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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
08/05/2005	00	New technical basis document for the Pinellas Plant – Site Description. Incorporates formal internal and NIOSH review comments. First approved issue. Initiated by Marquis P. Orr.
10/04/2006	01	Approved Revision 01 to make changes according to the public outreach meetings of 09/2004 and 11/2005 and claimant communications. Added required language from NIOSH in the Introduction. Incorporates internal formal review comments, including adding the pilot plant information at the end of section 2.2. Added a Purpose and Scope, Sections 2.1.1 and 2.1.2. Incorporates NIOSH formal review comments. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Paul J. Demopoulos.
04/01/2011	02	Revised predominantly to address SC&A comments on the document, as identified in SCA-TR-TASK1-0015. Incorporates a large amount of newly captured information. Incorporates formal internal and NIOSH review comments. Constitutes a total rewrite of the document. Training required: As determined by the Objective Manager. Initiated by Brian P. Gleckler.

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
CFR	Code of Federal Regulations
Ci	curie
cm	centimeter
CPE	Ceramic Product Engineering
d	deuteron
D	deuterium (^{2}H)
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ERDA	U.S. Energy Research and Development Administration
ft	foot
g	gram
GE	General Electric Company
GEND	GE Neutron Devices (a.k.a. the Pinellas Plant)
GENDD	GE Neutron Devices Department (a.k.a. the Pinellas Plant)
GEPP	GE Pinellas Plant
GEXF	GE X-Ray Division in Florida (a.k.a. the Pinellas Plant)
GEXM	GE X-Ray Division in Milwaukee, Wisconsin
H	hydrogen (^{1}H or protium)
HEPA	high-efficiency particulate air
hr	hour
in.	inch
keV	kilo-electron volt
LANL	Los Alamos National Laboratories
LMSC	Lockheed-Martin Specialty Components
m	meter
M&O	Managing and Operating
MeV	mega-electron volt
min	minute
MMSC	Martin Marietta Specialty Components
mrem	millirem
MT	metal tritide
mW	milliwatt
nCi	nanocurie
NIOSH	National Institute for Occupational Safety and Health

NTTL	neutron tube target loading
oz	ounce
PAO	Pinellas Area Office
PCIC	Pinellas County Industrial Council
POC	probability of causation
RMMA	radioactive material management area
RTG	radioisotopically-powered thermoelectric generator
s	second
SECS	stack effluent control system
SEM	scanning electron microscope
SNL	Sandia National Laboratory
SRS	Savannah River Site
T	tritium (^3H)
TRS	Tritium Recovery System
U.S.C.	United States Code
XRD	X-Ray Diffraction
XRE	X-Ray Emission
yr	year
µCi	microcurie
§	section or sections

2.0 SITE DESCRIPTION

2.1 INTRODUCTION

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as "any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)" [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled "Exposure in the Performance of Duty." That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer "shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation[1]] guidelines established under subsection (c) …" [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation, 42 C.F.R. Pt. 82) define "performance of duty" for DOE employees with a covered cancer or restrict the "duty" to nuclear weapons work (NIOSH 2010).

The statute also includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition excludes Naval Nuclear Propulsion Facilities from being covered under the Act, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally-derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external occupational radiation exposures are considered valid for inclusion in a dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived (NIOSH 2010):

- Background radiation, including radiation from naturally occurring radon present in conventional structures
- Radiation from X-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons.

[1] The U.S. Department of Labor (DOL) is ultimately responsible under the EEOICPA for determining the POC.

2.1.1 Purpose

This TBD represents a specific support mechanism concerning documentation of facilities and processes that manufactured neutron generators and other components for nuclear weapons. The manufacture of neutron generators required equipment, facilities, and expertise that could be applied to a variety of specialty components.

2.1.2 Scope

The Pinellas Plant Site Profile provides supporting technical data to evaluate the total Pinellas occupational radiation dose that can reasonably be associated with the worker's radiation exposure. This dose results from exposure to external and internal radiation sources in Pinellas facilities.

This site description provides general information on where some of the processes occurred and some details of the processes. This might include when the processes occurred and details of the devices produced. For example, neutron generators are described as consisting of a miniaturized linear ion accelerator assembled with pulsed electric power supplies. The ion accelerator, or neutron tube, required ultra-clean, high-vacuum technology; hermetic seals between glass, ceramic, glass-ceramic, and metal materials; and high-voltage generation and measurement technology. The Pinellas Plant manufactured only neutron generators for its first 10 years of operations.

2.2 SITE LOCATION

The Pinellas Plant is in central Pinellas County, Florida, on 99.9 acres in Section 13, Township 30S, Range 15E, of the Tallahassee Meridian (Figure 2-1). Pinellas County is in the west-central part of peninsular Florida. It is bounded on the north by Pasco County, on the east by Hillsborough County and Tampa Bay, and on the west and south by the Gulf of Mexico.

The site is bordered on the east by Belcher Road (Pinellas County Road 27), on the south by Bryan Dairy Road (Pinellas County Road 135), and on the west by a spur of the Seaboard Coastline Railroad. The area is surrounded by light industry and warehouse operations. The closest residential area is approximately 400 m (1,300 ft) from the Plant.

The area around the Pinellas Plant is characterized as urban land consisting of high-density residential developments, commercial buildings, streets, highways, parking lots, and other types of development (Lewis et al. 2004, p. 8). Figure 2-2 is an aerial photograph from 1992 that shows the proximity of residential and commercial development to the Pinellas site.

2.3 BACKGROUND AND HISTORY

The Pinellas Plant (Figures 2-2 and 2-3) has been known by several names throughout its history. Those names include: 908 Plant, Pinellas Peninsula Plant, GE X-ray Division-Florida (GEXF), GE Neutron Devices Department (GENDD), GE Neutron Devices (GEND), GE Pinellas Plant (GEPP), and the Pinellas Plant. The initial mission of the Plant was the manufacture of neutron generators and other components of nuclear weapons. Throughout their history, neutron generators have been referred to as external initiators, 908 products, portable radiographic instruments, Zippers, and nuclear weapons triggers. The manufacture of neutron generators required equipment, facilities, and expertise that could be applied to a variety of specialty components. As a consequence, DOE expanded the Plant mission to produce multiple electronic and support components for other DOE programs. These components included: neutron detectors, specialty capacitors, thermal batteries, electromagnetic devices, vacuum switch tubes, Lithium AMBient (LAMB) batteries, frequency control

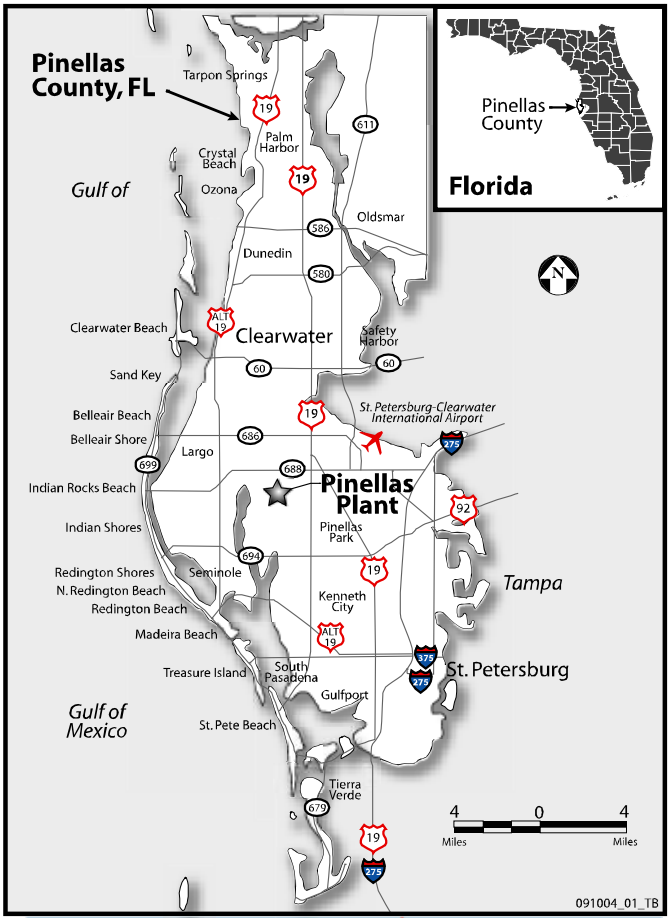

Figure 2-1. Location of Pinellas Plant in Pinellas County, Florida (FDOT 2005).

Figure 2-2. Aerial photograph of Pinellas Plant (FAS 2004).

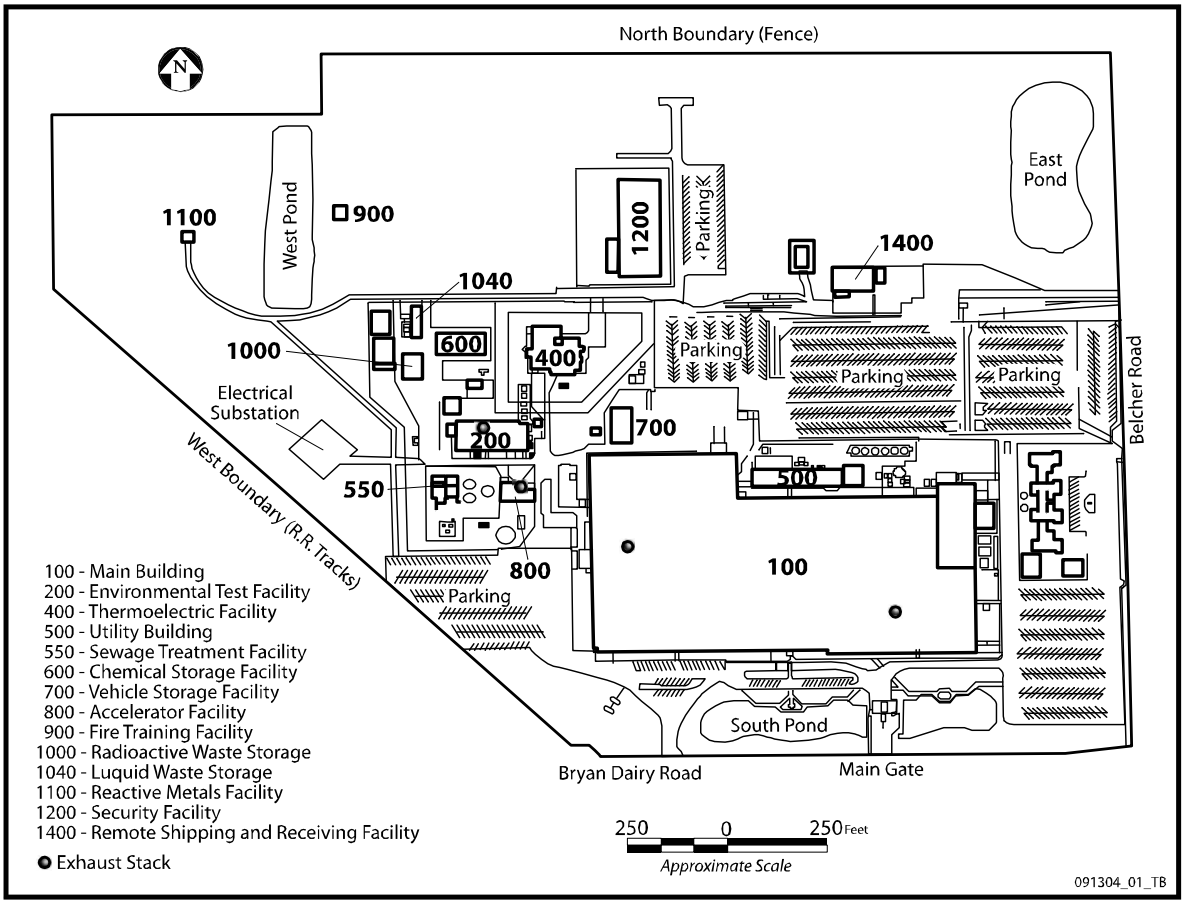

Figure 2-3. Site map (DOE 2002).

devices, resonant accelerometers, lightning arrestor connectors, foam support pads, product testers, alumina ceramics, alumina ceramic feedthroughs, ferroelectric ceramics, glass ceramics, optoelectronics, shock transducers, and radioisotopically-powered thermoelectric generators (RTGs) (GE 1990).

