the monitoring work. That was mainly his area of expertise while he was at CMX. And when they moved those facilities to Pile Engineering Division, up in the main laboratory, they subsequently brought Matt to do more safety studies related to loss of coolant accidents and Vascoe worked on that.

MS: I'm sorry, when did he start working with CMX?

AP: Let's see, he was a Chemical Engineering graduate up at Clemson uh … I'm … and he came three (3) or four (4) years after me at Clemson so, I'm guessing fifty-five (55), fifty-six (56) somewhere in there. And there was another guy from Clemson, a Mechanical Engineer that left and went back in the R&D Unit of Ray Patterson Air Force Base; Abercrombie. He's still alive I'm pretty sure; and he did work for me on the … [Tape side one ended here].

(Side Two)

AP: In my old career, which started the experiments at CMX and then up in the main lab where I had that and heat transfer work done. Then to reactor tank and the reactor tank, I had replaced John Maloney as Head of the Engineering Support Group. They had an Engineering Support Group, they had a Engineering Technology Group, and they had a Physics group in reactor tanks. And the interesting part about that is how that background from the initial experimental work all the way to see final setting world records on neutron and heat flux, I-flux reactors. That was a real rewarding experience. You know, I was a research supervisor at that time and sheet supervisor in reactor tech. But the way Du Pont operated; their supervisors were also working supervisors. All the way from technology into operations, so if you ended up as a desk supervisor, just strictly supervising people, you were not going to be very successful in Du Pont Company.

MS: Right.

AP: So, at any rate, it was … that was as equally challenging as the first criticality in our reactor, which I wasn't there for that, and … so those are very satisfying things in an engineer's life. There are others of course, but that one was particularly important. I can't … unless you've got some detailed questions, I can't think of anymore about CMX that might be of use to you.

MS: Uh, the questions that I've got are not probably going to be as comprehensive as what you've got, but there were some things that I remembered from doing some research years ago with that fiftieth (50th) anniversary history that we worked on.

AP: Yeah, yeah. By the way, I don't have that book.

MS: Oh, okay.

AP: But they showed a picture in there of me and identifying the guy with me is incorrect. That is Fred Welty. I told Walt Joseph, I think, about that.

MS: Oh, okay. I've got a copy of that book but I don't have it with me.

AP: But at any rate that was me in my twenties (20s) and Fred Welty was … let's see, he had a PhD in Chemical Engineering so he might have been late twenties (20s).

MS: What about … I read I think it was in Bebbington's that you mentioned that the CMX operation was shut down in 1984?

AP: That's possible. Dave Omar applied a lot of that work that was continued safety fashion sort of went back to the …

MS: [inaudible – cross talking]

AP: That’s what I was telling you about, where Vascoe Watley and Dave Muhlbaier went and so it was continued but the mission, the objective of the work was a little different.

MS: Uh-huh, uh-huh.

AP: But they were mainly doing hydraulic test under continuing safety analyses and in eighty-four (’84); well they brought me back in the plant to be Manager of Operations in eighty-two (’82) and so, you know, I didn’t keep up with all that was happening with CMX at that time because I had then transferred to the [inaudible] and back as Manager of the Laboratory. But I know that CMX was still in operation when I was managing the laboratory. That would have been seventy-nine (’79) through early eighty-two (’82).

MS: Okay.

AP: In eighty-four (’84) I became Manager of Plant Facilities & Services and also Manager of Transitions and that’s where I retired.

MS: Right. What was …

AP: But eighty-four (’84) as far as I know … I’ve got to tell you a little history about this book.

MS: Oh yeah, sure, go ahead.

AP: It was really my idea and Jim Conaway’s to do this because we had no idea based on the history of the United States government and the atomic program of doing histories.

MS: Right.

AP: History had started about at Hanford and that was so far down the pipe that uh, you know, just like today a lot of the people are dead. Jim Fletcher’s dead and he was a mentor of mine; but at any rate, to keep this book’s cost down, I did that in my basement of my house to keep this book down.

