U.S. Department of Energy
Technical Qualification Program

OAK RIDGE OPERATIONS OFFICE DEFENSE NUCLEAR FACILITIES

Study Guide

Developed by the
OAK RIDGE OPERATIONS OFFICE
TRAINING AND DEVELOPMENT DIVISION

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REVISION 0

FOREWORD

The information in this study guide was extracted from numerous sources such as facility safety analysis reports, basis for interim operations documents, site web pages, and department procedures, as well as interviews with facility subject matter experts. Though the information is considered to be accurate at the time of writing, this document is uncontrolled and must not be used for performing work in the facilities described.

The intent of this study guide is to present to the reader general information concerning Oak Ridge Operations (ORO) defense nuclear facilities and is not to make the reader an expert on the operation and capabilities of the facilities.

A review exercise covering the material is provided as an attachment. The reader is encouraged to use this review tool and refer to the guide as needed to determine the correctness of responses. A review key may be obtained by contacting ORO Training and Development Division.

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INTRODUCTION

This study guide was developed to support participants in the Department of Energy's Technical Qualification Program (TQP). In the TQP, critical competencies are identified for DOE personnel to demonstrate proficiency in their work positions. The study guide presents information identified through various ORO office/facility-specific qualification standards and is geared towards addressing basically one competency. The target competency states "...personnel shall demonstrate a familiarity level knowledge of the basic operations and processes for DOE-ORO defense nuclear facilities." The terminal learning objective of the study guide matches this competency statement.

The competency is further broken down into the following supporting knowledge and skill statements (which match the enabling learning objectives of the study guide):

- Discuss the primary mission(s) of ORO defense nuclear facilities (e.g., Y-12, ORNL Building 3019, East Tennessee Technology Park, and Paducah and Portsmouth gaseous diffusion plants).

- Describe some of the key operations processes performed at ORO defense nuclear facilities.

- Discuss the major nuclear safety risks to workers and the public resulting from operations at ORO defense nuclear facilities.

- Identify the major non-nuclear hazards associated with ORO defense nuclear facility operations.

- Discuss the primary safety systems and features at ORO defense nuclear facilities for preventing or mitigating operational accidents.

- Discuss the ORO's defense nuclear facilities' major waste streams from generation to disposal. (Senior Technical Safety Managers only)

This competency (and supporting knowledge and skills) was included in the following DOE ORO qualification standards:

- Assistant Manager for Construction and Engineering
- Emergency Management Program Office
- Environmental Management
- Portsmouth Site Office
- Paducah Site Office
- Safeguards and Security
- Senior Technical Safety Managers
- Training and Development Division

Learning Objectives

<u>Terminal Learning Objective</u>

After reviewing this study guide, Oak Ridge Operations (ORO) TQP participants shall demonstrate a familiarity level knowledge of the basic operations and processes for DOE ORO defense nuclear facilities.

<u>Enabling Learning Objectives</u>

1.1 **LIST** the ORO defense nuclear facilities.

1.2 **IDENTIFY** the primary mission(s) of the ORO defense nuclear facilities.

1.3 **DESCRIBE** the key operations processes performed at ORO defense nuclear facilities.

1.4 **EXPLAIN** the major nuclear and non-nuclear safety risks to workers and the public resulting from operations at ORO defense nuclear facilities.

1.5 **STATE** the primary safety systems and features at ORO defense nuclear facilities for preventing or mitigating operational accidents.

Senior Technical Safety Managers only

1.6 **SUMMARIZE** ORO's major waste streams from generation to disposal.

OVERVIEW

Based in Oak Ridge, Tennessee, the Department of Energy's Oak Ridge Operations Office (ORO) is rich in history, dating back to World War II when the organization played a major role in the production of materials for the first atomic weapon. Since then, ORO has expanded far beyond that first mission and today supports more than 60 major Department of Energy (DOE) activities including major energy research and development programs, dismantling and storing nuclear weapons components, environmental management, managing the national Formerly Utilized Site Remedial Action Program (FUSRAP), managing the closeout activities for the Superconducting Super Collider Project, landlord responsibility for the United States Enrichment Corporation, and various educational programs. This study guide will focus on one important aspect of ORO, defense nuclear facilities.

By definition, defense nuclear facilities include production and utilization facilities, facilities involved in assembly, disassembly, testing of weapons, and nuclear waste storage facilities (DOE Order 140.1-1). ORO sites at which defense nuclear facilities are located include:

- Y-12 — Oak Ridge, Tennessee
- East Tennessee Technology Park — Oak Ridge, Tennessee
- Oak Ridge National Laboratory — Oak Ridge, Tennessee
- Paducah Gaseous Diffusion Plant — Paducah, Kentucky
- Portsmouth Gaseous Diffusion Plant — Portsmouth, Ohio

I. Y-12

In light of recent nuclear arms reduction treaties and the end of the Cold War, the dominant role of the Y-12 Plant has shifted from weapons production to maintenance of the existing stockpile and dismantling and storage of retired weapons components. The Oak Ridge Y-12 Plant defense nuclear facilities support ten programmatic elements that together support national Defense Program missions. These ten programmatic elements are implemented through five functional organizations.

