U.S. Department of Energy
Technical Qualification Program

OAK RIDGE OPERATIONS OFFICE
DEFENSE NUCLEAR FACILITIES

Study Guide

Paducah Gaseous Diffusion Plant

Developed by the
OAK RIDGE OPERATIONS OFFICE
TRAINING AND DEVELOPMENT DIVISION

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REVISION 0

IV. PADUCAH GASEOUS DIFFUSION PLANT

The Paducah Gaseous Diffusion Plant (PGDP) is located in Paducah, Kentucky. All facilities and activities are for the purpose of enriching uranium or safely handling and disposing of the waste generated from that activity. The PGDP 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 PGDP defense nuclear facilities consists of:

- Cylinder Storage Yards
- C-746Q Hazardous and Low-Level Waste Storage Building

Cylinder Storage Yards

The UF_6 Cylinder Storage Yards are open areas on the PGDP plant used for temporary and long-term storage of cylinders filled with solid UF_6. The cylinder storage yards consists of C-745-C, -D, -F, -G, -K, -M, -N, and -P. The mostly gravel cylinder yards were built to support operations at PGDP and are currently used to store solid UF_6 material in various sized cylinders. Most of the cylinders contain depleted UF_6 (tails); however, clean empty cylinders; feed cylinders; cylinders with depleted, feed, or enriched heels or residues up to 3.1% U-235; or cylinders containing product material approximately 2% U-235 may also be stored in these yards. Some cylinder storage yards are controlled by DOE-ORO and others are controlled by USEC. Some yards are jointly controlled by the two organizations.

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 are permitted to 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. The cylinder heads face the aisles to facilitate inspection and physical inventories. The bottom rows of cylinders are positioned on oak or concrete cradles, where the second rows of cylinders rest on top of the bottom row cylinders.

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.

Safety

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. Safety Management programs, procedures, and administrative 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 or a cylinder drop which could result in loss of cylinder integrity. Additionally, PGDP 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. Additionally, 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.

C-746Q Hazardous and Low-Level Waste Storage Building

The C-746Q Hazardous and Low-Level Waste Storage Building (also known as the Green Salt Drum Storage Facility or Solid Waste Management Unit 46A) was constructed in 1978 and has been used since 1980 for the storage of drums containing UF_4, LLW, and other radioactive material, and other RCRA hazardous and mixed wastes.

Process Overview

C-746Q is used to store hazardous, low-level, and mixed RCRA wastes. In addition, some Toxic Substance Control Act of 1976 (TSCA) waste is also stored in this facility. C-746Q is divided into different areas that are used to segregate solid and liquid wastes as well as incompatible waste (e.g., acids and bases). Areas used for storing liquid wastes are diked to provide secondary containment. A separate area is identified for storage of fissile material (e.g., waste oil sludge and magnesium fluoride).

Activities in C-746Q include storing, sampling, repackaging, bulking, sorting, and transportation of RCRA/TSCA wastes. Fissile wastes are stored and transported and may be sampled. Activities involving fissile materials are performed under the requirements provided by the Nuclear Criticality Safety (NCS) Program.

Safety

C-746Q and 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 Portsmouth Gaseous Diffusion Plant (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 NCS Program.

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. Safety Management programs, procedures, and administrative 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 or a cylinder drop which could result in 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.

UF_6 Cylinders

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, but is not limited to, the following equipment: cylinder haulers, railcars, forklifts, cranes, and lifting fixtures. 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. The straddle carriers 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 designed to detect gamma radiation levels that would result from the minimum criticality accidents of concern. When a cluster detects these gamma radiation levels, it activates the cluster's evacuation horn, the building evacuation horns and lights and alarms in the Central Control Facility (CCF). Training and routine evacuation drills are conducted to ensure plant personnel promptly evacuate the affected areas. Additionally, the CCF Operator makes a public address announcement regarding the CAAS activation and the plant emergency staff is activated to respond to the alarm. The system detectors are installed where fissile material is expected to be stored, e.g., C-746-Q Hazardous and Low-Level Waste Storage Building.