I didn't pay myself a cent and didn't pay Conaway a cent but we did all of our interviewing and I hired people on contract, retirees, to help us with this whole darned book. That's the only reason we could do this book and get the department to pay for it and we … somebody wanted one of these books not too long ago and I checked the Chamber of Commerce to see whether they still had any … I talked to Bonner to give him two thousand (2000) over two thousand (2000) books, giving them, to the Chamber of Commerce. So they wrote all of that off but the total cost of the project was five thousand (5000) books. We managed the cost because people were interested in doing this for nothing essentially, to a fraction of what was charged for the big fiftieth (50th) anniversary. I wouldn't have done it otherwise, because I, you know, we were asking them to take it out of their commercial [inaudible] and pay for this darned book.

MS: Right, uh-huh.

AP: And the interesting thing is that we could only sell about a little over two thousand (2000) books.

MS: Right.

AP: Of the five thousand (5000) that were printed.

Millie: How are you?

AP: That's my wife Millie.

MS: Hey, how are you doing? I'm going to shut this off.

AP: You want to cut that off?

MS: Cutting this back on after our interruption here. Let's see, there are not that many other questions to ask but I did want to … did we mention, did we talk about how many people worked at CMX?

AP: No we didn't … counting the total number?

MS: Yeah.

AP: The peak was probably in the fifties (50s) and I'm guessing it was like uh, in the neighborhood of fifty (50) people counting the operators and counting the support people. The operators reported directly to us. The mechanics, the maintenance mechanics, electricians, HP people, those reported to their hierarchy and the laboratory. So they were not under out direct supervision, though they did exactly what we wanted them to do, so we directed their work. But they got their fitness reports from somewhere else.

MS: Oh, okay. What about the TNX?

AP: TNX I would say was about comparable size, around fifty (50) people or so at a max.

MS: Okay.

AP: Now when they … the Defense Waste Processing Facility, uh, that was in the eighties (80s) I would say may there was one hundred (100) people down there.

MS: Oh, okay, all right. What did … this is a little bit off of the track but since we're also interested in TNX eventually anyway, what exactly did TNX do for that … that program?

AP: For the uh …

MS: Yeah, Defense Waste.

AP: Defense Waste?

MS: Uh-huh.

AP: Uh, the Defense Waste Program; most all of their technical people came out of the separations technology group and in the hierarchy of things, the defense waste processing facility and the laboratory was in the same organizations of separations technology and it grew and expanded, it became particularly … you know like I was transferred into the plant in eighty-two ('82) to help them set up a project, Oriented Management Structure.

MS: Uh-huh.

AP: And that management structure put under a manager or general superintendent all of the resources directly reported to him to carry out his mission.

MS: Uh-huh.

AP: So like Joe Womack had reactors when he reported to me as Separations Manager and he had health protection, the maintenance department all reported directly to him.

MS: Uh-hum.

AP: The only thing that didn't report to him were that power people that supplied the utilities you see, water, steam and electricity. So the lab became also project oriented … I would say when a mission became fairly large in scope they would historically make a head of that. So Dan McIntosh, okay, became Research Director … or maybe he was a … what did they call it … he was a Section Director, I think, Section Director not a Research Director, Section Director of Defense Waste Processing Technology. So he had experimentation going on in the main laboratory and he had this big complex down at TNX and so he didn't report to the Section Director of Separations but it came out of Separations Technology. We did the same thing in the reactor business. When the whole problem came about that the reactors were beyond their useful life if we wanted to continue that, finally the Du Pont Management came around advocating building a new production reactor. So we formed, both in the plant and in the laboratory a separate team project management team to do that and Lowell Hibbard headed if up at the plant and he had people in the laboratory supporting that and I think at that time, because it never got off of the ground, they stayed in the 405 Engineering Division.

MS: Oh, okay.

MS: What did they do about security at CMX?