The Pinellas Plant (Figure 2-3) eventually had approximately 755,584 ft^2 of interior space on the 99.9-acre site. The Plant was constructed in 1956 by the General Electric Company (GE) for the development and production of nuclear generators for the nation's nuclear weapons programs. The U.S. Atomic Energy Commission (AEC) [predecessor of the U.S. Energy Research and Development Administration (ERDA) and DOE] purchased the Plant from GE in 1957, and contracted GE to operate it from its startup in 1957 until May 31, 1992. In June 1992, Martin Marietta Specialty Components, Inc. (MMSC) (later renamed Lockheed-Martin Specialty Components, Inc.) took over operation of the facility and served as the Managing and Operating (M&O) Contractor (FDHRS 1994, p. 1). As part of the strategy to promote commercial uses of the site, DOE sold the Pinellas Plant to the Pinellas County Industrial Council (PCIC) in 1995 (DOE 1995).

DOE has an ongoing environmental restoration program for a 20-acre plot in the northeast corner of the site and another 4.5-acre area near the northwest corner of the site. Both areas have groundwater contamination caused by previous storage and disposal of drummed waste and construction debris that contained solvents and volatile organic compounds. Remediation of these sites is being addressed under a Resource Conservation and Recovery Act permit that includes corrective action requirements and cleanup under Florida State Superfund statutes (DOE 1998, p. 1).

2.3.1 Origin of the Pinellas Plant and Relationship with GEXM

The Pinellas Plant was the progeny of the GE X-Ray Division's 908 Product Section in Milwaukee, Wisconsin. The X-Ray Division was originally located in Milwaukee, Wisconsin, and was also known as the GE X-Ray Department and GE X-Ray Division-Milwaukee (GEXM). In December 1952, Sandia National Laboratories (SNL) and Los Alamos National Laboratory (LANL) personnel agreed that the design and development of a new type of nuclear weapons external initiator would be assigned to GEXM. On July 16, 1954, the first unit of the new initiator design was delivered to SNL. These initiators were later referred to as neutron devices or neutron generators. GEXM work included the operation of a small pilot plant for the production of neutron generators. In December 1954, indications from SNL were that a release would be given to GEXM to proceed with the manufacturing of 50 neutron generators per month. GEXM estimated that 175,000 ft^2 of interior space would be needed in a new production facility to meet that requirement. Because there was no expansion acreage available at the GEXM site, it was necessary that the new plant be built at a remote location. On February 20, 1956, a letter of intent for production quantities came from SNL, which triggered accelerated activities for constructing the new production facility. In March 1956, it was decided to locate the new 908 Plant in Pinellas County, Florida. After reviewing several potential site locations in Pinellas County, the location on Bryan Dairy Road was selected and purchased in June 1956. On April 17, 1956, the H. K. Ferguson Company of Cleveland, Ohio, was awarded the contract to design and build the Pinellas Plant. On October 24, 1956, the contract order of intent for the Pinellas Plant was received with a new option for the AEC to buy the Pinellas Plant from GE within 30 days of the plant's completion (Persons 1977).

The GEXM relationship with the Pinellas Plant continued long after the Pinellas Plant became operational. GEXM continued to perform research and development work regarding the neutron generators and continued to assist with meeting the government's neutron generator production quotas through the continued operation of its pilot plant. The Pinellas Plant radiological control programs were originally based on the GEXM radiological control programs. However, once the Plant became operational, the available documents indicate that the GEXM radiological programs appear to have been managed by the Pinellas Plant (GE 1957–1973). In addition, the Pinellas Plant processed GEXM film dosimeters and performed tritium analyses on GEXM urine, water, oil, contamination smear, soil, and vegetation samples once it became operational (GE 1957–1973; Jech 1963).

During the years of 1956–1966, a number of GEXM employees transferred to the Pinellas Plant. Because the employment records received from GE typically do not identify which GE site that an employee worked at, the EEOICPA-covered employment for Pinellas Plant workers might include some GEXM employment at the beginning of their covered employment. When this has occurred, the amount of GEXM employment can typically be determined in the worker's dosimetry records. Because of the connection between the GEXM and Pinellas Plant dosimetry programs, the similarities between the activities performed at the sites, and the similarities between the doses received at these two sites, the GEXM dosimetry data can be assessed using the information provided in the Occupational External and Internal Dose TBDs for the Pinellas Plant (ORAUT 2011a,b).

On October 1, 1966, the 908 Product Section was reorganized into the Neutron Devices Department within GE's Nuclear Energy Division (Persons 1977). In 1966, all remaining neutron generator-related activities at the GEXM site were relocated to the Pinellas Plant, including a number of GEXM personnel.

2.3.2 Temporary Plant and Construction Era for Pinellas Plant

Because of the need for an interim manufacturing facility, a temporary plant was built near the intersection of 24th Street North and 26th Avenue North in St. Petersburg, Florida (DOE 1987; Forest 1974; Persons 1977). The temporary plant consisted of two concrete buildings that were leased by

GE. One was a 9,600-ft^2 building that was used mostly as a warehouse for equipment and tool storage, soldering training, quality control, shipping and receiving, and possibly maintenance. The other was a 20,000-ft^2 building that was used for offices and manufacturing (DOE 1987; Persons 1977). The H. K. Ferguson Company designed the internal arrangements for the 20,000-ft^2 building, which were completed in August 1956. The first neutron generator released to be built was the MC757. The manufacturing of this neutron generator began at the temporary plant on September 4, 1956. By early January 1957, there were 285 employees working at the temporary plant (Persons 1977).

The operations in the manufacturing section were similar to those now used in neutron generator production at the Pinellas Plant, except they were on a smaller scale. Tritium was first received at the temporary plant on December 12, 1956 (DOE 1987). Operations using tritium were performed in a 350–ft^2 hood room (Forest 1974).

On May 19, 1957, operations at the temporary plant were concluded (DOE 1987; Persons 1977). When operations at the temporary plant were terminated, the hoods were transferred to the Pinellas Plant for continued use; the liquid waste and the exhaust ventilation systems were disassembled, packaged, and shipped to the Savannah River Site (SRS) for burial; and the hood room was decontaminated to the minimum detectable radioactivity level of 50 dpm/100 cm^2 as measured by surface swipes (Forest 1974). In addition to the hood room, surveys were performed throughout the entire building (DOE 1987; Forest 1974). These surveys revealed no detectable contamination (Forest 1974). At the conclusion of the decontamination efforts, the building was unconditionally released, and the Pinellas County Health Department certified that the dismantling and decommissioning of the building and equipment were done satisfactorily (DOE 1987; Forest 1974).

On June 14, 1956, ground was broken for the construction of the Pinellas Plant. The Plant was originally built and owned by GE. The initial size of the total interior space was approximately 161,000 ft^2. Occupancy of the Plant began on January 5, 1957. With the exception of the Tube Exhaust Area, the move into the newly constructed plant was completed by January 29, 1957. On May 29, 1957, the AEC exercised its option to buy the Pinellas Plant, and on June 28 ownership of the plant was transferred to the AEC (Persons 1977).

2.3.3 Main Operating Era (1957–September 1994)

The AEC and its successor agencies (ERDA and DOE) contracted with GE to operate the Pinellas Plant from its startup in 1957 until May 31, 1992. In February 1958, the AEC established its Pinellas Area Office (PAO) (Persons 1977). On January 15, 1973, the PAO received formal notification of the assignment of production responsibility for the RTG to the Pinellas Plant (Kuntz 1973). In November 1975, Plant operations were expanded to include the production of RTGs (Author unknown undated a). In 1990, the RTG product line was discontinued (MMSC 1992). All plutonium, with the exception of calorimeter sources and very small instrument calibration check sources, was removed from the Plant in February 1991 (MMSC 1992).

On June 16, 1992, President Bush of the United States and President Yeltsin of Russia signed an arms agreement that significantly reduced nuclear weapons stockpiles and the corresponding production operations that supported them. To meet those challenges, the Secretary of Energy, James Watkins, reconfigured and consolidated the nuclear weapons complex into *Complex 21* (DOE 1993). In December 1991, Secretary Watkins identified the plants slated for closure and the preferred sites to which production activities would be transferred (Pope 2007). The Pinellas Plant was one of the plants slated for closure. After that, GE announced that it would no longer continue as the prime contractor for the Plant (YRSC 2010).

In June 1992, Martin Marietta Specialty Components, Inc. (MMSC) took over operation of the Pinellas Plant and served as the M&O Contractor. In November 1993, DOE initiated the phase-out of the production activities at the Plant, and the transition of the Plant from the DOE Office of Defense Programs to the Office of Environmental Management with the eventual goal of releasing the site for commercial use (DOE 1995). In 1994, Lockheed merged with Martin Marietta and the M&O Contractor was renamed Lockheed-Martin Specialty Components (LMSC).

On August 15, 1994, the Assistant Secretary of Energy for Environment, Safety and Health issued a Finding of No Significant Impact for the proposed action to allow mixed-use commercialization of the Pinellas Plant. The proposed action also allowed for limited cleanup activities in association with preparing the site for commercial uses (DOE 1995).

2.3.4 Decontamination and Decommissioning Era (October 1994–1997)

The Pinellas Plant completed its war reserve fabrication of neutron generators at the end of September 1994 and began the transition from a defense mission to an environmental management mission (Pope 2007; DOE 2010). Disconnection of the equipment at the Plant began in October 1994 and was completed by the end of September 1995. When the last war reserve product crossed a piece of equipment, the equipment was calibrated (when required), disconnected, packaged for shipment, and shipped to SNL (Pope 2007).

The new mission for the Pinellas Plant was to clean up the plant from the past AEC/ERDA/DOE mission and transition the plant to commercial uses (LMSC 1996). As part of the strategy to promote commercial uses of the site, the DOE sold the Pinellas Plant to the Pinellas County Industrial Council (PCIC) on March 17, 1995 (DOE 1995). The sales contract and related lease, which provides for continued DOE occupancy at the site, included clauses to ensure continued compliance with Federal, State of Florida, and local regulations and cleanup of the site (DOE 1995).

The first Pinellas Plant employees were transferred to the SNL in July 1994 to meet specific needs at the SNL. A few more employees were transferred over the next few months. The majority of the Pinellas Plant employees transferred to the SNL in September and October 1995. The last Pinellas Plant employees transferred to the SNL in December 1995. Approximately 83 individuals were transferred from the Pinellas Plant to the SNL. Those individuals were mostly managers, technical staff, and technicians. No floor operators were transferred to the SNL (Pope 2007).

With the cessation of operations in 1994, the remaining major sources of external radiation (neutron generators, ^{85}Kr leak detection systems, other radiation-generating devices) were removed. As indicated above, RTG plutonium sources, which were one of the other major sources of external radiation at the Pinellas Plant, were removed in February 1991. Table 2 of the 1995 ALARA report for the Plant confirms this, because a noticeable drop in the average and highest annual external doses to the workers occurred after the RTG plutonium sources were removed from the site (Weaver 1996).

In addition, there is no indication that any significant changes were made to Pinellas Plant radiological control practices as the Plant transitioned into its decontamination and decommissioning (D&D) era. Given that and given that LMSC remained the prime contractor through 1997, the radiological program documents that were in place during the pre-D&D era can be assumed to be applicable to the entire D&D era, which ended in 1997.

2.4 RADIATION SOURCES

Radiation sources at the Pinellas Plant included a variety of radioactive materials and radiation-generating devices. The following subsections identify the major sources of radioactivity and radiation at the Plant.

