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OAK RIDGE OPERATIONS OFFICE
DEFENSE NUCLEAR FACILITIES

Study Guide

Portsmouth Gaseous Diffusion Plant

Developed by the
OAK RIDGE OPERATIONS OFFICE
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REVISION 0

V. PORTSMOUTH GASEOUS DIFFUSION PLANT

The Portsmouth Gaseous Diffusion Plant (PORTS) is in Piketon, Ohio. The sole mission of the site is to produce commercial-grade enriched uranium. All facilities and activities are for the purpose of enriching uranium or safely handling and disposing of the waste generated from that activity. The PORTS production facilities are operated by the United States Enrichment Corporation (USEC) and the remainder of the site is retained by DOE. DOE-ORO is responsible for the legacy wastes and associated facilities in site. Operation of the gaseous production facilities is overseen by the Nuclear Regulatory Commission (NRC).

The ORO defense nuclear facilities on site include:

- Storage Cage X-326L
- Special Nuclear Material Storage X-345
- Oxide Conversion Area X-705E
- Bulk Non-UESA Storage Building X744G
- UF_6 Cylinder Storage Yards X-745-C, E
- Recycle and Assembly Building X-7725
- Recycle/Assembly Storage Yard X-7745R

Storage Cage X-326L

The X-326L Cage is a storage unit used to store such hazardous waste as high-assay uranium-bearing materials, asphyxiants, mixed wastes, technetium-bearing material, asbestos, and polychlorinated biphenyls (PCBs).

<u>Safety</u>

X-326L and the other ORO waste storage and handling facilities primarily handle and store RCRA waste as well as uranium-bearing compounds. The most significant hazard associated with a fire is the RCRA waste. Fires can be caused by welding and burning operations, electrical failures, and vehicle accidents. The primary concern associated with the facility fire is the loss of system integrity and the release of toxic material.

A criticality accident is also possible in the waste storage and handling facilities and would result in the uncontrolled release of energy from an assemblage of fissile material. The criticality accident would pose a severe threat to those individuals in the immediate area, with little to no threat to the general public. Considering East Tennessee Technology Park, PGDP, and PORTS, there have been over 100 cumulative years of diffusion plant operation without a criticality accident. Controls are in place to prevent this type of accident through the requirements of the Nuclear Criticality Safety Program.

There are no identified safety structures, systems or components for the ORO PORTS facilities.

Special Nuclear Material Storage X-345

The X-345 SNM Storage Facility comprises three major areas: two SNM storage vaults and a work and drum-storage area located between the storage vaults. Building X-345 houses areas for the storage of SNM containers, handling, sampling, and weighing of in-process Category I SNM, a high-assay sampling area (inactive), and ancillary areas.

The X-345 SNM Storage Facility is a material access area (MAA) because the facility contains greater than 5 kg of uranium at a ^{235}U assay in excess of 20%. The HEU stored in X-345 is not required for programmatic purposes. The designation as a MAA requires access controls for the building such as:

- Electronically controlled security system to restrict access to the facility to only authorized personnel.
- The implementation of the two-man rule. (Requires that access to this area by a single individual is not allowable.)
- The requirement that the security force be present whenever X-345 is occupied.

Downblending Activities

The HEU stored by DOE in X-345 is available for downblending to LEU product by USEC. The HEU is in part available through working agreements between the government of the United States and the government of the Russian Federation. The non-proliferation agreements have been adopted in order to safely reduce the number of nuclear weapons and weapons grade materials. The HEU refeed material is stored in cylinders inside Building X-345. The HEU is moved under DOE oversight by secure transport from the X-345 facility to the X-326 Product Withdrawal Facility across plant roadways.

Once in the Product Withdrawal Facility, the cylinders are stored in a secure, DOE-regulated vault until feed is required. After feed orders are issued, HEU cylinders are connected to one of 22 feed manifolds and fed by sublimation directly to suction of a centrifugal compressor in the LEU enrichment cascade. The HEU feed rate is controlled to ensure that there is no more than 50 kg of ^{235}U in 10-20 wt % ^{235}U enriched uranium in geometrically unfavorable components of the system during routine operations. A sample is taken twice daily below the UF_6 front end, and the enrichment found in the sample is used to calculate the amount of gaseous UF_6 enriched from 10 to 20 wt % ^{235}U and to verify that the calculated amount does not exceed 50 kg ^{235}U. This material is present, but it is not withdrawn as product and is not easily accessible because of its physical and chemical condition and because of the safeguards control in place. This ensures that the ^{235}U possession limits are not exceeded.