AP: Well, we had security. We had, you know, it was a fenced off area with guards and as that work became declassified with time, they eliminated the security. But in my day down there you had to have an Q-clearance. We couldn't do our work without knowledge … detailed knowledge of the engineering and physics characteristics and the operating conditions and the reduction, which was all top secret at that time. But as that became more and more declassified with time, my recollection is they had the guardhouse and they had a gate but they eliminated the guard. I'm guessing that was maybe late seventies (70s) or early eighties (80s) before they shut it down.

MS: Oh, okay, uh-huh, all right.

AP: Something like that.

MS: What about the … did CMX have any direct dealings with the reactor works they maintained at Triple Seven (777) or was it just apples and oranges?

AP: They … Triple Seven (777) was in the physics organization and we shared technology between all groups in the laboratory because we periodically had technical reviews at the main laboratory; so for instance, I think the first speech I ever gave was in the composite meeting of people from all of the divisions and it was on that work on the mixing … sub-channels. So other people got to see you and keep abreast of the technology. They had to have clearance for that however, but some of it was highly compartmentalized and wasn't shared.

MS: Right.

AP: Something like the mixing was, you know, more of a fundamental hydraulic thing so that wasn't a problem. The other thing of course was the research reports that came out monthly from the laboratory. Those were all classified secret so you had to have with your acute clearance … for instance, I didn't have access to the tritium work until I became a General Superintendent of production in the plant and they were under me. That's the first time that I had a special clearance for the tritium work.

MS: Oh okay, okay.

AP: So there was a compartmentalization of the work; in the early days everything was compartmentalized.

MS: Right and that was probably a security measure as well.

AP: Oh yes, that was a big security measure.

MS: What about the actual term CMX? Bebbington says that that doesn't mean anything at all.

AP: He's correct.

MS: But I've heard that people cooked something up.

AP: Yeah we cooked up corrosion, mechanical and experimental.

MS: That's what I heard, yeah.

AP: That's just … see Bebbington never worked at either CMX or TNX, he came up through the heavy water technology branch and was in Separations. I don't know that anyone … you need to ask, when you stop talking to TNX people, you need to ask them did they come with a phrase for TNX. We did for CMX just what I told you. I don't know whether there were others, there may have been others but not to my knowledge.

MS: Was the CMX area ever called anything else?

AP: No, not to my knowledge.

MS: Swamp?

AP: Yeah, we called ourselves in sports activities, we would have softball teams all over the plant and our name was, both CMX and TNX, in those events were the Swamp Rats.

MS: Oh, okay, okay. Let's see uh, what kind of shifts did they have at uh …?

AP: Regular shifts; three shifts, twenty-four (24) hours because see all of those tests went around the clock. We'd run erosion mechanical, like vibration tests on fuel elements for ninety (90) days, sometimes one hundred twenty (120) days.

MS: Yeah, uh-huh, all right.

AP: And so all of that went around the clock. We had operators responsible for taking the bulk shift data. In other words, we would provide them with data sheets that we wanted … we had special instrumentation …

MS: Yeah.

AP: … and they would record that for us.

MS: If it was an on-going experiment that the experiment … the engineer had to be there?

MS: Uh-huh.

AP: You stayed there.

MS: Uh-huh.

AP: So I … in my early days I've spent eighteen to twenty (18-20) hours on an experiment.

MS: Hmmm.

AP: Because it was … you needed that data … like one thing we found out in the reactors, we had two (2) types of monitor pins, are you aware of that? In the nuclear [inaudible]. One's a solid pin with full thermocouple holes in it and a pressure pin. The other one that was installed in K, L, &C has cores through it where part of the flow … initially all of the flow went over the thermocouple and out of the sides. Well they found when they started up with the higher flows with these new type monitor pins that they had unstable hydraulic signals from the monitor pins and the one thing you don't want in a nuclear reactor is an unstable signal; whether it's a hydraulic or temperature or a flex … you don't want those unstable signals. So all of the experimental work to solve that problem was a … I was the first principal investigator on that.

MS: Yeah.