- Disassembly and Storage Organization (DSO)
- Depleted Uranium Operations (DUO)
- Enriched Uranium Operations (EUO)
- Special Materials
- Development Operations

The programmatic elements and their missions are:

- The Nuclear Materials Management and Storage Program mission is to receive, store, protect, and manage strategic and nuclear materials.

- The Quality Evaluation and Surveillance Program mission is to provide evaluation, scheduled surveillance, enhanced surveillance, and testing of weapon components and assemblies to assess the integrity and life expectancy of the stockpile.

- The Weapons Receipt, Dismantlement, and Disposal Program mission is to receive, dismantle, and disposition retired weapon components and subassemblies from the stockpile.

- The Stockpile Evaluation and Maintenance Program mission is to support maintenance and evaluation of the stockpile through manufacturing, process technology, and development support. This program provides the manufacture and delivery of directive schedule requirements including war reserve components, joint test assemblies, and limited life components.

- The Material Recycle and Recovery Program mission is to recycle and recover highly enriched uranium (HEU) and lithium-6 materials from process residues, dismantlement operations, and manufacturing processes.

- The Facility Transition Program mission is to reduce the Defense Programs' footprint and landlord responsibilities by identifying and preparing facilities and related infrastructure for deactivation and safe shutdown.

- The Enriched Uranium Operations Process-Based Restart Program mission is to achieve resumption of Enriched Uranium Operations in the Y-12 Plant.

- The Nuclear Packaging Systems Program mission is to provide certified and economical packaging for transporting and storing radioactive and hazardous materials.

- The Advanced Manufacturing, Design, and Production Technologies Program mission is to continue and accelerate the development and prototyping of advanced, cost-effective, environmentally-acceptable nuclear weapons production technologies and design processes required to maintain an affordable and reliable nuclear weapons stockpile.

- The Manufacturing Processes and Stockpile Support Systems Program mission is to implement and maintain production processes and manufacturing information systems that are responsive to weapon component production requirements in support of the weapons stockpile and national security needs.

Y-12 has literally over a hundred buildings that fall into the category of defense nuclear facilities and all are enclosed within the protected area in the west end of the plant.

Disassembly and Storage Organization

DSO includes:

1. Nuclear Materials Safeguarded Shipping and Storage Warehouse — The mission carried out in the warehouse includes the shipping and receiving of nuclear materials, materials management, material verification, storage, container unpacking, and glovebox operations.

   The warehouse, Building 9720-5, contains storage vaults, modular storage vaults, storage cages, weighing stations, confirmatory measurement, forklifts, and criticality accident alarm stations. The materials handled in the warehouse include uranium, lithium, beryllium, and thorium and come in the form of canned subassemblies, fuel assemblies, oxides, metals, and alloys.

2. Quality Evaluation — The mission of Quality Evaluation (QE) is to perform stockpile evaluation for special nuclear material (SNM) and non-nuclear components. QE provides for the activities required to assess the integrity of the stockpile including safety, reliability, design compatibility, and functionality of components over the weapon’s stockpile life. Confidence in the safety and reliability of the nation’s nuclear weapon stockpile is acquired and sustained through a QE program beginning in early production and continuing throughout each weapon’s stockpile life to retirement. The condition of the stockpile is determined through a number of unique tests.

   Quality Evaluation, Building 9204-4, contains equipment such as improved moisture outgassing monitors, inert gloveboxes, matching equipment, drying ovens, nondestructive test booth, thermal decomposition ovens, multimass leak detection, gas sampling, disassembly booth, assembly stand, storage areas, and criticality accident alarm stations. The materials handled here include uranium, lithium, beryllium, and thorium in the form of canned subassemblies, fuel assemblies, oxides, metals, and alloys.

3. Disassembly and Assembly Operations — The mission of Disassembly and Assembly Operations is for the production, special production, test assemblies, disassembly, material verification/accountability, and container refurbishment and storage. Warhead components (without explosives) are returned to Y-12 as weapon systems directly from the military or from the Pantex Plant after initial dismantlement. At Y-12, these components are stored in various material access area storage facilities prior to further disassembly. Many of the disassembly processes required to separate and remove the various components have been implemented, while other processes are being developed or modified to enhance protection of personnel health and safety, or to the environment. The nuclear and special materials are sent to the appropriate processing steps for material recycle; the remainder of the components are sanitized and/or demilitarized (e.g., by melting and recasting, pyrolysis, or chemically altering the material to remove classified features of the components).

   Major equipment involved with Disassembly and Assembly Operations in Building 9204-2E includes environmental room, disassembly walk-in booth, electron beam welder, laser welders, high-vacuum leak detectors, vacuum furnaces, linear accelerator, computer-controlled measuring machines, x-ray equipment, component cleaning, dimensional inspection, dye penetrant, and criticality accident alarm stations. The materials handled here include uranium, lithium, beryllium, and thorium in the form of canned subassemblies and components.

Depleted Uranium Operations

The mission of DUO is to manufacture weapon components from depleted uranium, depleted uranium alloys, and non-uranium metals such as steel and aluminum.