If it becomes necessary to remove from the cascade some or all of the uranium enriched from 10 to 20 wt% ^{235}U as a result of HEU refeed, the PORTS NRC resident inspector is notified before the removal, and all of the uranium enriched above 10 wt% that is removed is protected according to the requirements of 10 CFR 73.67(d), or the material is transferred to a DOE-regulated facility or area for storage or downblending to less than 10 wt % ^{235}U.

After a cylinder has been fed, it is removed from the feed position and weighed to determine the amount of uranium fed to the LEU enrichment process. A relatively small amount of nonvolatile uranium typically remains in the cylinder after feeding. This "heel" is removed by a cleaning process conducted in a DOE-regulated X-705 Small Cylinder Cleaning Area or shipped off site for cleaning. Solutions resulting from the cleaning process are blended with solutions containing normal or depleted uranium or LEU to reduce the assay to less than 10 wt % ^{235}U. The solution is then transferred to the uranium recovery area, where it is converted to uranium oxides; finally, the oxides are stored for future disposition. The cleaned cylinders and any cylinders destroyed during the cleaning process are returned to DOE.

As part of the normal operation of the gaseous diffusion process, cells are treated with oxidant gases to remove deposits of uranyl fluoride and other compounds from the cascade equipment surfaces. Generally, these treatments liberate a few hundred to several thousand grams of uranium from deposits. The treatment gases, including any uranium liberated from deposits as UF_6 are evacuated to surge drums and then returned to the enrichment cascade at a point near their origin.

Cell treatment may result in the liberation of small quantities of residual HEU that was left in USEC process equipment following completion of the DOE cleanup process. This may occur at any point during the remaining operational life of the enrichment cascade. The liberated material will mix with the LEU material in the process equipment and surge drums, and the treatment gases will be returned to the cascade, where they will be mixed with much larger quantities of uranium present in the interstage flow at LEU enrichments. This process ensures that the blended stream remains within the ^{235}U possession limits. Uranium enrichment is not analyzed before the mixtures are returned to the cascade. Any changes in uranium inventory as a result of recovery of the relatively small amounts of HEU will be reflected in USEC's enrichment cascade inventory difference during periodic inventories.

In addition to HEU downblending activities, there may be occasions when equipment or components removed from the LEU cascade, Building X-705, or other USEC facilities contain moderately enriched uranium (10 - 20 wt % ^{235}U) or HEU because of the presence of residual deposits of material that were not completely removed during the HEU suspension program. On those limited occasions, the equipment is disassembled and decontaminated in an area in Building X-705 that is temporarily placed under DOE regulation with appropriate safeguards in place. Material removed that exceeds 10 wt % ^{235}U is retained by DOE or is blended with LEU solution until the overall enrichment is less than 10 wt % ^{235}U. DOE regulation and associated safeguards cease to be applied when material equal to or greater than 10 wt % ^{235}U is no longer present. The blended-down solution is processed through uranium recovery as described above.

Oxide Conversion Area X-705E

The X-705E Oxide Conversion Area is a section of the X-705 Decontamination and Recovery Building. The "E" area served as an oxide conversion facility from 1967 until 1978. Equipment in this facility contains radioactive contaminants and entry into the area is administratively

controlled.

Bulk Non-UESA Storage Building X744G

X-744G Bulk Non-UESA (Uranium Enrichment Service Activity) Storage Building is used for the storage of contaminated cascade trapping materials (alumina and sodium fluoride), contaminated solid scrap [metals, oil absorbent (Sorbol) from the process buildings], and uranium oxide and nitrates (from the X-705 decontamination processes and off-site sources). This facility is also used for the sampling of solid contaminated scrap. X-744G was previously used as a SNM storage facility and houses the aluminum smelter (no longer used).

UF_6 Cylinder Storage Yards X-745-C, E

The UF_6 cylinder storage yards are open areas on the PORTS site used for temporary and long-term storage of cylinders filled with solid UF_6. The cylinder yards were built to support operations at the plant. Most of the cylinders contain depleted UF_6 (tails). However, clean empty cylinders; feed cylinders; cylinders with depleted, feed, or enriched heels; or cylinders with product material $\leq$5.0% ^{235}U may also be stored in these yards.