AP: And what happened was, due to the accumulation of tolerances on the monitor pin and the sleeve that fit in the reactor, it's about four (4) or five (5) feet long. That … if the tolerances were on the negative side for the monitor pin and on the positive side for the sleeves and that bottom shield of that reactor where the flow would come out horizontally … you drilled a hole, four (4) holes through this monitor pin nose and you slotted it around so the flow would come out.

MS: Uh-huh.

AP: Well, if that bottom part of the pin was below the top of the sleeve, there was a critical point there in terms of a few thousandths of an inch where the flow would oscillate like this.

MS: Hmmm, uh-huh.

AP: It wouldn't be steady, it'd be up sometimes and it would oscillate frequently so the solution to that problem, and that's one where I probably worked around the clock to characterize that thing.

MS: Yeah.

MS: Uh-huh.

AP: What we did was take up and pin down some of the gaskets. You had double O rings sealing this monitor pin in the bottom of the thermal shield and you also had a gasket, flat gasket, we had to take that flat gasket up and rely on the O rings only.

MS: Yeah, uh-huh, right.

AP: And that would raise the monitor pin and that solved the problem most of the time, like ninety (90) to ninety-five (95) percent of the time. Not always, but most of the time. So that's where a type of an experiment that would go over a normal shift. The experimenter would stay there and he would have operators. At CMX and TNX we used operators not technicians.

MS: Ummm, hmmm.

AP: They were on a different wave scale.

MS: Oh, okay.

AP: And the technicians in the main laboratory were technicians, they were on a weekly pay rate. The hourly people were on an hourly pay rate and there was lots of friction sometimes between … as far as the Scope of Work on whether this technician should get paid more.

MS: Yeah, uh-huh, right.

AP: Uh, that sort of thing went on at both CMX and TNX but the operators were there to carry on a … the carryover work, which was fairly routine, they couldn't adjust to anything other than maintaining the flows that we wanted and the temperature that they wanted and to operate the clarification facilities for the heat exchanger work, operate the boiler. We had two (2) boiler explosions due to this operation, minor explosions, fortunately nobody was injured. The first one of those occurred when we had engineers around the clock on shift. Originally, CMX and TNX had engineers working three (3) shifts, seven days a week.

MS: Ummm, uh-huh.

AP: And as that became more standardized and the rush wasn't on to support the startup of a nuclear reactor or startup of a separation facility that … we got away from having the technical people on shifts.

MS: Yeah, right. That's when you just had the operators?

AP: Operators, right.

MS: Operators couldn't change dials or … okay, uh, hmmm that's pretty good. Did they ever have any …?

AP: Oh, by the way.

MS: Yeah, go ahead.

AP: Did Dave Muhlbaier tell you about the work and characterizing the flow into the reactors moderator space? I think he did mention that, is that the one where they had the … well, he worked for me on that and that was very interesting.

MS: That was up in the plenum, was that it?

AP: Well we did the work in this tank okay, we developed a sub-mister and I'm pretty sure Dave was my principal investigator on that at the time but he and I worked on this darn thing.

MS: He talked about a number of programs; I'd have to go back and listen to the tape, but one was where you …

AP: He developed a little sensor that was based on a sub-mister that we could change the direction of this sub-mister inside an instrument tube in the reactor and the monitor, it would tell us which way the flow was going, officially. If it was going up some angle this way or it wasn't moving at all. So we developed that and when a reactor was down from routine charge … discharge, we took this device, Dave and I took this device over there and mapped that tank … mapped a reactor on the full hydraulic pool conditions.

MS: Uh-huh.

MS: Hmmm.

AP: And one place we stuck the damned probe in the reactor and it just stuck right here. We twisted it a little bit and we got it out but that ended the experiment right there we didn't go any further.

MS: Uh-huh.

AP: And the reason for that was again, was the accumulation of tolerances between the plenum and the shield, their sleeves, and one of those instruments position we put this thing in; there was a radial … there was a plus or minus tolerance railing going up on these big huge things so they had a little shift and you could stick that probe in and that's what happened, it got caught in the top thermo shield, it was okay in the plenum.

MS: Yeah, uh-huh.