DUO facilities (Buildings 9998, 9201-5, 9215, 9204-4, 9201-5N, and 9201-2) contain furnaces, molds and crucibles, saws, shears, presses, welders, mills, lathes, ultrasonic cleaners, dimensional inspection, x-ray, and dye penetrant. Materials handled in the facilities include depleted uranium, uranium oxides, chips, and fines, and beryllium in the form of virgin metal, scrap, reclaimed parts, billets, and ingots.

<u>9201-5</u>

Arc Melt Operations are the primary DUO activity and are located in Building 9201-5. Arc Melt Operations process depleted uranium (DU), DU alloys, and non-uranium materials. The operation primarily melts and casts DU-alloys (U-2 wt % [niobium] Nb) with Nb metal to produce U-6 wt % Nb DU-alloy. Additional processes performed include DU scrap metal processing, sawing, DU oxide and sawfines mixing, and depolymerization and melting operations.

In addition to Arc Melt Operations, 9201-5 houses other independent operations which are explained later. Those operations include EUO storage area, Beryllium Operation, 9201-5E Production Machining Operation, 9201-5W Production Machining Operation, Lithium Storage Area, and a Certification/Dimensional Testing Operation.

DU and DU-alloys present radiological and toxic hazards. All equipment associated with processing these materials remains contaminated with DU and DU-alloys. Other hazards are associated with sodium-potassium (NaK). NaK is used as a coolant for the skull casting operation and is extremely reactive with moisture and most other liquids. The NaK/moisture reaction presents an explosion hazard and generates caustic sodium hydroxide and potassium hydroxide, both of which are irritants to the eyes, skin, and respiratory tract.

9201-5N

Together with 9201-5, 9201-5N houses the Production Machining Operations. Production Machining Operations process DU metal, DU metal alloys, and non-uranium metals such as steel, aluminum alloys, cast iron, magnesium alloys, and bronze. These processes consist of standard industrial operations such as milling, sawing, wire-feed electrical discharge, single-point turning, lopping, grinding, and boring.

Process Overview

DUO includes seven primary processes. These processes and facilities are:

H-1 Foundry Operations — The H-1 Foundry in Building 9998 houses thirteen induction casting furnaces where virgin metal, salvageable scrap, and reclaimed parts are cast into billets, ingots, and other shapes using a vacuum induction melt casting process. Non-routine operations include processing non-uranium metals, sintering compacts, high temperature heat treatment, and swaging.

Rolling and Forming Operations — The Third Mill Area within 9215 houses the 66-inch Bliss Rolling Mill where uranium and other metal billets can be rolled. Associated processes include heat treating, shearing, and machining blanks of depleted uranium, depleted uranium alloys, and other metals. The P-Wing Area within Building 9215 houses the Sendzimir Secondary Rolling Mill and Fenn Rolling Mill where precision sheet and foil are rolled. This area also houses hydro-forms and a 200-ton press where sheet material is pressed into shapes. Associated processes include furnaces for heat treating, annealing, and aging of metals.

Arc Melt Operations — The Arc Melt Operations in Building 9201-5 primarily melts and casts depleted uranium alloys 2% and 6% niobium into billets that are rolled into plate at the Third Mill; then blanked and formed for machining into components. The processes are vacuum arc melting, skull cast melting, sawing, scrap consolidation, depleted uranium oxide and saw fines mixing and disposal, and scrap storage.

Metal Working — The metal working operations (Building 9204-4) house three large conventional triple-action presses where blanks are pressed into shapes for machining. Associated processes include heat treating furnaces, shears and torches for cutting metal, grit blasters for cleaning metal, and a coordinate measuring machine for measuring formed parts. An explosive forming facility is located to the north of Building 9204-4 and is used frequently to form large reactor components.

Production Machining — The production machining operations are housed in Buildings 9201-5W and 9201-5N and consist of a wide array of state-of-the-art machine tools that are used to machine depleted uranium, depleted uranium alloys, and standard industrial materials into finished weapons components. The processes include milling, turning, sawing, electrical discharge machining, lapping, grinding, and boring with both computer-controlled and manually-operated machine tools of various sizes.

Plating and Surface Coating Operations — The plating and surface coating operations include ion plating and precious metals plating in 9201-5N, nickel and cadmium plating in 9204-4, and the general plating facility in Building 9401-2. The 9201-5N and 9204-4 plating facilities are located in controlled areas where depleted uranium and uranium alloys are plated.

Inspections Operations — The inspections operations include dimensional, radiography, dye penetrant, ultrasonics, and other nondestructive testing processes that are conducted in 9201-5, 9204-4, and 9201-5N.

Enriched Uranium Operations

The mission of EUO is to process highly enriched uranium (HEU) safely into usable uranium products or into forms suitable for storage. The casting operations can produce weapons components, reactor fuel, or convert retired weapons material into forms suitable for long-term storage. The chemical recovery operations recover and purify HEU from scrap generated by Y-12 Plant operations or from off-site commercial customers.

EUO facilities (Buildings 9206, 9212, and 9215) contain furnaces, neutron sources, wet and dry vacuum systems, presses, shears, rollers, recovery and purification, chemical, decontamination, and criticality accident alarm stations. The equipment is designed to provide control of airborne contaminants individually in forms ranging from spot ventilation to complete enclosures with glove ports. Materials handled in the facilities include enriched uranium billets, buttons, chips, scraps, and solutions that are handled in cans, drums, birdcages, safe bottles, and tanks.