Waste Streams

The production of enriched uranium at the PGDP 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

The solid/liquid radioactive and hazardous waste stream from DOE facilities includes:

- Low-level radioactive waste
- Mixed radioactive waste
- Nonradioactive hazardous and PCB waste
- Asbestos
- Nonhazardous, residential, medical, and industrial/inert waste

PGDP generates solid and liquid, low-assay LLW. DOE's largest LLW contributor is construction/ demolition rubble such as dirt, concrete, and gravel generated primarily by environmental restoration and D&D activities. As environmental programs are completed, this source is expected to fall off. Contaminated scrap metal is another form of DOE solid, low-assay LLW. Liquid LLW originated from activities required to maintain the enrichment cascades and consists primarily of water.

The DOE portion of the PGDP waste stream includes a small amount of high-assay LLW from

the routine cleaning of various pieces of process equipment from the enrichment cascades.

DOE manages technetium wastes at PORTS and PGDP. The technetium originated from the early French breeder reactor program and makes the waste classified greater-than-class C LLW.

DOE is responsible for various forms of mixed radioactive waste at PGDP such as hazardous mixed radioactive waste and PCB/radioactive mixed waste. Solid hazardous mixed radioactive wastes are generated as a result of (1) solution treatment processes occurring in the C-400 facility; (2) chemical analyses and procedures performed in laboratories; and (3) fabrication and maintenance that involve equipment repair, rebuilding, construction, metal machining, welding, instrument repair, carpentry, painting, and field services. Many of these activities produce radioactive contaminated scrap metal that also contains a hazardous chemical constituent. Approximately 65% of the solid mixed wastes are generated by D&D; 20% results from environmental restoration. Activities associated with engineering, process support, and legacy waste management make up the remainder.

Mixed radioactive solid wastes at PGDP are composed primarily of PCB-contaminated wastes including dirt/soils, asbestos, absorbent materials, light ballasts, and assorted trash. Construction activities associated with the C-337-A vaporizer facility have uncovered many hazardous as well as PCB- and uranium-contaminated materials.

Liquid mixed wastes originate at PGDP from fabrication, maintenance activities, and chemical operations. Sources of liquid mixed wastes include spent solvents, sludges, discarded commercial cleaners, PCB-contaminated wastes, and waste oils. Many of these wastes contain ignitable, corrosive, reactive, or Toxicity Characteristic Leaching Procedure (TCLP) components. Uranium salvage solutions are another source of liquid mixed waste generated at PGDP.

The liquid hazardous and toxic waste streams are assumed to be mixed wastes unless the absence of radioactive species is demonstrable. Liquid hazardous wastes encompass a wide-ranging set of substances that are toxic, ignitable, corrosive, reactive, or explosive. The wastes are generated by:

- Utility operations which contain chromium
- Fabrication and maintenance activities
- Spills and runoff that generate wastewaters containing hazardous chemicals and PCBs

Nonradioactive hazardous and PCB wastes are generated by five primary sources at PGDP: (1) chemical operations, (2) utility operations, (3) fabrication and maintenance activities, (4) laboratory operations, and (5) remedial action activities.

The major source of asbestos waste at PGDP is friable insulating materials generated by plant maintenance activities. Both radioactive and nonradioactive asbestos wastes are generated by these activities. Small amounts of asbestos that were present on nickel ingots stored by DOE in on-site scrap yards have been abated. This asbestos was part of the mold used during ingot casting. Some of the asbestos adhered to the ingots. An additional legacy source of radioactive

asbestos managed by DOE was the C-340 uranium alloy remelting operation facility, which has been shut down and is undergoing D&D.

Waste Handling/Treatment

No on-site disposal of wastes occurs at PGDP. PGDP wastes are treated at the K-1435 TSCA incinerator located at the East Tennessee Technology Park site in Oak Ridge, Tennessee. Off-site waste disposal occurs at (1) the DOE Hanford Site located in Richland, Washington, and (2) Envirocare of Utah, Inc., which is a commercial radioactive waste disposal facility located 80 miles west of Salt Lake City, Utah. Remaining wastes are stored until provisions can be made for the proper treatment and/or disposal (e.g., waste vitrification facility).

PGDP/ORO is responsible for legacy transuranic waste. The waste is stored in C-746-Q and Solid Waste Storage Area 5 (ORNL). There is no permanent disposal of TRU waste at PGDP. It is assumed that TRU wastes from PGDP ultimately will be disposed of in the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

Section Review

1. *What are the operations for the cylinder yards?*

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

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

4. *Identify the location(s) to which PGDP waste may be transported.*

5. *What is the function of the CAAS?*