In addition to storage, the following activities are expected in the cylinder storage yards:

- Cylinder movement
- Periodic cylinder inspection
- Cylinder repair
- Cylinder refurbishing
- Cylinder corrosion studies
- Cylinder yard maintenance

Full cylinders containing depleted and normal-assay material may be double-stacked in straight double rows with a small aisleway between each double row. The aisleways are wide enough to allow personnel access but not wide enough to allow mobile equipment. Most cylinder heads face the aisle in order to facilitate inspection and taking physical inventories. The bottom rows of cylinders are positioned on oak or concrete cradles, whereas the second rows of cylinders rest on top of the bottom rows. Empty cylinders or cylinders with heels may be triple-stacked in straight double rows with a small aisleway between each double row.

Cylinders with $\geq$ 50 lb (23 kg) of material that is enriched to greater than 1.0% ^{235}U are spaced and stacked in accordance with the requirements of the Nuclear Criticality Safety Program.

<u>Safety</u>

During routine cylinder lifting or moving operations within various facilities as well as during on-site transportation, various initiators are present that could result in a loss of cylinder integrity. Normal controls are provided to minimize the potential for loss of cylinder integrity, however, single operator error or an equipment failure could result in a cylinder valve failure and loss of

cylinder integrity. Additionally, past operational history shows that these types of accidents happen.

UF_6 is the primary hazard of concern at diffusion plants. Principally, this is because of the chemical toxicity of UF_6 and its reaction products and because of the radioactivity and toxicity of uranium. In addition, in a UF_6 release to the atmosphere, UF_6 reacts with water vapor in the air to create hydrogen fluoride (HF) which is a highly toxic material.

Recycle and Assembly Building X-7725

The X-7725 Recycle and Assembly Building was originally intended to be used for assembling new centrifuges and rebuilding and testing used ones. The building is now a RCRA waste storage facility and includes areas for unloading, sampling, and staging areas for wastes prior to shipping. More information concerning the waste handled in this facility is presented later in this guide, under Waste Streams.

Recycle/Assembly Storage Yard X-7745R

The X-7745R Recycle/Assembly storage Yard was used to store new (unused) centrifuge casings from 1983 to 1985. The yard is now used to store miscellaneous equipment and materials, including various hazardous or contaminated materials in drums, crates, cars, trailers, and mobile tankers. The stored materials include asbestos, radiological contaminants, PCB-contaminated oils, radioactive wastes, and corrosives.

Safety

The safety concerns for the DOE areas of the PGDP and PORTS are as similar as the process operations of the two plants. While most of the hazards are the same as for any industrial process plant, there are some hazards that are unique due to the materials handled. During routine cylinder lifting or moving operations within various facilities as well as during on-site transportation, various initiators are present that could result in a loss of UF_6 cylinder integrity. Normal controls are provided to minimize the potential for loss of cylinder integrity, however, single operator error or an equipment failure could result in a cylinder valve failure and loss of cylinder integrity. Additionally, past operational history shows that these types of accidents happen.

UF_6 is the primary hazard of concern at diffusion plants. Principally, this is because of the chemical toxicity of UF_6 and its reaction products and because of the radioactivity and toxicity of uranium. In addition, in a UF_6 release to the atmosphere, UF_6 reacts with water vapor in the air to create hydrogen fluoride (HF) which is a highly toxic material. There are no identified safety-class structures, systems or components for the ORO PGDP or PORTS facilities. There are several safety-significant items to note.

<u>UF_6 Cylinders</u>

The UF_6 cylinders are designed as safety-significant for the ORO cylinder handling/storage process. Various sizes of UF_6 cylinders are used at the cylinder yards. The cylinders are typically stacked no more than three high and are routinely inspected to detect potential corrosion and damage. The system consists of the cylinders, cylinder valves, and cylinder plugs.

UF_6 Cylinder Handling Equipment

The UF_6 cylinder handling equipment are designated safety-significant for the ORO UF_6 cylinder handling/storage process. The equipment includes various pieces for lifting and moving UF_6 cylinders containing UF_6. This system includes equipment, but is not limited to, cylinder haulers, railcars, and forklifts. Cylinder haulers (e.g., stackers and straddle carriers) similar to those used in the lumber industry are modified for transporting UF_6 cylinders after they have cooled. Some of the cylinder haulers have a positive lifting device attached to the ears on the cylinders to provide a secondary catch to the carrier shoes should the cylinder lifting ear break contact with the carrier shoes. The positive lifting device helps prevent a cylinder drop.