EUO products include the following:

- Oxide or metal for storage
- Reactor fuel (uranium oxide)
- Specialty compounds (for standards or research)
- Reactor fuel (uranium metal or uranium alloy), and
- Weapons components

<u>Process Overview</u>

EUO has three process functional areas: manufacturing and inspection; chemical recovery process; and storage/decontamination/transportation activities.

Manufacturing and Inspection Operations — The primary mission of EUO manufacturing operations is to fabricate metal shapes as needed for nuclear weapons and to provide storage and handling of enriched uranium inventories.

Enriched uranium feedstock is prepared in E-wing/9212 and cast into either a part shape or a billet. Part shapes are transferred to Building 9215 M-wing, where the part is machine finished. Billets are transferred to Building 9215 O-wing, where they are rolled and formed. After processing, the billet is transferred to M-wing for final machining.

Chips from M-wing machining activities are collected in a storage and transfer area known as the "Blister". From the Blister, the chips are transferred to Building 9212 E-wing for reprocessing and reuse. The Blister, which adjoins M-Wing, also contains a high-rise storage facility.

Chip Processing Operation — The Chip Processing Operations consist of cleaning, drying, and compressing enriched uranium chips into briquettes. The chips are generated from machining operations and are sometimes referred to as machine turnings. Chips are transported and temporarily stored in nuclear-favorable chip cylinders on dollies. Each cylinder contains a removable basket which holds the chips that need to be cleaned (degreased). The chip cleaning facility in Building 9212, Room 1009 has two processing lines consisting of a water wash, freon dryer, and ultrasonic cleaners. The chips are cleaned, dried, and compressed into briquettes for use such as a source for casting feedstock.

The drying hood contains an area for emptying a basket of degreased chips and provides access to the four drying ovens. Given the reactivity of the uranium chips with the air (pyrophoristic), a continuous positive flow of argon is maintained through the drying hood during the drying process.

After drying, the chips are transferred to the press hood. The press hood also has an argon atmosphere and contains a 75-ton hydraulic press. The press is used to compress the chips into a briquette. The briquette is then pushed into a removal box below the press, retrieved, and placed into a plastic bag which is placed into a hospital can and stored in the batch make-up area.

Metal Pickling Operation — Pieces of oxidized or plated enriched uranium metal (e.g., rolling mill scrap, broken/sheared metal, and broken buttons) are cleaned in the Metal Pickling System to prepare them for casting feedstock. The metal is cleaned in a nitric acid solution to remove oxide, grease, and salts. After the pickling operation is complete, the material is transferred to storage for later use.

Casting Operations — Casting activities include batch make-up, stack assembly, furnace operation, and stack disassembly. A batch normally consists of reduction buttons, rolling mill scrap, retirement scrap, and/or lugs removed from previous cast shapes. Various combinations of batch makeup materials are used to control the chemistry of the batch. Batches are weighed, placed in stainless steel pans or hospital cans, and then transferred to storage racks as needed.

The stack assembly consists of the pallet subassembly, the mold subassembly, and the crucible subassembly. The pallet subassembly forms the foundation for the stack. The mold subassembly contains the mold for the cast shapes and has overflow holes to permit any molten uranium to flow into the nuclear safe catch ring. The crucible subassembly sits on top of the mold assembly and contains the metal pieces (batch make-up) to be melted. The stack assembly is charged by selecting the casting batch from storage for the specific part to be cast. The stack assembly is transferred to the vacuum induction furnace where the metal is melted. After the melt is complete, a rupture disc in the bottom of the crucible is punctured by an operator, allowing the melt to empty into the mold subassembly located in the stack assembly below the crucible. The stack assembly is unloaded from the furnace and the casting is removed. Depending on whether the part is a shaped part or billet, the cast is then ready to be machined or rolled and formed.

Rolling and Forming Operations — Uranium billets are received in O-Wing from Building 9212 Casting Operations and are processed using operations such as heat treating, rolling, shearing, and forming. The principle equipment is housed inside an enclosure that isolates the enriched uranium from the surrounding space. The billets are preheated using salt baths in preparation for rolling. The heated billets are rolled into plates of various thicknesses in the primary rolling mill. Salt baths are then used to anneal the plates.

A sheet rinse is used to wash residual salt crystals from plates treated in the salt baths. The spray water is drained to safe-geometry tanks in the basement, filtered, and pumped back to the spray nozzles. Recirculating the rinse water through the filters removes enriched uranium and associated oxides suspended during rinsing operations.

After rinsing, the plates pass through a roller leveler unit that removes the warp-deformation created during the annealing process. The square plates are then heated using a propane-oxygen torch system and are cut into two pieces in the square shear. Plates are stored in a rack located inside the process enclosure.

A circle-shear cuts circular blanks from the plates. The remaining scrap metal is removed from the enclosure and processed for recycle. A vertical turret lathe outside the enclosure is used to cut blanks from plates that are too thick for the circle-shear.

In preparation for pressing, the blanks are heated in an argon atmosphere in the hydroform preheat oven. Heated blanks are then pressed into the desired shape in the hydroform.