2.4.1 Radioactive Materials

Radionuclides were used at the Pinellas Plant for the following purposes:

1. To be made part of a product, such as tritium in neutron generators, plutonium in RTGs, and uranium in certain borosilicate glass products;

2. Leak-testing certain products, as in the site's use of ^{85}Kr;

3. Tritium storage, as in the site's use of depleted uranium in sealed containers;

4. Instrument and dosimeter calibrations and checks; and

5. Analytical standards for laboratory analyses, as in plutonium and tritium analyses of urine samples.

With the exceptions of radionuclides used as analytical standards, tritium (^{3}H), ^{14}C, and ^{85}Kr were the only dispersible radionuclides normally encountered at the Pinellas Plant. All other radionuclides at the Plant were in nondispersible forms (plated sources, containerized sources, encapsulated sources, solid metal sources, etc.). Tritium, ^{85}Kr, plutonium, and uranium were the radionuclides encountered by the most workers. The remaining radionuclides were predominantly calibration and check sources that were used by the relatively small number of workers who were involved with calibrating dosimeters, response-checking instruments, and calibrating instruments (MMSC 1995; Author unknown undated b; Weaver 1995a).

For the purposes of this TBD, a containerized source is a radionuclide in any form (liquid, gas, or solid) that is normally kept sealed in a container that would only be unsealed in an accident situation. The most common examples of containerized sources at the Pinellas Plant were liquid scintillation calibration sources and the depleted uranium metal powder contained in the tritium storage beds.

The following subsections describe the forms and uses of the predominant radionuclides that were encountered at the Pinellas Plant.

2.4.1.1 Tritium

Tritium (also denoted as T, H-3, and ^{3}H) is a hydrogen atom with two neutrons. It is the heaviest of the three isotopes of hydrogen [protium (^{1}H), deuterium (^{2}H), and tritium (^{3}H)] and is the only radioactive hydrogen isotope. Tritium is a low-energy, beta-emitting radionuclide with a half-life of 12.28 years. The average and maximum beta particle energies are 5.7 keV and 18.6 keV, respectively (Kocher 1981). Between 1957 and 1993, annual tritium inventories at the Pinellas Plant ranged from 5.44 g (5.24×10^{4} Ci) to 53.27 g (5.14×10^{5} Ci) (Biedermann 1994). Tritium is not considered to be an external radiation hazard, because the beta particles being emitted have too low of an energy to penetrate human skin. However, inside the body its radiation can cause damage to tissues and organs.

Four primary forms of tritium were present at the Pinellas Plant – tritiated water (HTO), tritium gas (HT or T_2), organically bound tritium (OBT), and metal tritides (MTs). One of the most common forms of organically bound tritium at the Plant was contaminated pump oils. The MTs (primarily scandium tritide, erbium tritide, and titanium tritide) formed during production processes could have been released in the work environment as particulate aerosols. The gas was allowed to react with metal surfaces, thin metal coatings, and metal powders for various purposes. Powders were normally contained with vacuum systems, and metal systems normally remain intact (Burkhart 1995, p. 2).

2.4.1.2 Plutonium

In terms of radioactive decay, ^{238}Pu and ^{239}Pu are alpha and X-ray-emitting radionuclides with half-lives of 87.75 years and 24,131 years, respectively (Kocher 1981). The alpha particle emissions from these two radionuclides are the primary concerns for internal dose. The photon (gamma ray and X-ray) and neutron radiation emitted from the sources containing plutonium are the primary concerns for external dose. Gamma rays and neutrons are predominately emitted from the spontaneous fissions of plutonium, alpha-neutron reactions, and photon-neutron reactions.

The first plutonium at the Pinellas Plant was a 7-g ^{239}Pu source that was received in January 1957. The source was used for calibrating health physics monitoring equipment. Based on the available information on this source and its use, it was most likely an encapsulated plutonium-beryllium (Pu-Be) neutron source. The triply encapsulated plutonium oxide ($^{238}PuO_2$) heat sources used for RTGs did not start arriving at the Plant until November 1975 (Author unknown undated b). There were two different types of $^{238}PuO_2$ heat sources, 8.75-g sources and 10-g sources (DOE 1982). With the exception of 1975, no information was found on the annual inventories of $^{238}PuO_2$ heat sources. In November 1975, the site received seven $^{238}PuO_2$ heat sources (Author unknown undated b). All plutonium, with the exception of calorimeter sources and very small instrument calibration check sources, was removed from the Plant in February 1991 (MMSC 1992).

2.4.1.3 Krypton-85

Krypton-85 is a noble gas and a beta-emitting radionuclide with a half-life of 10.72 years. The average and maximum beta particle energies are 251.4 keV and 687.0 keV, respectively. Krypton-85 emits a 513-keV gamma ray for less than 1% of its decays (Kocher 1981).

Relatively small quantities of ^{85}Kr were used in two leak detection systems (Radiflo® and TracerFlo systems) that were used at the Pinellas Plant from September 1963 until 1996 (Burkhart 1990; LMSC 1997a; MMSC 1993a). These systems were housed in separate rooms in Area 109 and surrounded by ventilation shrouds (DOE 1983, 1987). Each shroud was connected to ductwork that exhausted 3,300 ft^3/min to the east main exhaust stack (DOE 1983). During 1996, this leak detection equipment was decontaminated and relocated, along with unused storage containers of ^{85}Kr gas, to Building 800 (LMSC 1997a). By the end of 1996, all the Radiflo® and TracerFlo leak detection equipment and unused cylinders of ^{85}Kr gas were shipped back to their manufacturers (LMSC 1997a).

2.4.1.4 Uranium

Depleted and natural uranium, which consist of ^{234}U, ^{235}U, ^{238}U and some of the radioactive progeny for these radionuclides, were present at the Pinellas Plant. In terms of radioactive decay, the uranium isotopes emit alpha particles and X-rays. However, some of the radioactive progeny emit beta particles and gamma rays.

The major use of depleted uranium was for the tritium storage beds that were first used in 1968 (Phillips 1975). Depleted uranium metal was used for the particulate uranium metal tritide in the tritium storage beds (Ward 1973). Because the uranium in the tritium storage beds was sealed in stainless-steel canisters, it was a containerized source and would have posed little to no internal dose hazard. There was no indication that the uranium ever leaked from the storage beds at the Pinellas Plant. Given that particulate uranium metal is pyrophoric, any uranium metal leaking from the tritium storage beds would have ignited and resulted in a uranium fire incident. Of the reported incidents for the Plant, which are summarized in Table 2-4, none were uranium releases or uranium fire incidents. The depleted uranium (mainly ^{238}U) inside the tritium storage beds presented no significant external radiation hazard due to the low specific activity and the nonpenetrating radiation.

The major use of natural uranium was the use of borosilicate glass that was doped with natural uranium (1.5% by weight) in the form of U_3O_8 (Weaver 1992). Because the uranium would have been encapsulated in the glass prior to its arrival at the Pinellas Plant, the glass was considered to be a sealed source and would have posed little to no internal dose hazard.

2.4.1.5 Nickel-63

Nickel-63 is a low-energy, beta-emitting radionuclide with a half-life of 100.1 years. The average and maximum beta particle energies are 17.13 keV and 65.87 keV, respectively (Kocher 1981).

The information on the Pinellas Plant's use of ^{63}Ni includes documents from the GEXM site. Because many of the same nuclear weapons-related activities were performed at the Pinellas Plant and GEXM and because many items were obtained from the same vendors, use of ^{63}Ni and the form in which it was obtained were likely the same for both sites.

Nickel-63 was electroplated onto a nickel mesh inside a sealed glass tube (a *krytron*) by U.S. Radium, and averaged 0.3 µCi per spark gap (Weaver 1994a; Jech 1963). Krytrons are cold-cathode, gas-filled tubes intended for use as very-high-speed switches, which have been used for igniting exploding-bridge wire detonators and slapper detonators in nuclear weapons. The ^{63}Ni is used in conjunction with the keep-alive electrode, where the beta particles being emitted by the ^{63}Ni make the ionization inside the krytron easier. The available information indicates that the Pinellas Plant was not involved with the process of electroplating ^{63}Ni to the keep-alive electrodes for the spark gap bodies, and received only the spark gap bodies containing the electroplated ^{63}Ni from U.S. Radium. It is not known if the electrodes plated with ^{63}Ni were already sealed in the glass tubes before they arrived at the Plant or if the Plant was creating and sealing the electrodes in the glass tubes. Given that one of the Plant's areas of expertise was glass formulation, it was likely sealing the electroplated ^{63}Ni electrodes into the glass tubes to create the krytron.

2.4.1.6 Carbon-14

Carbon-14 is a low-energy, beta-emitting radionuclide with a half-life of 5,730 years. The average and maximum beta particle energies are 49.47 keV and 156.48 keV, respectively (Kocher 1981).

The use of ^{14}C at the Pinellas Plant is indicated only in the gaseous effluent release reports and an environmental assessment (DOE 1983; GE 1980, 1981, 1982a, 1983, 1984). The gaseous effluent release reports indicate that ^{14}C was used between 1979 and 1983 (GE 1980, 1981, 1982a, 1984). Based on the reported gaseous effluent releases for those years, ^{14}C was used in much smaller quantities than tritium. A comparison of the annual quantities of gaseous effluents released indicates that the curies of tritium being processed were over 100,000 times greater than the curies of ^{14}C being processed. A 1983 environmental assessment indicated that small quantities of ^{14}C labeled solvents were used in a laboratory testing operation (DOE 1983). No other documentation was found to indicate other uses of ^{14}C.

2.4.2 Radiation-Generating Devices

Radioactive materials were not the only source of ionizing radiation at the Pinellas Plant. Many pieces of equipment produced and used at the Plant were capable of generating radiation. Unlike radioactive materials, radiation-generating devices emit radiation only when they are connected to a power supply and are activated. When not in use, these devices did not emit radiation.

The most common type of radiation-generating device at the Pinellas Plant was its primary product, the neutron generator. Neutron generators are miniaturized linear ion accelerators (DOE 1987). A pulsed electric power supply accelerates deuterons (i.e., deuterium nuclei) into either a tritium or

deuterium target, depending on the type of neutron generator, to create a controlled source of neutrons (DOE 1987; NCRP 1983; Weaver 1994b). The neutrons are generated by either a $T(d,n)^4He$ or $D(d,n)^3He$ fusion reaction. Most units produced at the Pinellas Plant were the $T(d,n)^4He$ type that produced 14-MeV neutrons; however, a few were constructed to produce 2.5-MeV neutrons from the $D(d,n)^3He$ reaction (Weaver 1994b; NCRP 1983). The neutron generators also produce some X-rays by other interactions within the accelerator (NCRP 1983).

An ion accelerator, a Model 200 HP Ion Implanter that was manufactured by Accelerator Inc., was also used at the Pinellas Plant (Malbrough 1983). It was a Cockroft-Walton-type linear ion accelerator and was first installed in 1975 in Area 161 of Building 100 for use by the Chemistry Laboratory (GE 1977; Malbrough 1983). The accelerator was originally used for ion implantation work and eventually for target assessment work prior to being relocated (GE 1977; Malbrough 1983). In 1979, the accelerator was relocated to Building 800. After the accelerator's relocation, it was used for a larger variety of activities that included target assessment; material analysis; low-energy nuclear, solid-state, and atomic physics; and material science (Malbrough 1983). Personnel working with this accelerator were required to wear dosimeters that measured both photon and neutron doses (Weaver 1994b).

Table 2-1 summarizes the remaining types of radiation-generating devices that were used at the Pinellas Plant and their locations. In addition to the devices identified in Table 2-1, a diagnostic medical X-ray unit was used in the Plant's Medical Center. More information on that device can be found in the Pinellas Plant Occupational Medical Dose TBD (ORAUT 2006).

2.5 OVERVIEW OF MAJOR SITE OPERATIONS

The major operations described in this document primarily focus on the operations that potentially contributed to the Pinellas Plant workers' radiological exposures.