Criticality Accident Alarm System (CAAS)

The CAAS is designated as a safety-significant system and is applicable to the following facilities:

- Seven cages containing RCRA waste (X-326-L)
- Oxide conversion area (X-705-E)
- Bulk storage building (X-744-G)
- Recycle/assembly building (X-7725), and
- Recycle/assembly storage yard (X-7745-R[S])

CAAS detects neutrons, provides a distinctive, audible signal that will alert personnel to evacuate the areas that are potentially affected, and provide sufficient information to a central remote location for initiation of emergency response activities.

Waste Streams

The production of enriched uranium at the PORTS results in the generation of radioactive, hazardous, toxic, mixed radioactive, and conventional sanitary/residential/industrial wastes. Activities associated with DOE's environmental management mission also generate significant quantities of wastes. The environmental restoration activities and resulting wastes pose moderate-to-high hazards to workers, the population, and the environment. Hazard minimization of these wastes is accomplished by waste management, packaging, and on-site storage or disposal.

Waste generated within USEC facilities are handled, treated, stored, and disposed of in USEC waste facilities. The USEC wastes are transferred to, handled, treated, stored, or disposed of in DOE-managed waste facilities if (1) USEC wastes are inappropriate for USEC facilities, (2) USEC facilities are at a maximum capacity, or (3) time limits are exceeded for wastes residing in USEC staging/accumulation areas.

Wastes

DOE/ORO (PORTS) is responsible for:

- Low-level radioactive waste
- Transuranic waste
- Mixed radioactive waste
- Radioactive asbestos
- Hazardous waste
- Toxic waste
- Combined hazardous and toxic waste
- Scrap metal

The principal sources of low-assay LLW generated at PORTS are (1) solid compactible and non-compactible wastes (which may be burnable) resulting from enrichment operations; (2) scrap metal, rubble, and aggregates derived from discarded facility parts and components, construction and renovation activities, and replacement of equipment; and (3) soil and concrete derived from environmental restoration and D&D. Day-to-day plant operations generate radioactive contaminated wastes consisting primarily of paper, personal protective equipment, cardboard, fiberglass, cloth, rubber, and air filters.

Liquid LLW packaged for storage at PORTS consists of wet sludges, sludge-laden liquids, and semisolids. Most liquid LLWs are legacy wastes that were generated as a result of previous DOE activities no longer performed at PORTS.

DOE/ORO maintains responsibility for the legacy high-assay LLW stored on the PORTS site.

Waste that is contaminated with ^{99}Tc is classified as greater-than-class C LLW. PORTS generates spent ion exchange resins exhibiting levels of radioactivity attributable to ^{99}Tc. Also, DOE/ORO are responsible for ^{99}Tc waste from the early French breeder reactor program. These wastes require special packaging, handling, and transport.

Mixed hazardous wastes are generated at PORTS by fabrication and maintenance activities, major equipment repair, rebuilding and construction, metal machining, welding, instrument repair, carpentry and painting, field maintenance, and environmental restoration. Many of these activities produce radioactive scrap metal, whereas others generate soil, concrete, and rubble.

The principal sources of liquid mixed radioactive wastes are spent solvents, sludges, discarded commercial chemicals, PCB-contaminated wastes, and metal machining and cutting fluids consisting primarily of oils, and lubricating oils, as well as ignitable, corrosive, reactive, and TCLP wastes. These wastes originate from fabrication, maintenance operations, and chemical operations.

The largest and most common source of mixed toxic wastes generated at PORTS is PCBs. The radioactive wastes are generated through (1) collection of floor sweepings, (2) the use of wipes to

collect and clean up lubricating oil leaks and ventilation duct seam leakage, and (3) ventilator duct gaskets contaminated by contact with PCBs.

DOE/ORO is responsible for mixed hazardous and toxic radioactive waste at PORTS. Maintenance activities involving equipment contaminated with PCBs result in the generation of wastes with both hazardous and toxic constituents that also are radioactive. Although small quantities of mixed hazardous and toxic radioactive solid wastes are generated at PORTS, waste oils from the main process buildings are the principal contributor to this waste category.