The formed shapes are placed in individual birdcages that are stored in designated racks prior to being shipped for further processing. Additionally, an Abar vacuum furnace and a packaged salt-annealing and washing system (Ajax system) are available for heat treatment and annealing.

Machining Operations — Enriched uranium cast forms from Building 9212 and pressed forms from Building 9215 are received in the M-Wing Blister Area. Forms may be placed in either of two interim storage arrays or taken directly to a machine station to be machined to final dimensions. Machining is performed using both computer-controlled and manual machine tools, such as lathes, milling machines, and drill presses. Although specific operations differ from machine to machine, the basic features are essentially identical at each location. During machining, a low-velocity jet of aqueous machine coolant containing propylene glycol and dissolved boron is directed at the cutting location to cool the machine tools and to prevent the cuttings (chips) from igniting spontaneously. The cuttings from the machine operations are collected in a coolant reservoir that keeps the chips wet to prevent fires. Chips are transferred to stainless steel hospital cans as necessary to prevent overflowing the reservoir.

A small enclosure confines the cutting area at each machine station. Air from this space is exhausted to the process ventilation exhaust system. A mist eliminator at each machine removes coolant aerosols and entrained uranium particles and also serves to prevent chips from reaching exhaust filters.

Several birdcage storage areas (fissile storage arrays) are located in the machining, shipping, and inspection areas for storage of finished parts. Long-term storage of finished parts is provided in the Blister.

Machine coolant from machining operations is recirculated. It is passed through a screen filter at each machine and returned to tanks and pumps in the basement. There the coolant is collected in favorable geometry settling trays that collect most suspended particles. The overflow is collected in tanks lined with boron alloy plates and pumped back to the operating machines. Collected solids are removed from the settling pans and the coolant is purified in centrifuges, filters, and ion exchange units. The purified coolant is stored for reuse. Uranium collected during coolant purification, along with contaminated filters and ion exchange resins, is sent to Building 9212 for recovery and recycle.

Mop water normally containing only small quantities of enriched uranium is drained to favorable geometry tanks located along the south wall in the M-Wing basement. Water containing uranium is transferred to Building 9212 for uranium recovery. The purified water is transferred to an exterior tank for disposal. The exterior tank is not geometry favorable.

Finished enriched uranium metal parts are dimensionally inspected and certified in the H-2 Dimensional Inspection Area. Individual machine stations similar to those in M-Wing are also available in the H-2 area for machining. The H-2 storage area provides additional storage capacity for SNM.

Material handling activities within the M-Wing Blister area include shipping and receiving, collection, packaging, and storage. Incoming and outgoing enriched uranium scrap metal is stored in high bay racks. Chips from machining operations are transferred to the chip-packing station in the Blister where the chips are collected for transfer to recycle operations in Building 9212. In preparation for transfer, cans are dumped into one of two favorable geometry tanks mounted on a dolly. Liquid Freon is added to keep the chips wet. Long-term storage of finished parts is provided in vaults.

Inspection — Product certification is a critical element of weapons production. To ensure the product meets design specification requirements, various types of nondestructive tests are performed. Nondestructive testing certification includes physical and dimensional measurements, hydrostatic density testing, density determination, ultrasonic testing, dye penetrant testing, visual inspection, and radiographic examination. Dimensional Inspection primarily is concerned with physical measurements such as height, radius, contour, wall thickness, and generally those dimensional parameters that will assure proper assembly interface. Other inspections are generally concerned with physical properties such as material soundness, mass-distribution uniformity, bulk density, fabricated-joint integrity, material strength, and microstructure.

Chemical Recovery Operations — While the basic scheme of uranium recovery and purification can be described in simple terms, the actual processes require complex chemistry and equipment. The recovery and purification process can be divided into the following five general groupings:

1. Bulk reduction and dissolution for HEU concentration (headend),
2. Purification and recovery of the HEU (continuous recovery),
3. Conversion of the HEU to metal (reduction),
4. Production of special materials and special scrap dissolution (special processing), and
5. Nitrate waste processing and non-HEU-materials recovery (waste streams and material recovery).

HEU is processed to produce uranium metal and oxide suitable for storage, reactor fuels, specialty compounds, or weapons components. The recovery and purification operation reprocesses HEU-bearing scrap and waste into forms suitable for reuse or accountability of the HEU contained therein. The majority of this scrap and waste is generated by the Y-12 Plant's weapon production or disassembly operations and by the recovery processes themselves. Some scrap and waste is generated through nuclear materials production; additional scrap is received from other sites for recovery or for accountability of the HEU it contains. The nature of these HEU-bearing materials varies from combustible and noncombustible solids to aqueous and organic solutions. Concentrations of HEU vary in these materials from pure uranium compounds and alloys to trace quantities in combustibles and solutions.

The recovery and purification process for HEU relies on the unique physical and chemical properties of uranium in a nitrate system, where uranium forms a strong cationic complex with nitrate anions in the form of uranyl nitrate. The approach to recovery and purification, therefore, consists of chemically changing HEU (contained in scrap and waste) into a nitrate solution through dissolution, leaching, and other processes and using the chemical properties of uranium to concentrate, purify, extract, and, finally, convert the HEU into a pure, metallic form.