2.5.1 Neutron Generator Production

The Pinellas Plant manufactured precisely timed neutron generators, which were used to initiate nuclear explosions, as its primary product from 1957 until 1994. As older nuclear weapons, which used Po-Be initiators, were removed from the national stockpile, they were gradually replaced by nuclear weapons of newer designs that used accelerator-type neutron generators produced at the Pinellas Plant. In addition, neutron generator production at the Plant was used to replace decayed accelerator-type neutron generators in the nation's aging nuclear weapons stockpile because of the relatively short half-life of tritium.

Table 2-1. Other radiation-generating devices.[a]

Location	Quantity	Type	ID Number
107	2	X-Ray Emission (XRE) Units	CCN87103, CCN99591
114	2	Industrial X-Ray Units	MN87904, MN87851
114	1	Faxitron X-Ray Corporation	MN87243
114	1	TFI X-Ray Television	None found
127	1	Inspector Unit	None found
138	1	Electron Beam Welder	MN62183
161B	2	X-Ray Diffraction (XRD) Units	MN86640, MN86641
140/141	1	Electron Beam Welder[b]	140/141
161B	1	Micro XRD Unit	MN86747
161B	1	Electron Microprobe	MN86607
161B	1	Energy Dispersive Analyzer	MN86475A
162	2	Scanning Electron Microscope (SEM)	MN94109, MN94225
162	1	Transmission Electron Microscope	MN94168
163	1	X-Ray Thickness Gage	MN550042
164	1	Cabinet X-Ray Unit	CCN91407
175	1	XRD Unit	CN87952
176	1	XRE Unit	None found
192B	1	Sedigraph	MN94285
193N	1	SEM	MN91992
194E	1	Picker (Cabinet X-Ray Unit)	MN87042
300	2	Electron Beam Welder	MN61660, MN76803
300	1	Phillips (Cabinet X-Ray Unit)	MN87810
300	2	Faxitron X-Ray Corporation	MN088001, MN099915
400	2	Electron Beam Welder	MN61346, None found
400	1	Cabinet X-Ray Unit	MN63294
Warehouse	1	X-Ray Television	None found

a. Sources: Author unknown (undated c); GE (1986, p. 1).
b. Murray (2005).

Neutron generators are miniaturized linear ion accelerators (DOE 1987). A neutron generator consists of a neutron tube, power supply, and timer (March et al. 1999). There are two basic types of neutron generators, those with discrete electronic power supplies and those with ferroelectric ceramic power supplies (DOE 1987; March et al. 1999). In ferroelectric ceramic power supplies, the ferroelectric materials are activated by an explosive charge that destroys the structure of the material (DOE 1987). Neutron generator parts and assemblies were encapsulated with phenolic resins and/or foam to provide electrical or mechanical insulation (DOE 1998).

The main subassembly of a neutron generator is the neutron tube, which contains tritium and deuterium (DOE 1987). The neutron tubes themselves are capable of generating neutrons when activated. Initial design and development of the vacuum tubes used in neutron generators occurred in Areas 181 and 182 of Building 100. Normal production of the neutron tubes took place in Areas 107, 108, 109, and 126.

The neutron tubes are a glass, metal, and ceramic construction with glass-to-metal and metal-to-ceramic seals (DOE 1987). Neutron generator tube production involves loading various metal films with deuterium and tritium under vacuum conditions to form metal hydrides (Burkhart 1990). When the metal hydrides were used for capturing tritium gas or tritium gas storage, they are referred to as *metal tritides* (MT). Each neutron tube contains an MT target and a deuterium gas reservoir in the form of a metal hydride.

Neutron tube target loading (NTTL) was an operation that involved the loading of tritium gas onto metal target disks. At the Pinellas Plant the processes used to perform the NTTL changed over the years. The significance between the earlier and later processes is that the early NTTL process

involved the entire neutron tube and the processing systems included a significant number of glass components. The later NTTL process involved only the targets, which were installed in the neutron tubes after they were loaded, and the processing systems were an all-metal construction. The following subsections describe the processes for two different eras. Information indicates that portions of these processing systems transitioned from a glass to a stainless-steel construction during the period of 1965–1968 (GE 1979, Phillips 1975). The available information does provide a more precise date on the hydride storage beds, which were a key part of those processing systems. In 1968, the Plant transitioned from using titanium hydride encased in glass to depleted uranium hydride encased in stainless-steel for the hydride storage beds (Phillips 1975).

2.5.1.1 Early Neutron Tube Loading

The early neutron tube loading systems included a significant number of glass components that were subject to breakage. Because glass breakage was a frequent occurrence with these systems, the systems were eventually replaced with all-metal systems (Burkhart 1990). From 1957 through 1967, glass tritide storage beds that utilized titanium metal were used. These storage beds were glass cylinders that contained an extremely fine titanium metal powder (similar to talc). On occasion, breakage of a glass tritide storage bed would cause high levels of floor contamination due to the high specific activity of the titanium tritide that existed as an extremely fine powder (Burkhart 1990). This was the primary reason for the replacement of the glass tritide storage beds in 1968.

Elemental target material (typically erbium, scandium, or titanium) was deposited as a vapor onto a ceramic or metal target substrate (DOE 1987; LMSC 1995), after which the targets were loaded in the neutron tubes. The nearly completed neutron tubes were then attached to a glass manifold vacuum system under an exhaust hood. The normal arrangement had two neutron tubes on each system and four systems under each hood. There were 20 hoods in Area 108, but not all were used all the time (Burkhart 1990).

As shown in Figure 2-4, the system contained two vacuum pumps and a quartz glass manifold to which deuterium and tritium bearing hydride storage beds and the neutron tubes were attached. A roughing vacuum pump was used for the initial system evacuation. A mercury diffusion pump reduced system pressure to a near-perfect vacuum as measured on a mercury U-tube manometer. Once the system reached vacuum, valves isolated the manifold and the tritium or deuterium bearing hydride storage bed was heated to flood the system with tritium or deuterium gas. After the required exposure time, the storage beds were allowed to cool, which caused the hydrogen gas to be reabsorbed (Burkhart 1990, p. 1).

When the manometer showed zero system pressure, the operator would use a mobile pulse tank to test the functionality of the neutron tubes still attached to the manifold. The pulse tank would cause the neutron tube to fire a brief burst of neutrons. This in-place testing of the freshly loaded neutron tubes was discontinued in April 1966. Tubes that functioned correctly were removed using a torch to melt the glass manifold connection, seal the neutron tubes, and cut them free of the manifold (Burkhart 1990).

After manufacture, the neutron tubes were leak-tested. Initial leak-testing used helium or Freon for leak detection. In 1963, the nonradioactive leak-testing units were changed to leak detection systems that used ^{85}Kr gas (Radiflo® and TracerFlo systems) (Burkhart 1990; DOE 1983; MMSC 1993a).

Tritium releases to the environment occurred during removal of neutron-generating tubes and the maintenance of the system. Vacuum pump seal oil would become contaminated with tritium gas, tritium oxide, and mercury vapors. The interior of the glass manifold would become coated with grease containing tritium and deuterium. The pumps and valves were removed periodically to a separate hood area to be cleaned and repaired while the glass manifold was cleaned with solvents to

remove accumulated greases. In addition, components in the glass systems occasionally exploded or imploded, causing gas release, loss of contamination control, and personnel exposure (Burkhart 1990).

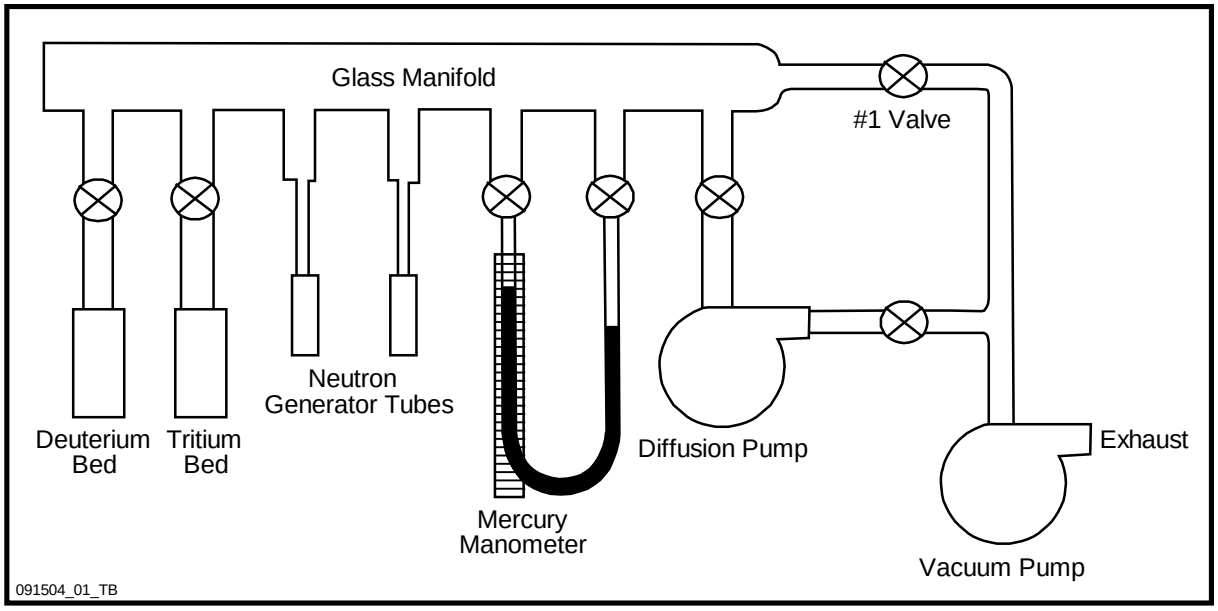

Figure 2-4. Early neutron tube tritium loading manifold (Burkhart 1990).

2.5.1.2 Later Neutron Tube Loading

The later neutron tube loading systems were metal systems that minimized accidental tritium releases. The general design of the metal systems was similar to that of the glass systems. In addition, the glass encased titanium hydride storage beds were replaced with stainless-steel encased depleted uranium hydride storage beds in 1968 (Phillips 1975).

Target manufacturing involved depositing elemental target material (typically erbium, scandium, or titanium) as a vapor onto a metal target substrate (DOE 1987; LMSC 1995; March et al. 1999). This was achieved by heating the elemental target material in a vacuum to the point of elevated vapor pressure. At such elevated temperatures in a vacuum, the metal evaporates and then condenses on any cooler surface in the line of sight, including the substrates to be coated (March et al. 1999).

Neutron tube target loading was an operation that involved the loading of tritium gas onto metal target disks (hydriding) under an inert nitrogen atmosphere using a glovebox. In the later process, the targets were hydrided prior to being installed in the neutron tubes. After the targets were hydrided, they were assembled into neutron tubes. Quality evaluations would include the destructive testing of a limited number of neutron tube targets. The targets would be destructively tested by heating them to measure the amount of tritium released from the surface of the target disk (MMSC 1994).

After manufacture, the neutron tubes were leak-tested using leak detection systems that used radioactive ^{85}Kr gas (Radiflo® and TracerFlo systems) (DOE 1983; MMSC 1993a). Functional testing of the completed neutron tubes was performed in Area 128 (LMSC 1997b).

After a uranium hydride storage bed was determined to no longer be useful as a process bed, it was stabilized by converting the pyrophoric uranium metal powder to a more stable uranium oxide before proper disposal. To do this, the uranium hydride storage bed was installed on the uranium bed oxidation system in Room 21 of Area 108C. The hydrogen isotopes were evolved from the hydride storage bed by heating it and absorbed by another hydride storage bed that was at room temperature.

After all the hydrogen was released and the hydride storage bed had returned to room temperature, oxygen was added to the bed by a batch process. This process continued until there was no more oxygen uptake by the uranium in the hydride storage bed. The oxidized uranium hydride storage bed was then leak-tested and removed from the uranium bed oxidation system for disposal (MMSC 1994).