AP: It got caught there and you had stainless steel on the stainless steel and that is, you know, bad if you've got any close tolerances. So out it came. But at any rate, that work is all published too.

MS: You wouldn't have the name of that would you?

AP: No, I can't remember the name of it or how we characterized that thing but I'm pretty sure that work was published; it wouldn't have been in here. That might … I can't remember whether we mentioned that or not in that book. But Dave Muhlbaier would remember.

MS: Okay.

MS: He may have mentioned that …

AP: Wait a minute! Wait a minute, it's not Dave … Dave was not the man.

MS: Oh, okay.

AP: Another one you should contact.

MS: Okay.

AP: It's hard for me to remember all of these folks from back that far; Elwin Wingo.

MS: Oh, I've got the …

AP: Elwin Wingo did the basic work on that.

MS: Okay, okay, I'm going to talk to him. I've got to call him after Christmas because this wasn't a good time and he wanted to do it after Christmas.

AP: I know Elwin's still alive; at least I saw him a year or so ago.

MS: Yeah, I talked to him last week, that same day that I called you I told him about it.

AP: Bill Durant, both of them live in North Augusta.

MS: Uhhhh, okay, okay. Bill Durant and Vascoe Watley, I haven't contacted them so I'll try to reach them …

AP: There's an interesting fellow, when you get around … you going to do TNX?

MS: Yeah, uh-huh, right. I've got Claude Goodlett for TNX and Art Osbourne.

AP: I didn't know that Art was at TNX, he might have been, I can't remember. Who else do you have?

MS: That's it for TNX. So is there anybody else that you can …?

AP: You should talk to Bill Mottel.

MS: Bill?

AP: Mottel, M-O-T-T-E-L. Gives you a nice trip down to Hilton Head.

Bill Mottel and I were colleagues at the same time at TNX and CMX. Now he was transferred from TNX into Separations Technology before I moved …

MS: Oh okay.

AP: … from CMX. Ultimately, Bill Mottel became Plant Manager and I was his Assistant Plant Manager so here you had … back in those early days they tried to match separations and reactor people into management level.

MS: Oh, okay, all right.

AP: Bill was Plant Manager when I was Assistant Plant Manager and I was transferred to Texas.

MS: Oh, okay.

AP: So that would have been seventy-eight ('78) 1978. I actually transferred at the end of seventy-seven ('77) and came back in January of seventy-nine ('79). But Bill Mottel was in that early TNX work. I'm pretty sure Bill was there when they had an explosion at TNX and I can't remember the particulars about that.

MS: Hmmm, oh, okay.

AP: Most of his technical experience, or engineering experience in the technology part of Separations in the plant was in tritium complex.

MS: Oh, okay.

AP: And to give you another example. My next assignment out of reactor technology was Superintendent of PU reactor and that was one of the most satisfying assignments I ever had from a people standpoint.

MS: Uh-huh, okay.

AP: Then from there I was a Chief Supervisor reporting directly to Bill Mottel who was a General Superintendent of Separations. I was in a Separations project team heading on a mission I can't even tell you about today.

MS: Hmmm.

MS: Hmmm. Well that's interesting.

AP: That one never flew.

MS: Yeah, uh-hum.

AP: Never flew and Bob Mahr replaced me in that assignment and ultimately Bob Mahr worked for me and he replaced me as Manager of Operations in the plant, now Bob's dead now but he was a great guy.

MS: Uh-huh, all right, okay.

MS: Great, great.

AP: That shows you how one way you can be reporting to a guy and then subsequently he can be reporting to you. It just depends upon the timing of retirements and things like that.

MS: Right yeah.

MS: I guess it's kind of the way Du Pont ran the place they kind of put people in management …

AP: Well, the people that they wanted in management, they moved and that was … I tell people I never had a slack day or slow day in my entire life with Du Pont at that plant.

MS: Uh-huh.

AP: And part of that's true because I had so many different assignments throughout the whole plant, and commercial experience was extremely rewarding because I got to see the project management system at Victoria, the Victoria Texas Plant.