Storage/Decontamination/Transportation Activities — EUO storage provides primarily short term storage for special processing. Horizontal safe tanks can function to receive and transfer solutions. The liquids stored come from precipitator filtrate, tray dissolvers, and beaker leaching operations as well as mop-water solutions. Also safe tanks are used to store and process trap solutions from Building 9818 operations.

Numerous in-process storage arrays are located throughout EUO facilities. Some arrays are directly associated with processes (e.g., an approved secured location for a safe bottle adjacent to a hood where waste solutions can be gathered). In other cases, they are formally approved storage arrays. In all solution areas, approved storage locations are marked by sunbursts or by rigid structures that maintain approved spacing. Materials stored on carts can be stored in open areas because the design of the cart ensures that favorable geometry spacing is maintained.

EUO uses many types of approved containers: Y-12 Plant-approved containers including safe bottles and birdcages; U.S. Department of Transportation (DOT)-, DOE-, and NRC-approved off-site shipping containers; drums; sealed plastic bags of combustibles; and Y-12 Plant-approved dollies, such as safe bottle dollies, chip dollies, and salt bath liner dollies. In addition to approved containers for handling and transporting uranium materials, approved housekeeping equipment and sample carriers (transfers samples to the plant lab) are used in EUO processing areas.

Decontamination activities serve to reduce operation costs by allowing areas and equipment to be used again in EUO or other areas. Decontamination efforts also serve to reduce facility man-rem exposure, improve task performance schedules, and minimize waste production from EUO processes. Decontamination methods include sandblasting, grinding, acid baths, and general cleaning with soap and water.

Special Materials

The mission of Special Materials is to salvage and recycle lithium including wet chemistry processes, metal production, powder production, parts production, machining, and storage for weapon production. Lithium hydride and deuteride are processed through a series of chemical operations to recover purified lithium in the form of lithium chloride powder. Lithium hydride and lithium deuteride components from retired weapons are sent to Building 9204-2 to be placed into material accountability and stored in one of two storage areas: Buildings 9201-5 and 9720-46. The stored materials are run through a series of chemical operations in Building 9204-2 to convert the lithium hydride and deuteride compounds into lithium chloride.

Special Materials facilities (Buildings 9204-2, 9720-46, 9201-5) contain a hydrogen generator, neutralization tanks, evaporators, calciners, reduction furnaces, conversion ovens, crusher grinders, gloveboxes, and presses. The material types handled in the facilities include nitrogen, chlorine, argon, hydrogen, deuterides, and lithium compounds. The materials are handled in the form of powder, gases, and metals.

Development Operations

The mission of Development Operations is the advanced development, process development, and process support for the nuclear weapons complex. The goal is to accelerate the development and prototyping of advanced, cost-effective, and environmentally acceptable nuclear weapons production technologies and design processes required to maintain an affordable and reliable nuclear weapons stockpile. Functions of Development Operations include advanced development, process development, and process support for the nuclear weapons complex; plant assistance and troubleshooting for the Y-12 Plant; and various work-for-others projects.

Research and development includes a multitude of operations and experimental techniques such as processing of metals and ceramics, synthesis of organic compounds, microanalysis, robotics, computer software development, precision machining and measurement, and materials recovery.

These operations are carried out in approximately 80 laboratories in four major buildings. These facilities (Buildings 9202, 9731, 9203, and 9998) contain various laboratory equipment, foundry equipment, various instrumentation, gloveboxes, and presses for the process support mission. Not all of these buildings are located within the Protected Area. Materials handled in these facilities include uranium compounds, lithium, beryllium, hydrogen, and ceramics.

Weapons Dismantlement, Storage, and Evaluation — Work in this area includes some oversight of the disassembly of returned weapons components and quality evaluation for the existing weapons stockpile. Minimum processing is used to reach a state of safe, secure, legally compliant, and economical storage of the materials.

Enriched Uranium Material Warehousing and Management — This area of work includes some oversight of the secure storage of Special Nuclear Materials (SNM) and processing of enriched uranium for various applications.

National Security Programs — This office provides support to DOE in the development and monitoring of arms control and nonproliferation. The group also provides support for national and international nuclear safeguards procedures development and implementation and operates the Nuclear Materials Management and Safeguards System.

Safety

9201-5 houses Depleted Uranium Operations and DU and DU-alloys present radiological and toxic hazards. All equipment associated with processing these materials remains contaminated with DU and DU-alloys. Other hazards include sodium-potassium (NaK). NaK is used as a coolant for the skull casting operation and is extremely reactive with moisture and most other liquids. The NaK/moisture reaction presents an explosion hazard and generates caustic sodium hydroxide and potassium hydroxide, both which are irritants to eyes, skin, and respiratory tract.

EUO storage areas may present hazards in the form of contamination and combustible material. EU-contaminated combustibles include mopheads, wipes, protective clothing, and similar items. The EU, primarily U-235, is dispersed throughout the building and is not considered to be a criticality hazard due to the concentration levels and mass present.

Nuclear facility processes contain numerous safety-related SSCs to protect workers, structures, the environment, and the public. The following is a partial list of safety-class, safety significant, or defense-in-depth structures, systems, and components (SSCs) found in Y-12 defense nuclear facilities.