Improved management control of the hydride process and replacement of the mercury manometer with vacuum gauges in 1959 and 1960 significantly reduced the amount of tritium released to the environment. Additional reduction resulted after installation of the Stack Effluent Control System (SECS), which used heated copper wire in the exhaust stream to convert tritium gas to tritium oxide. Chillers and demisters condensed and collected the vapor, and that liquid was routed to underground tanks for dilution and discharge (Burkhart 1990).

The neutron tube assembly area was exhausted through a ventilation system that vented a total of 802.5 m^3/s (28,340 ft^3/min) from two exhaust stacks in the building roof. An exhaust stack alarm was activated when the discharge exceeded 60 µCi/m^3 for more than 2 minutes (Ward 1973).

2.5.1.3 Neutron Generator Testing

Neutron generator testing involves experimental testing and production-lot sample testing of explosive neutron generators (i.e., ferroelectric neutron generators) and 100% functional testing of electronic neutron generators. Explosive neutron generators are one-use items that are tested in a protective enclosure, and testing results in the generation of classified mixed waste. Electronic neutron generators are reusable and typically do not generate waste when tested (March et al. 1999). Final testing of the neutron generators for production purposes was performed in Area 131 (LMSC 1997b). Neutron generator testing for laboratory support and development took place in a number of areas in the western portion of Building 100 (GE 1978).

2.5.2 RTG Production

RTG production took place in Building 400 at the Pinellas Plant from late 1975 though 1990 (DOE 1982; Author unknown undated b; MMSC 1992). The facility was able to produce approximately 50 units per month and production rarely exceeded 500 units per year (Author unknown 1988b, p. 4). Outside the source inspection hood (i.e., where the receipt inspections of the plutonium sources were performed), no plutonium contamination was ever found in the facility or the environment at the Plant. No releases of plutonium from Plant operations have been detected in the environment (GE 1982b; 1991a; Author unknown undated a).

RTGs are used to provide a long-life source of relatively low-energy electric power (approximately 25 mW at 2 volts for more than 25 years). An RTG consisted of a sealed heat source containing a small amount of $^{238}PuO_2$ (manufactured at another site) and a thermopile (manufactured at the Pinellas Plant) that was enclosed in thermal insulation and packaged in a welded steel case. Figure 2-5 shows a cut-away view of an RTG unit (GE 1982b).

Two different heat sources were used in the RTG units. One contained 8.75 g of plutonium dioxide and the other contained 10 g. The configuration of both types of heat sources is the same; both were triple encapsulated. Figure 2-6 shows an exploded view of a plutonium heat source. The outer layer was a nickel alloy and the two inner layers were a tantalum alloy. The plutonium was predominately composed of ^{238}Pu with significantly smaller percentages of other plutonium isotopes, decay products, and radioactive impurities (GE 1982b).

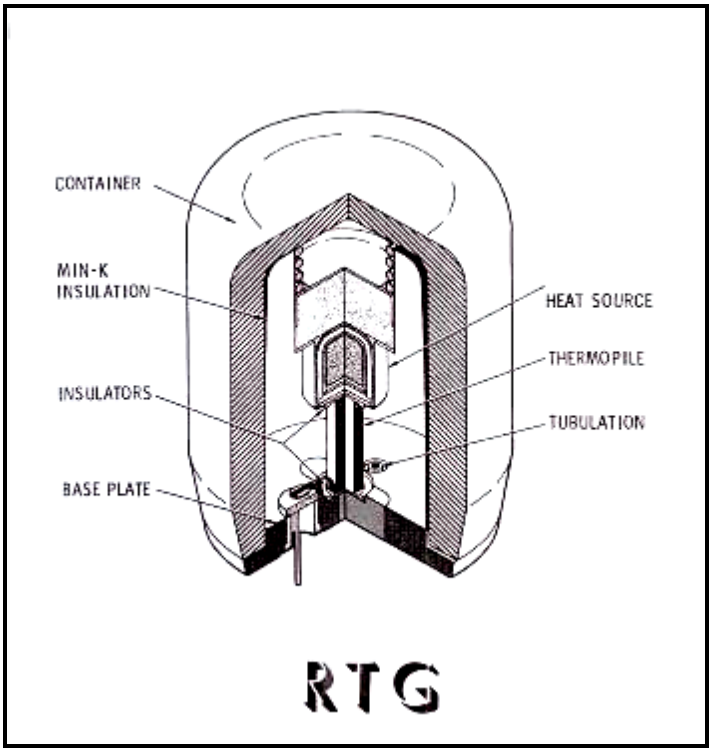

Figure 2-5. Cut-away illustration of an RTG unit (GE 1982b).

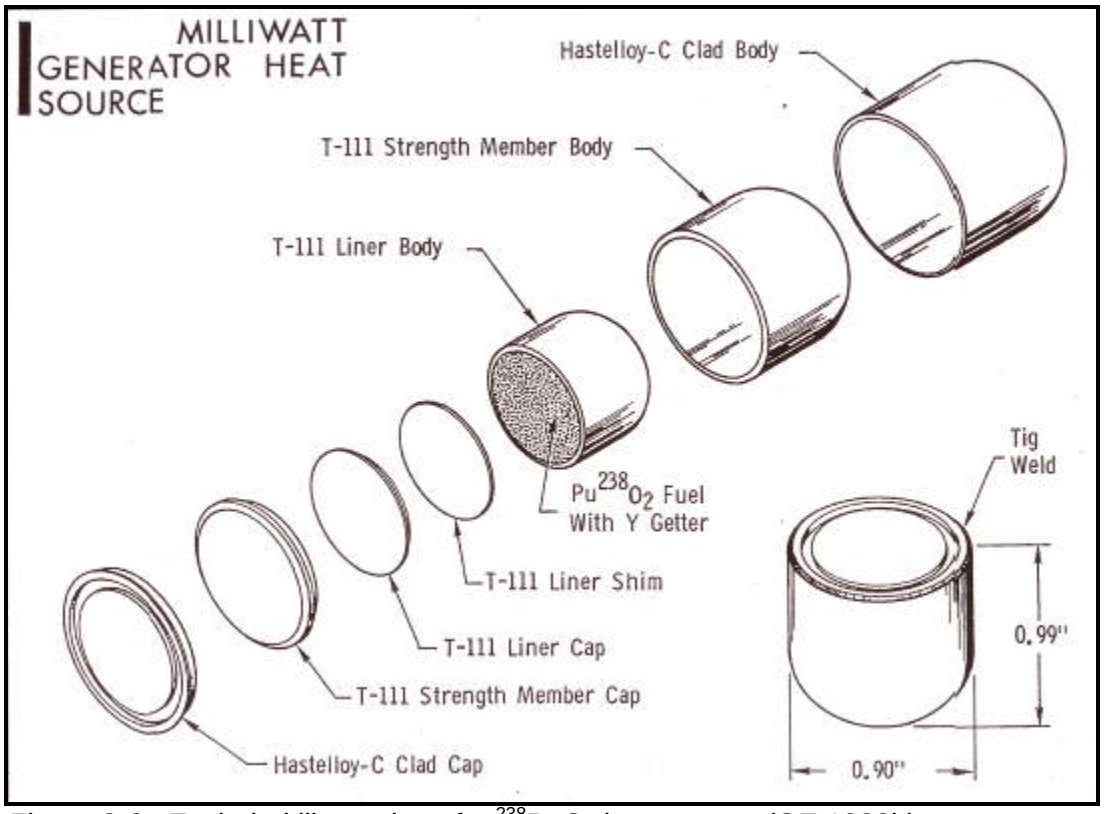

Figure 2-6. Exploded illustration of a $^{238}PuO_2$ heat source (GE 1982b).

Shipments of the $^{238}PuO_2$ heat sources were delivered directly to Building 400. The shipping packages were surveyed for surface contamination by instrument and swipe, then transferred to the source storage vault room. When shipping packages were to be opened, they were moved from the vault room to the source inspection hood. Upon opening the shipping packages, the sources were surveyed for contamination. If the sources were free of contamination, they were placed in a source storage container and returned to the vault. Contaminated sources with less than 200 dpm of alpha contamination were decontaminated before returning them to the vault. Contaminated sources with 200 dpm or more of alpha contamination would have been repackaged and immediately returned to the manufacturer; however, no sources were ever found to have that much contamination (GE 1982b).

When $^{238}PuO_2$ heat sources were needed for assembly into an RTG, they were transferred from the vault to the source inspection hood, surveyed again, cleaned with alcohol, placed in a clean source storage container, and transferred to an assembly glovebox. The other components for final RTG assembly were introduced through a pass box that was evacuated and then backfilled with argon before moving them to the assembly glovebox. The heat source was removed from the source container and placed on the top insulator using tongs. The RTG container was slid over the assembly, the base plate, and container configured for the joining operation. The base plate container joint was then tack-welded. The heat source was not damaged by the excessive heat input during the welding cycle because of its location in the center of the assembly and the protection provided by the insulation in the RTG unit. The RTG was then placed in a rotating welding fixture in the electron beam welder chamber and the weld operation was completed. The RTG units were then leak-tested. After leak testing, the RTG units were removed from the glovebox line via a pass box. The RTG units then received a final contamination survey, after which they were not considered a potential source of contamination. They were then moved to a workstation where a final pinch-off operation was made. A protective cover was then cemented over the pinch-off (GE 1982b).

The completed RTG units were then subjected to a series of testing procedures. These included: dimensioning, electrical input, temperature, vibration, and shock tests. Shelf-life studies were also performed on the RTG units. When testing was completed, the RTG units awaiting shipment were stored in the vault room (GE 1982b).

2.5.3 Neutron Detector Production

Neutron detectors were small electronic assemblies used in joint test assemblies to verify the output of a neutron generator during actual tests. The neutron detectors were used to verify operability of the weapon system without initiating a nuclear explosion (GE 1990, p. 15). These components were manufactured in Building 100 and tested using the linear accelerator in Building 800.

2.5.4 Target Assessment

The ion accelerator, originally located in Area 161 of Building 100 prior to being relocated to Building 800, was used to assess various tritium targets (GE 1977; Malbrough 1983). Target assessments were performed by accelerating a beam of deuterons (deuterium nuclei) to determine the 14-MeV neutron output of various types of tritium targets. This operation was performed in the ion accelerator's pulse mode, which duplicated the testing of the neutron tubes in Building 100 (GE 1977).

2.5.5 Other Products

In addition to the products discussed, the Pinellas Plant produced other special mechanical and electronic devices and test equipment for a variety of DOE and GE applications. These components included long-life batteries, high-speed switching circuits, and specially designed capacitors. These

products did not require direct use of radioactive isotopes for their manufacture, and this document does not cover them further.

2.5.6 Research and Development

Research and development at the Pinellas Plant was normally limited to the applied research necessary for the production of the Plant's products. Extensive product development was also conducted at the Plant. In conjunction with SNL, the Pinellas Plant did production development work on all the products it produced. Development consisted primarily of the receipt of a basic product design from SNL and the construction of sufficient numbers of those products in a laboratory environment to determine the factors and parameters whose variations could cause production difficulties. The advantage of this arrangement was obvious. It assembled a cadre of technical personnel who had the experience and the intimate product knowledge necessary to solve, efficiently and quickly, production problems that might have been encountered (GE 1983).

2.5.7 Product Testing

Mechanical and electrical testing of products, including the destructive testing of neutron generators, was conducted in Building 200. A typical regimen includes tests of vibration, acceleration, temperature and pressure cycling, and mechanical shock. Such testing ensured compliance with product specifications (DOE 1987).

The destructive testing of neutron generators included shock, vibration, and explosive tests. The explosive tests involved the destruction of the neutron generators by explosive detonation, resulting in fragments of the neutron generators as well as other materials. The neutron generators were typically packed in urethane foam that also fragmented, adding to the radioactive waste. The Styrofoam was rigid and ranged from pieces to grain sized. Styrofoam was also used as a spacer to position the neutron generators in relation to the measurement instrument. In addition, instrumentation cables and connectors became part of the waste. The following subsections describe some of the destructive testing processes and equipment.