The principal sources of liquid hazardous and toxic wastes are (1) several RCRA groundwater and groundwater-related aqueous wastes, (2) X-710 lab wastes, (3) various oils, and (4) spray booth waters. Chemical operations generate relatively small quantities of spent cyanide from plating solutions, and hazardous liquid wastes using a small-parts nickel-deplating process.

Sources of radioactive asbestos and nonradioactive asbestos at PORTS are friable insulation around water and steam lines and other heat-related processes. The generation of these materials usually is associated with plant maintenance activities.

Six major sources of hazardous wastes are generated at PORTS: (1) chemical operations, (2) utility operations, (3) fabrication and maintenance activities, (4) laboratory operations, (5) remedial action activities, and (6) environmental restoration. Relatively large quantities of solid RCRA hazardous wastes such as organic materials and discarded laboratory chemicals are generated by PORTS lab activities. Demolition and construction associated with remedial action activities produce hazardous wastes. Other hazardous wastes include dried painting wastes containing ignitable and corrosive substances, dewatered sludges, and discarded commercial cleaners. When changed out, spent HEPA filters are drummed and stored on site as hazardous waste.

Toxic wastes are generated as a result of equipment and materials coming into contact with dielectric fluids and lubricating oils that contain PCBs. Spent gaskets, light ballasts, capacitors, and transformers whose PCBs have been drained are examples of toxic solid waste.

Waste Handling/Disposal

On-site disposal at PORTS is limited to the X-735 sanitary landfill and the X-736 construction spoils landfill which are both managed by DOE. Some off-site treatment of PORTS wastes occurs at the K-1435 TSCA incinerator located on the East Tennessee Technology Park site in Oak Ridge, TN. Ash that remains after incineration is either stored in waste facilities with the K-1535 facility, disposed of in an appropriate off-site facility, or returned to PORTS for treatment, storage, or disposal. Most wastes generated at PORTS are packaged into drums, bottles, boxes, and tanks and then stored in dedicated facilities to await disposal.

All radioactive wastes generated at PORTS are classified as LLW or mixed waste and are stored on site to await disposal at the DOE Hanford Site in Richland, Washington. High assay product is not considered LLW and requires special precautions to prevent nuclear criticality accidents. The high assay product is stored in DOE facilities under extreme security controls.

Dewatered spent ion exchange resins generated at PORTS containing ^{99}Tc are packaged and stored in the unrestricted X-744G warehouse. The resins are handled and stored as greater-than-class C low-level radioactive waste.

A small quantity of TRU wastes is stored by DOE at PORTS. No future TRU waste storage space requirements are anticipated because TRU wastes are no longer produced at PORTS.

ORO PORTS waste is shipped from X-7725. Wastes handled in the facility include product and process wastes, RCRA characteristic wastes, low-level radioactive waste (contaminated primarily with uranium and/or ^{99}Tc), TSCA wastes containing PCBs or asbestos, and combinations of the above wastes. The majority of these wastes are liquid (containing arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, and benzene), spent halongenated and nonhalongenated solvents, and/or radioactive wastes generated from laboratory wastes, decontamination solutions, and a variety of plant processes and cleanup operations.

Some off-site disposal of PORTS mixed radioactive wastes occurs at Envirocare of Utah, Inc., which is a commercial radioactive waste disposal facility west of Salt Lake City, Utah. Hazardous wastes and toxic wastes are stored on-site at PORTS. On-site disposal does not occur at PORTS. The waste is shipped off-site to commercial incinerators for treatment, based upon availability.

On-site disposal of hazardous wastes and/or toxic wastes does not occur at PORTS. Ultimate disposal of PORTS hazardous wastes and/or toxic wastes depends on the availability of commercial off-site treatment and/or disposal facilities.

All activities involving fissile materials are performed under the requirements provided by the Nuclear Criticality Safety Program.

Section Review

1. *List the PORTS defense nuclear facilities.*

2. *Explain the hazards associated with a UF_6 leak/release.*

3. *Identify the safety significant systems, structures, and components associated with PORTS defense nuclear facilities.*

4. *Identify the buildings monitored by the site CAAS.*

5. *List the six major sources of hazardous wastes are generated at PORTS.*

6. *Describe how PCB wastes are generated at PORTS.*