- HEPA filters — installed in exhaust ventilation ducts to mitigate the release of EU particles.

- Fire detection and Halon extinguishing systems — detects fires, isolates appropriate section(s) of ventilation ducts, and activates the Halon release to extinguish the fire.

- H_2 detectors — detects presence of hydrogen gas inside and outside an area. At a H_2 concentration of 1.6%, the H_2 detector activates an alarm and shuts H_2 block valves and opens a vent valve to allow the H_2 to vent to the roof. H_2 gas in concentrations greater than 4% will burn and concentrations greater than 8% can be explosive.

- Tube furnace door seal — prevents in-leakage of air to the furnace or out-leakage of H_2 from the furnace.

- Control interlocks — tube furnace low exhaust flow interlock detects a loss of exhaust ventilation flow from the tube furnace enclosure and shuts H_2 block valves and opens a vent valve. This interlock prevents an accidental H_2 leak from building up to a flammable level while exhaust ventilation is not running.

- Destruction distillation unit (DDU) pressure relief door — provides overpressure relief path to mitigate the consequences of an explosion inside the DDU.

- Building H_2 supply excess flow valve — shuts off H_2 flow to the building if flow rate exceeds setpoint. Excess flow valve prevents buildup of dangerous levels of H_2 .
- Reduction reactor vent fan shaft speed interlock — detects a loss of reduction reactor exhaust ventilation by sensing a reduction in fan speed and then automatically shuts off H_2 flow.

- Reduction reactor enclosure exhaust fan interlock — ensures that H_2 flow to reduction reactor is blocked whenever the enclosure exhaust flow rate is too low to adequately dilute a H_2 leak in the enclosure.

- Reduction reactor H_2 manual isolation switch — shuts H_2 supply isolation valve to reduction reactor.

- Tube furnace H_2 supply flow orifice — limits H_2 flow rate to a value below a flammable level considering minimum vent exhaust flow.

- Tube furnace exhaust oil-filled traps and door seals — prevents air (O_2) from back flowing into the furnace and causing back flash (H_2 combustion).

- High capacity and intermediate capacity evaporators steam supply pressure relief valves — prevent steam pressure and steam temperature from rising to a level that would support *red oil* conditions (explosion). Additionally, the pressure relief valves ensure that the design pressure of the heat exchangers are not exceeded.

  [Red oil condition — involves TBP (tributylphosphate) and nitric acid (HNO_3) mixtures at elevated temperatures under increased pressures. TBP and HNO_3 produce vigorous chemical reaction in which organics are oxidized with nitric acid.]

- Muffle furnace blast door — prevents the explosion of debris from an over-pressurization event.

- Phase separator devices — to provide separation of organics and HNO_3 constituents and prevent the introduction of organics further into the process.

- Process tank vents — prevent pressure buildup in a tank during an organic/nitrate reaction.

- Pencil (safe geometry) tanks — limit thermal runaway of red oil reaction by providing a high surface area-to-volume ration that results in a large amount of heat transfer from the surface.

- Dry vacuum trap level monitoring and DDU/carbon burner — to alarm and automatically shut off the associated vacuum producer when the secondary cyclone or bag filter tank trap rises to a predetermined setpoint. The bag filter presents an unfavorable geometry where if the trap were to become full with EU, a criticality could occur.

- Dry vacuum fire sprinkler actuation interlock — detects sprinkler system flow and shuts off all three dry vacuum producers. System consists of a pressure switch to sense sprinkler system flow and relays to shut off the vacuum producers.

- Dry vacuum bag filter differential pressure interlock and DDU/carbon burner — prevents an excessive buildup of EU dust on the bag filters in the dry vacuum system bag filter tank.

- Casting furnace water detection system — detects water in the casting furnaces, alarms, and shuts off furnace cooling water and power. Each of the 14 casting furnaces has a water detector and interlock.

- Wet vacuum conductivity probe interlock — detects solution EU in one of the final wet vacuum system traps and closes an isolation valve to stop the flow of material through the system.

- CAAS — Detects criticality and alarms an evacuation signal (audible and visual) to personnel within 200 feet of the accident.

- Auxiliary casting furnaces Pu-Be sources — mitigates the consequences of a criticality in the auxiliary casters due to molten enriched uranium leaking from the casting assembly and assuming an unfavorable geometry.

- Complex utility backflow preventer — prevents EU-bearing process solution from backflowing into the unfavorable geometry of instrument air or process water supply systems.

- Drain holes in unfavorable geometry equipment — prevent the accumulation of process solution containing EU in equipment structures that are not favorable geometry designs. Drain holes allow the solution to leak out to the floor in a favorable geometry.

- ½-inch gap in dry vacuum baghouse enclosure doors — allows water to flow out of baghouse enclosures and thereby remove moderator from EU area.

Buildings 9212 and 9215 contain EU. The EU handled in MAAs is a fissile material with the attendant potential for nuclear criticality. The safety significance of systems that support machining is due almost entirely to the possibility of accumulating unsafe quantities of enriched uranium through various combinations of hardware failure and failure to follow established procedures. Similar failures during handling and storage can lead to unsafe conditions.