2.5.7.1 Spin Tests

The spin testing equipment looked like a big top-loading washing machine, as shown in Figure 2-7. It was located inside the secured room. The neutron generators were wired and assembled in a hard plastic material fixture and inserted into a heavy aluminum fixture. The very heavy lid on top of the equipment was closed. The workers left the secured room and detonated the neutron generator. After the test, the equipment was opened, the fixture was removed, and the debris contents (neutron generator and plastic fixture pieces) were manually pried out, placed on a workbench, and placed in a plastic bag. There was no direct vent for this equipment other than the room's ventilation.

Figure 2-7. Spin tester (Demopoulos 2006).

2.5.7.2 Explosive Tests

These quality assurance tests included destructive testing of the units inside test chambers known as "*boom boxes*". There were two complete testing systems, each having instrumentation, firing tubes, and boom boxes. Each system had two firing tubes (large and small) on one side of the wall, and on the opposite side of the wall a boom box was located. The boom box had two compartments (chambers), two access doors, and two sliding trapdoors, all of which was aligned behind each firing tube. The boom box was actually one large welded unit and had a permanent steel barrier between each compartment (Zerfas 2005). Figure 2-8 is an illustration of the configuration of this test equipment.

The neutron generator was wired and assembled in a urethane foam fixture and inserted into the firing tube. The tube was closed and the area where the firing tubes were located was cleared before the neutron generator was detonated. On the opposite side of the wall (in the secured room), a steel boom box was mounted. The boom box contained the detonation. The top of the boom box was connected to a duct system. The bottom had a funnel shape with a sliding trap door. After the detonation, a plastic bag was placed in a standard office trash can placed under the boom box. The firing tube was opened and a rammer inserted to push debris out of the tube into the boom box. The boom box's trap door was opened, and the main access door was opened as well. Any surviving debris was brushed down using a standard dust pan brush. The bag was tied and stored in case further examination was needed. The test technicians might not have used protective wear (gloves, dust masks, or respirators). The ventilation system for Building 200 passed through high-efficiency particulate air (HEPA) filters before exhausting out the building roof.

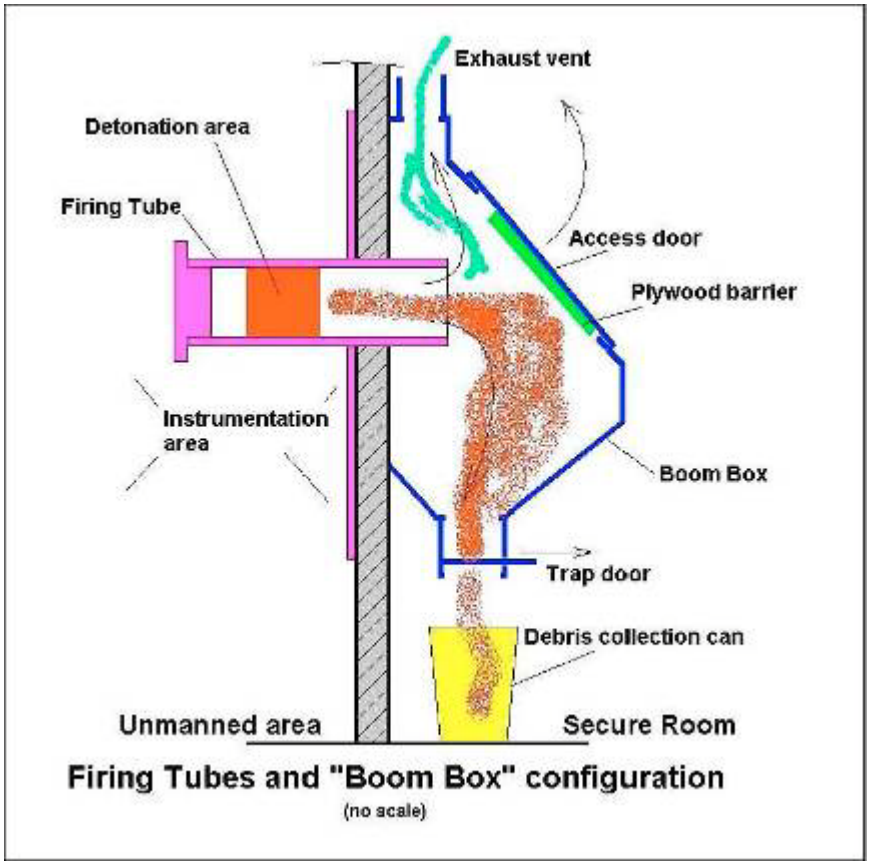

Figure 2-8. Firing tubes and the boom box configuration (Zerfas 2005).

The radioactive waste would have consisted of the generator remains, Styrofoam pieces and particulates, plywood, cables, and connectors. This would be collected in the container as shown in Figure 2-9. (Zerfas 2005)

Figure 2-9. Boom box and collection container (Demopoulos 2006).

For the boom boxes, a special treated plywood barrier was installed inside the chamber doors to deflect some of the detonation. The barriers were rotated 90 degrees after each generator test, enabling four tests. Particles of the generator would imbed into these boards. The outer part of the

boom boxes were constructed of steel, about $^{1}/_{8}$ to $^{1}/_{4}$ inch thick. They were of welded construction. The hinged doors swung up to access the area to be cleaned (neutron generator debris). On the back side of the door, the plywood panel was mounted in a simple frame. The door was flat sheet metal with about a $^{1}/_{8}$ inch gasket cemented to the inside to make contact with the boom box face. It was by no means an airtight fit. The door was not latched down, but held in place by elastic cords. On top of each chamber was an exhaust duct, about 4 in. × 8 in., that joined together and then went up to the exhaust system. The sliding door on the bottom was of a guillotine design.

2.5.8 Radioactive Waste Disposal

2.5.8.1 Liquid Radioactive Waste

Four types of liquid waste were generated during Pinellas Plant operation: sanitary, industrial, chemical and, potentially, tritium-contaminated waste. Before 1982, sanitary wastes were processed by an onsite sewage treatment facility and mixed with neutralized industrial waste in the west pond. Chemical drain lines from inside the plant routed industrial waste to an onsite treatment facility where it was chemically neutralized and pumped to the west pond. Water from the west pond was sprayed on a 10-acre irrigation field. A subsurface drain system under the 10-acre field collected liquids and routed them to the east pond. Liquid in the east pond was sampled and periodically discharged to a Pinellas County drainage pipe and roadside ditch that drained into Cross Bayou Canal and Tampa Bay (DOE 1983, p. 2-14).

It is possible that tritium-contaminated liquid waste generated during operations and tritium oxide from the Tritium Recovery System (TRS) was piped to a group of three underground holding tanks in the health physics area outside the southwest corner of Building 100. The liquid was sampled and discharged if the radioactive content was below the limits specified in Chapter XI of DOE Order 5480.1 (DOE 1980). Liquids with higher concentrations of tritium were incorporated into a solid for offsite burial. Effluent discharge from the holding tanks was pumped to the west pond where it mixed with the sanitary and industrial wastes discussed above (DOE 1983, p. 2-13).

2.5.8.2 Solid Radioactive Waste

The majority of radioactive waste from the site consisted of tritium-contaminated classified components. These components were packaged and shipped to a DOE-controlled site for disposal. Small quantities of radioactive liquids were solidified with absorbing compounds and included with the solid radioactive waste (DOE 1983, p. 2-21). Between 1965 and 1982, tritium-contaminated paper was incinerated at the site (DOE 1987).

2.5.8.3 Gaseous Radioactive Waste

Gaseous radioactive effluents were produced and released during the operation of the Pinellas Plant. Gaseous tritium, tritium oxide, ^{85}Kr, and a very small quantity of ^{14}C were the only identified releases. The four main discharge points were the two exhaust stacks on Building 100 and the single exhaust stacks on Buildings 200 and 800. During the initial years of Plant operation, tritium releases were as high as 42,400 Ci/yr. Installation of the SECS in 1960 reduced tritium emissions to less than 1,000 Ci/yr, and installation of the TRS in 1982 further reduced tritium emissions to less than 500 Ci/yr.

2.6 MAJOR FACILITY DESCRIPTIONS

The Pinellas Plant contains multiple structures and support facilities within the controlled area. Table 2-2 lists the floor space and function of each building, and the following sections discuss each building.

Table 2-2. Functions and sizes of Pinellas Plant buildings.

Building	Function	Area	
		Square meters	Square feet
Building 100/300 – 1st Floor	Offices, Production, Laboratory	42,271	455,000
– 2nd Floor	Offices, Utilities	9,625	103,600
– Mezzanines	Offices	6,317	68,000
Building 100/300 – Total	All floors and areas	58,213	626,600
Building 200	Product Quality Assurance Testing	1,505	16,200
Building 400	RTG Assembly and Testing	1,375	14,800
Building 500	Utilities, Deionized Water Plant	1,691	18,200
Building 550	Wastewater Neutralization	204	2,200
Building 600	Chemical Storage	669	7,200
Building 700	Maintenance Bldg., Fire Department	464	5,000
Building 710	Maintenance Storage Shed	36	384
Building 800	Ion Accelerator Facility	334	3,600
Building 900	Fire Training	65	700
Building 1000 and 1040	Waste Storage and Management	790	8,500
Building 1010	New Container Storage	232	2,500
Building 1100	Special Storage	37	400
Building 1200	Security	2,722	29,300
Building 1400	Remote Receiving	669	7,200
Building 1500 and 1600	School, Child Day Care	1,189	12,800
Site Total		**70,195**	**755,584**

Source: DOE (1995, p. 3-3).

2.6.1 Building 100

Building 100 was the initial plant building. During DOE ownership of the Pinellas Plant, Building 100 provided space for manufacturing, engineering, and administrative support services. Figure 2-10 shows the layout of Building 100.

Radioactive materials in Building 100 were used in the production, manufacture, storage, and testing of various weapons components. Multiple areas were considered Radioactive Material Management Areas (RMMAs), which indicated the possible presence of unconfined radioactive materials or emissions (DOE 1995, p. 5-2; 1991b, pp. 2, 3, 11, and 13). Table 2-3 lists the RMMAs in Building 100.

Area 107 was the assembly area for neutron tubes. A neutron tube is the main subassembly of the neutron generator. The neutron tube is a high-vacuum tube similar in operation to a miniature linear ion accelerator (GE 1990, p. 14). Tube manufacturing required clean-room conditions and used specialized vacuum-sealing technologies and metal spray deposition equipment (Author unknown undated d). Section 2.5.1 provides additional information on the production of neutron tubes.

Area 108 was the primary tritium handling area at the Pinellas Plant. Pure tritium gas was received from the SRS in standard LP50 containers and transferred to depleted uranium beds for storage. Overall tritium use at Pinellas was generally low, with an average yearly inventory of approximately 15 g (0.53 oz) (Author unknown undated e, p. 94). Using a specific activity of 9,640 Ci/g, the average yearly inventory of tritium was approximately 144,600 Ci. There have been indications that maintenance workers were asked to reset tritium radiation area alarms in Area 108 without the use of respirators during power outages. This occurred with no negative pressure for the gloveboxes (Williams 2004).

The major tritium activity in Area 108 was production loading of neutron tubes and other components with tritium. The assemblies were loaded with tritium through a hydriding process in which the

assemblies were evacuated and filled with tritium gas and the tritium was captured by a thin film of metal on the inside of the tube. Initial test firing of the neutron tubes occurred in Area 108 until April 1966 (Burkhart 1990), after which test firing took place in Area 128.

Other activities in Area 108 included mass spectrometer analysis of gas samples and maintenance of the spent uranium storage beds for use and disposal (MMSC 1994). Most tritium was stored and used in Area 108 (Author unknown undated e, p. 94).

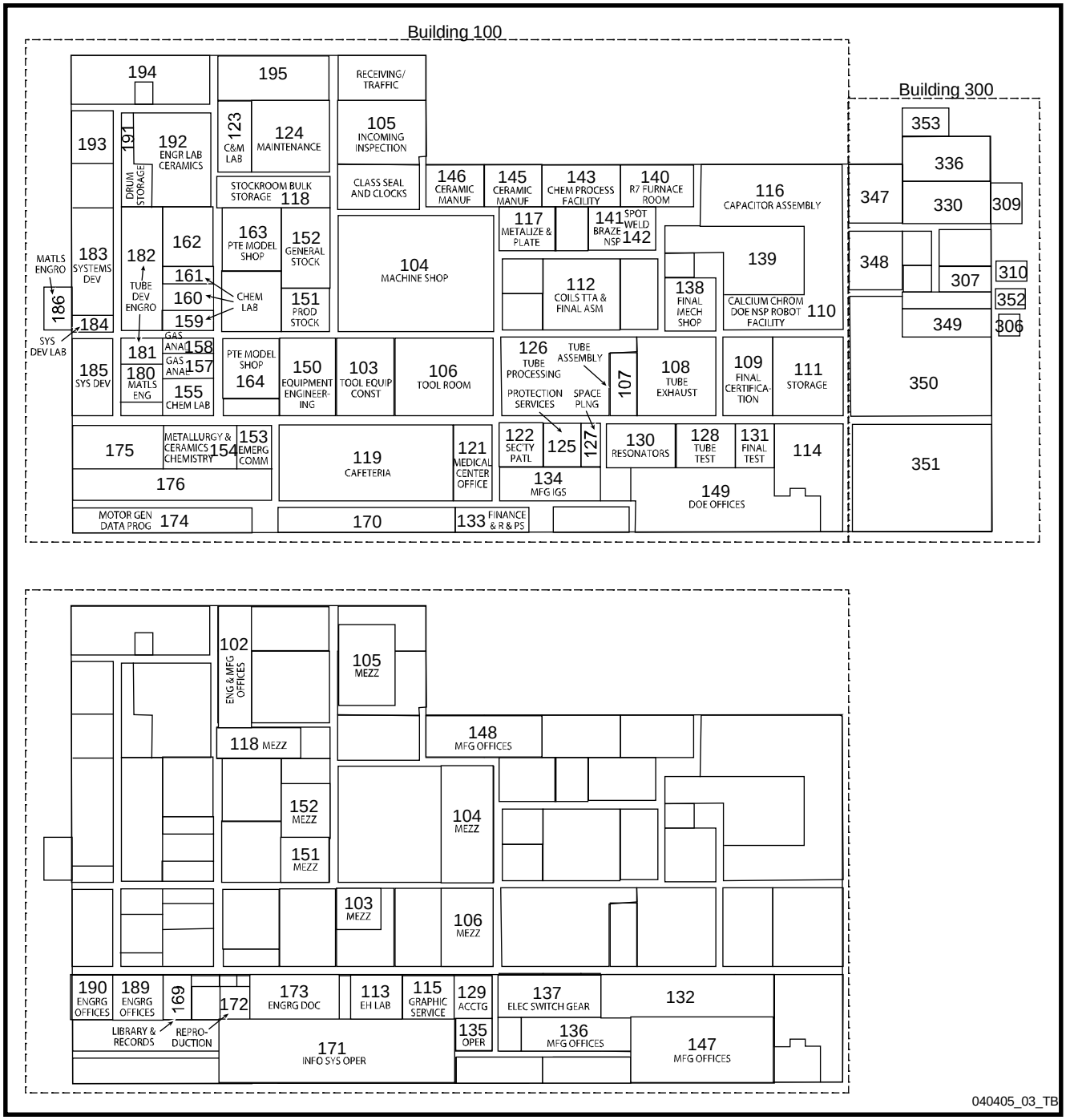

Figure 2-10. Building 100-300 with second floor mezzanines and offices (DOE 1994).

Table 2-3. RMMAs in Building 100.

Room/Area	Name	Activity
107	Tube Assembly	Vacuum tube manufacturing and coating
108	Tube Exhaust and Test	Vacuum tube evacuation and testing
109	Product Analysis	Magnetic and radioactive gas leak checking
113 Mezz	Health Physics Laboratory	Instrument calibration and check sources
132 Mezz	Fan Room	Stack effluent control and tritium recovery
157/158	Gas Analysis Laboratory	Hydrogen isotope analysis
176	Radioanalytical Laboratory	Radiological Laboratory, tritium recovery
182-C	Tube Assembly	Vacuum tube development and testing
182-G	Tube Exhaust	Vacuum tube development and testing
191	CPE Hood Room	Ceramic product testing facility

Source: DOE (1995, p. 5-3).

Area 109 contained product testing and analysis facilities for neutron tubes and completed neutron generators. Manufactured components were tested for operability and vacuum-sealed components were checked for leakage in Area 109. Part of the neutron generator testing included test firing of the devices and leak testing. Initial leak testing used helium and Freon leak-checking systems. In 1963, the Pinellas Plant began using leak test equipment that utilized radioactive ^{85}Kr gas for leak checking vacuum tubes (Author unknown undated d).

Area 113M was on the second floor of Building 100 and housed the check sources and calibration laboratory for health physics instruments.

Area 126 was the tube processing area, which included the deposition of the neutron tube target material onto the target substrates (DOE 1987).

Area 128 was used to test fire completed neutron tubes from April 1966 and later.

Area 131 was the final testing area for the neutron generators.

Area 132M was on the second floor of Building 100 and housed the central exhaust fan room. It contained the SECS from 1960 until 1982, when that system was replaced by the TRS (Weaver 1993, p. 3).

Area 157/158 contained the gas analysis laboratory. This area was used for tritium target sample preparation for the linear accelerator in Building 800 and mass spectrometer analysis of completed components for tritium content. Most of the activities in Area 157/158 were completed inside ventilated laboratory hoods that exhausted through the west exhaust stack.

Area 161 was the initial location for the ion accelerator from 1975 to 1979 (GE 1977; Malbrough 1983). This area also served as a surface science and X-ray analysis laboratory (LMSC 1997b). Those activities included surface analyses, thin films analyses, X-ray analyses, and process development (LMSC 1997b).

Area 182 was the vacuum tube development engineering section. It was used to engineer, design, fabricate, and test prototype vacuum tubes for neutron generators and other components. Areas 182-C and 182-G were considered RMMAs due to the small quantities of tritium used in vacuum tube development. Area 182 was exhausted through the west main stack on Building 100.

Area 191/192 was the ceramic product engineering (CPE) section. Minor levels of tritium were used in the production and development of specialty ceramic components.

The Radioanalytical Laboratory was installed in 1966 in Area 176 on the southwest corner of Building 100. It housed the TRS from 1982 until plant shutdown in 1992. The TRS recovered tritium from the plant ventilation stacks and converted it to tritium oxide for dilution and disposal.

Building 100 has two exhaust stacks. The west main stack exhausted 770 m^3/min (27,200 ft^3/min) from the west side of Building 100. The stack is 1.5 m (5 ft) in diameter and 30.5 m (100 ft) high (DOE 1983, p. 2-18). The east main stack exhausted 1,140 m^3/min (40,240 ft^3/min) from the east side of Building 100. The stack is 2.4 m (8 ft) in diameter and 21 m (70 ft) high (DOE 1983, p. 2-18). During plant operation, both stacks exhausted tritium and ^{85}Kr from the vacuum tube exhaust, test, and assembly areas. Both stacks were equipped with continuous samplers to monitor the exhaust stream. An additional 12 sampling stations were located around the plant perimeter. All measured discharges of tritium and ^{85}Kr were well below DOE and U.S. Environmental Protection Agency standards, and no plutonium release was ever detected during manufacturing or decontamination (MMSC 1995a, p. 3-2). Section 2.3.2 provides additional information on the annual tritium and krypton releases.

In 1988, a modernization task force conducted a detailed radiological survey of Building 100 to identify the level and extent of radiological contamination. A June 17, 1988, survey showed smearable tritium contamination in approximately 13% of Building 100. The maximum reading was a 1×10^8 dpm/ 100 cm^2 smear on the interior of an exhaust hood in Area 108. The average reading throughout the building was less than 220 dpm/100 cm^2 (Author unknown 1988a, Bldg. 100/300 survey).

2.6.2 Building 200

Building 200 was built in stages between 1959 and 1978; it covers approximately 1,505 m^3 (16,200 ft^2). The building was used for destructive testing of neutron generators and other components manufactured at the Pinellas Plant (Author unknown 1988a, Bldg. 200 survey). Destructive testing included shock, vibration, and explosive tests.

The modernization task force completed a radiological survey of Building 200 in 1988 to identify the general level of radiological contamination and perform an initial decontamination cost estimate. The June 1988 survey showed less than 5% of Building 200 contaminated with tritium. The maximum contamination level was a 1×10^4 dpm/100 cm^2 smear inside a testing chamber, and the average contamination was less than 220 dpm/100 cm^2 (Author unknown 1988a, Bldg. 200 survey). The final characterization report in 1997 found that radioactive waste and tritium were present in the building but did not identify specific contamination levels or types of radioactive waste; the report found that all quantities were less than reportable amounts required by 40 CFR Part 355 or 40 CFR Part 302.4 (Author unknown 1996, p. 3).

During operation, the building exhaust system maintained negative pressure on three testing chambers (boom boxes) and a single radiological waste drum. The ventilation system passed through HEPA filters before being exhausted from the building roof (MMSC 1995b, p. 5-4). The stack exhausted 36.8 m^3/min (2,300 ft^3/min). It is 17.7 m (58 ft) tall and 30.5 cm (12 in.) in diameter.

2.6.3 Building 300

Building 300 primarily performed nonradiological activities. However, radioactive materials were handled in a number of areas within Building 300. Tritium was handled in Area 348 and glass doped with natural uranium was handled in Areas 327, 330, 331, and 336 (LMSC 1997b).

2.6.4 Building 400

Building 400 was built in 1968 for development and testing activities. It was expanded in 1978 and again in 1986. The facility was used to assemble and test RTGs from 1975 until 1990. Figure 2-11 is a layout of Building 400.

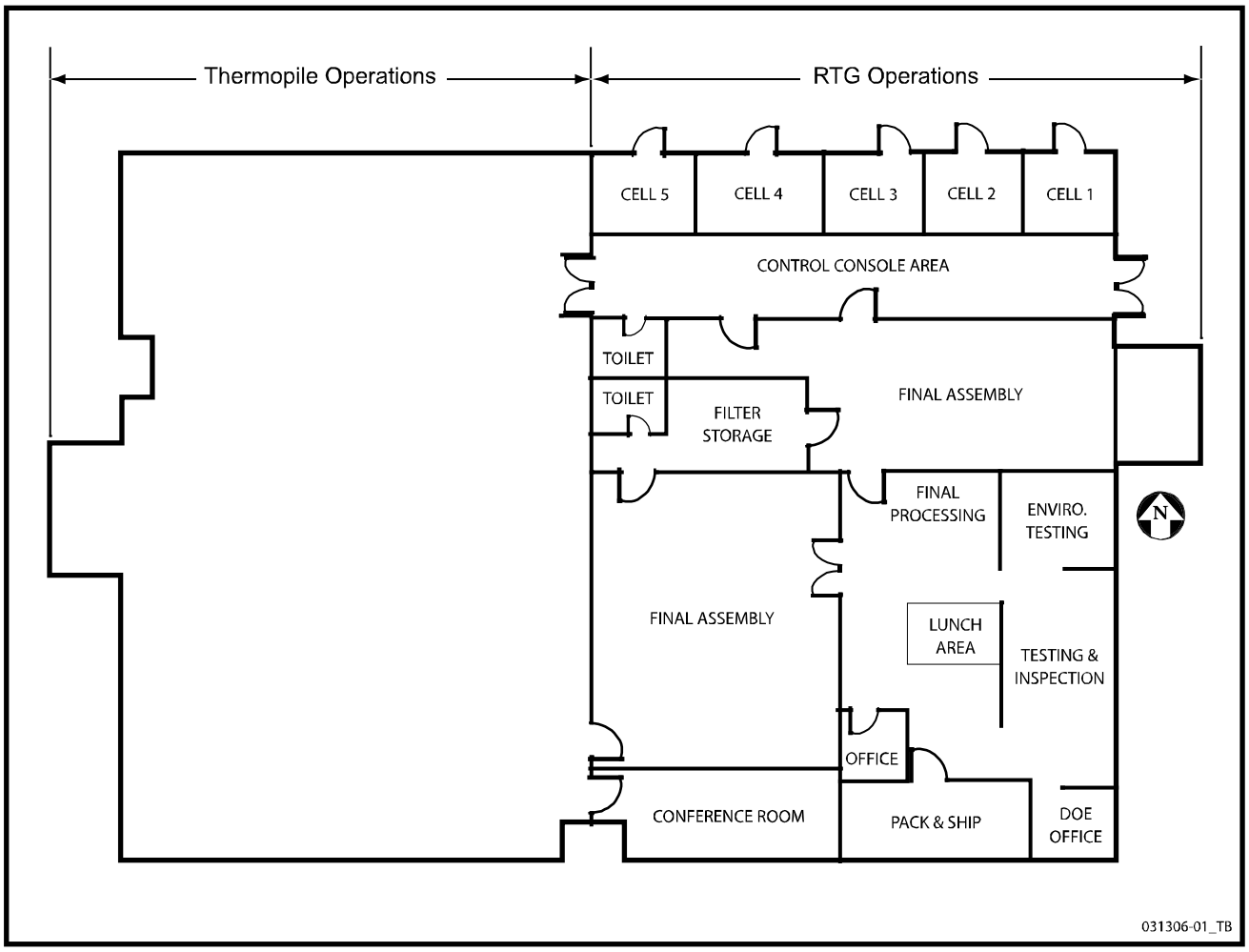

Figure 2-11. Layout of Building 400 (GE 1982b, pg. 9).

The western half of Building 400 was used for nonradiological thermopile operations. The eastern half of the building was used for RTG assembly operations, which is where the $^{238}PuO_2$ heat sources were stored and handled. The $^{238}PuO_2$ heat sources and completed RTG units were stored in the source storage vault room (depicted as Cell 4 in Figure 2-11) (GE 1982b). Other than the source storage vault room and source inspection hood, the $^{238}PuO_2$ heat sources were handled only in the gloveboxes in the final assembly areas (GE 1982b). Completed RTG units, containing the heat sources, were also handled in the final processing, inspection, and testing areas of the eastern portion of Building 400 (GE 1982b).

After production of RTG devices ceased in 1990, all plutonium heat sources were shipped off the site. During 1994, the building was fully decontaminated and released for use by a commercial tenant. The final decontamination survey found indoor radon levels to be below the action levels of the Indoor Radon Abatement Act. Other radiological surveys of the building showed residual radiation levels below free release limits (MMSC 1995b, p. 4-1).

2.6.5 Building 800

Building 800 housed the ion accelerator. After the accelerator's relocation from Area 161 in Building 100 to Building 800 in 1979, it was used for a larger variety of activities that included target assessment; material analysis; low-energy nuclear, solid-state and atomic physics; and material science (Malbrough 1983). Figure 2-12 shows the layout of Building 800.

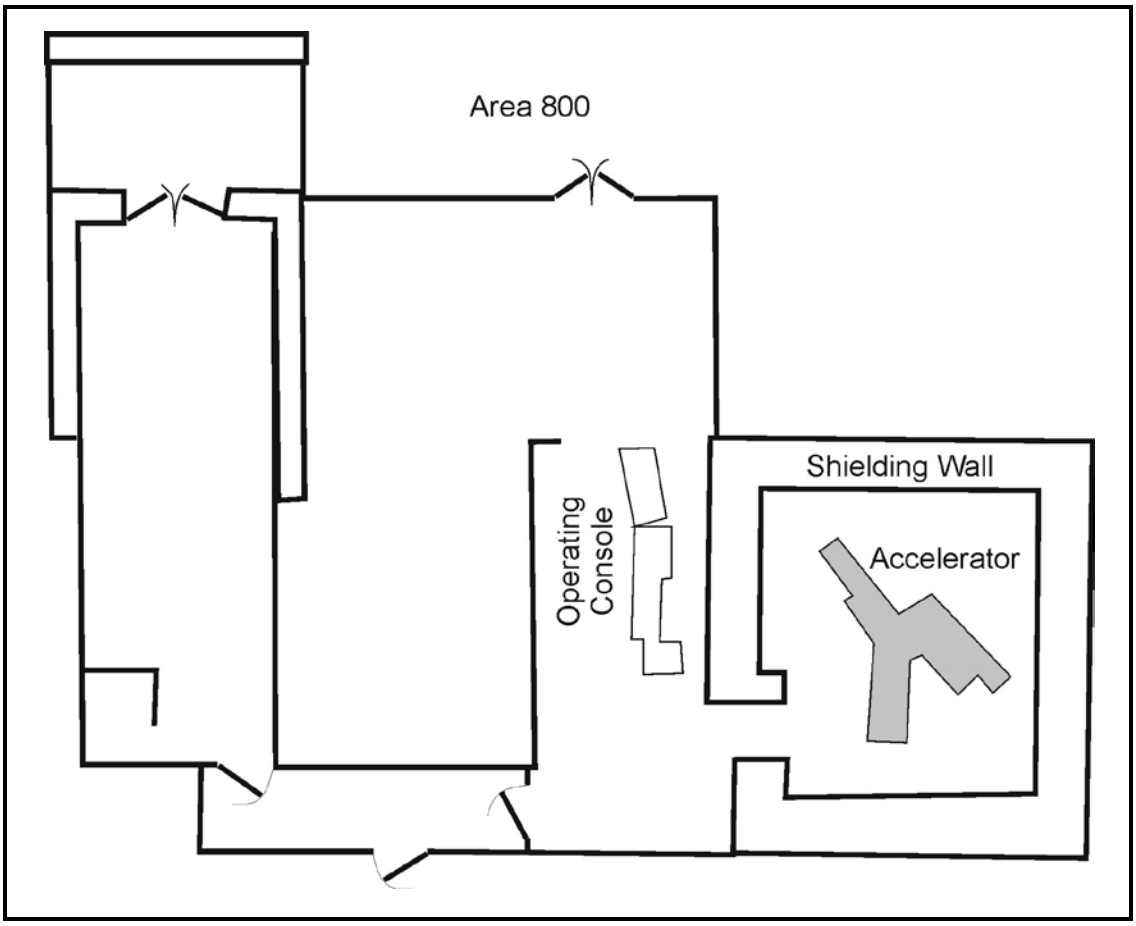

Figure 2-12. Layout of Building 800 (MMSC 1993b, pg. 5).

The building ventilation system exhausted 38 m^3/min (1,350 ft^3/min) through a 25 cm × 33 cm (10 in. × 13 in.) exhaust stack that extends 6.3 m (20.8 ft) above the ground (DOE 1983, p. 2-18).

A radiological survey in 1988 identified a maximum reading of 1×10^8 dpm on a smear from inside the accelerator, and the average contamination was less than 220 dpm/100 cm^2. Less than 5% of the building area was considered contaminated (Author unknown 1988a, Bldg. 800 survey sheet).

2.6.6 Building 1000

Building 1000 was used to store low-level solid radioactive waste, solidified waste oil, and used equipment (MMSC 1995b, p. 5-5). Waste material was stored in the building until a sufficient quantity was collected for shipment to a DOE-approved disposal facility or for sale as scrap.

A radiological survey completed in 1988 identified low levels of contamination in as much as 75% of the radiological waste storage bay. The maximum measured contamination was less than 220 dpm/ 100 cm^2 (Author unknown 1988a, Bldg. 800 survey sheet).

2.7 RADIOLOGICAL RELEASES

2.7.1 Environmental Releases

Radioactive airborne effluent releases were limited to tritium, ^{85}Kr, and ^{14}C. The majority of those releases were through the four exhaust stacks on Buildings 100, 200, and 800. Table 4-2 of the Occupational Environmental Dose TBD for the Pinellas Plant (ORAUT 2011c) lists the annual radioactive airborne effluent releases of these radionuclides.

Radioactive liquid effluent releases were limited to tritium. These releases were discharged to the west and east retention ponds through November 1982 (DOE 1983). After November 1982, they were discharged to the Pinellas County Publically Owned Treatment Works (POTW) (DOE 1983). Table 4-3 of the Occupational Environmental Dose TBD for the Pinellas Plant (ORAUT 2011c) lists the annual radioactive liquid effluent discharges from the east retention pond.

2.7.2 Releases Due to Unusual Events

Other releases of radionuclides during operation of the Pinellas Plant have been identified. These were caused by accidents, operator errors, or similar unplanned events. Table 2-4 lists a chronology of some of the unusual events and the resultant radiological releases (if known) at the Plant from startup through 1982. In addition, Table 2-4 includes external radiation exposures incidents for the Plant.

Table 2-4. Chronology of unusual events.

Date	Description	Curies released
11-1957	Neutron generator output measured at 10 mrem/pulse at 2.5 cm (1 inch).	
12-1957	Raytheon X-ray units found to contain 10 nCi of Co-60	
12-10-57	Operator error in reading manometer in Room 18	458
2-11-58	Error estimating amount of tritium remaining in charging system in Room 18	1,253
7-8-58	Glass system breakage in Room 22	280
3-7-58	Glass system breakage in Room 18	567
8-16-58	Operator error with tritium loader valve position in Room 21	780
8-18-58	Glass manifold breakage in Room 21	1,180
2-10-59	Operator error in valve positioning in Room 8	286
6-4-59	Personnel error working on SECS test system in Room 21	753
6-18-59	Excess air released from tritium loading system	423
1-1960	Operator error – stopcock left open on tritium loading system	40
2-5-60	Glass manifold broke from strain	72
2-11-60	Operator error – stopcock left open on tritium loading system	308
7-8-60	Broken sample bulb	6.8
2-1964	E-beam welder found reading 250 mrem/hr at startup – shielded to 4 mrem/hr.	
2-4-65	Explosion during cold trapping of krypton	38
12-1965	X-ray diffraction unit found leaking – new shielding installed	
5-1966	SECS cold water removal problems	252
1-27-67	Glovebox vacuum pump oil degassed	32
4-1967	HP surveying new X-ray machine received 1.6-rad exposure. Shielding installed.	
1-17-68	Faulty relay in Radiflo® unit No. 1 – vented krypton-85 when placed in manual	129
2-1969	Leaking flange at absorption pump in Area 108	8
2-3-69	Equipment failure – Radiflo® valve did not seat properly – Kr-85 vented	20
9-1969	X-ray unit in Area 155 found leaking to 1.6 rad/hr	

12-28-70	SECS column saturated due to air leak in Area 108	117
3-12-71	Copper gasket uncovered in Room 18 hood – high internal dose	7.3
10-9-71	Radiflo® Unit No. 1 – Krypton-85 storage tank leak	6.1
10-21-71	Tritium release from improperly baked evaporator system in Area 182D	129
4-1972	Area contaminated from liquid discharge in Area 182D	1.5
5-1972	Hand exposure from XRE X-ray emission unit No. 7R during cleaning	
8-3-72	Leaking absorption pump	12
1-31-75	Improper valve closure on uranium bed	150
2-10-75	Absorption pump leak – Area 182D	42
4-19-1993	TracerFlo - Leak Test Unit No. 2 – Kr-85 leak	<10

Sources: Burkhart (1990); Hare (1993).

2.8 ATTRIBUTIONS AND ANNOTATIONS

All information requiring identification was addressed via references integrated into the reference section of this document.

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