Beryllium (Be) is also found in several defense nuclear facilities in the Y-12 West End. Be is a toxic metal that is carefully controlled under the industrial hygiene program. Beryllium oxide is toxic due to the presence of Be. Airborne Be can cause pulmonary disorders including coughing, berylliosis, and possible cancer. Be is also an eye irritant.

Building 9720-5 presents some significant safety concerns due to the materials frequently stored there. As a warehouse in a manufacturing environment, the building includes the standard industrial hazards: electrical energy, thermal energy, kinetic energy, and potential energy. Additionally, the building frequently houses radioactive materials such as EU, thorium, uranium, and neptunium. The building also houses toxic/corrosive/carcinogenic/reactive materials such as uranium, lithium hydroxide/deuteride, deuterium, UF_6, beryllium, and deterrent foam.

Building 9720-5 is equipped with two safety significant systems: the fire protection system and CAAS. The function of the fire protection system is to detect a fire condition, activate the fire suppression system, and provide alarms and signals that notify personnel of the extent and location of a fire. 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

Just as Y-12 has the most defense nuclear facilities in the ORO complex, Y-12 also has the most diverse waste stream for ORO. Characteristics of the Y-12 waste stream, just as other defense facility waste streams, have undergone major changes as the facility missions have changed. These characteristics shall continue to change as the new mission(s) is better defined.

The following are the Y-12 waste management/processing facilities:

- Liquid Storage Facility
- Groundwater Treatment Facility
- Uranium Chip Oxidation Facility
- Waste Coolant Processing Facility
- Plating Rinsewater Treatment Facility

- Central Pollution Control Facility
- Cyanide Treatment Facility
- West End Treatment Facility
- Steam Plant Wastewater Treatment Facility
- Lake Reality
- Trash Monitoring Station
- Waste Feed Preparation Facility
- East End Waste Facility
- Plant Storage Facilities

Three of these facilities are of primary concern for defense nuclear facilities:

- Uranium Chip Oxidation Facility
- Central Pollution Control Facility
- West End Treatment Facility

Uranium Chip Oxidation Facility — The Uranium Chip Oxidation Facility (UCOF) reduces the volume of the depleted uranium materials received and converts them to the chemically stable (U_3O_8) oxide form.

UCOF processes one 55-gallon drum in an oxidation chamber at a time. Processing includes uranium chip handling, weighing, and oxidation; system off-gas treatment; and uranium oxide handling and packaging.

Uranium metal chips are received at UCOF in 55-gallon drums that also contain machine coolant. This coolant, which is used during machining in this case, reduces the exposure of chips to air and, consequently, the potential for fire. Nitrogen blankets are used around the drums to further reduce exposure to air when the drum contents are inspected. After the drums containing the chips and machine coolant are weighed using a jib crane scale, the drums are emptied onto a chip feeder tray. The machine coolant drains to a 600-gallon poly tank, which will be sent to the Waste Coolant Processing Facility. The chip feeder tray is remotely operated to dump the chips into one of six oxidation (burn) chambers. If the chips do not spontaneously ignite, a burning sheet of paper is used to ignite them. Additional air is mixed with the off-gas after leaving the burn chamber. The off-gas passes through one of the redundant banks of filters before discharge to a stack. Each bank consists of a moisture separator, pre-filter, and HEPA filters. Any moisture collected by the separators is combined with the machine coolant in the 600-gallon poly tank. Automatic switching to the redundant equipment occurs if a low or high differential pressure is measured across the filters or if an exhaust fan trips off. As part of the automatic switching, the primary fan is de-energized when the redundant equipment is energized. The stack is equipped with sample devices to monitor for uranium in the off-gas. An alarm sounds if the uranium concentration in the off-gas exceeds a predetermined level.

Water from a circulating cooling water system is sprayed onto the exterior walls of the oxidizers for cooling. The water is pumped from two interconnected water surge tanks by two of three cooling water recirculation pumps, then through two of three cooling water filters to the spray system and onto the oxidizer. The cooling water drains to a collection pan and back to the cooling water supply system. When oxidation is complete and the oxide has cooled, a screw conveyor at the bottom of the oxidizer transfers the uranium oxide into a 55-gallon drum. The facility uses a central vacuum system during the oxidizer unloading process to contain uranium oxide particles that might otherwise escape around the top of the drum being loaded. Any uranium oxide trapped by the central vacuum system is collected in a drum. This drum and the regular drums of uranium oxide are transferred to the Y-12 Uranium Oxide Storage Vaults.

Central Pollution Control Facility — the Central Pollution Control Facility (CPCF) is the primary facility for the routine treatment of wastes that are not nitrated. The CPCF receives concentrated acidic or caustic wastes and oil and mop-water wastes containing beryllium, thorium, uranium, emulsified oils, and commercial soaps or cleansers. The CPCF also receives the treated effluents from the Waste Coolant Processing Facility (WCPF) and Plating Rinsewater Treatment Facility (PRTF) and sludge from the PRTF for further processing. Waste liquids are delivered to the CPCF in 5,000-gallon tankers and 600-gallon poly tanks.

The CPCF operates eight hours per day and involves physical and chemical processing steps. The processing includes oil/water separation, neutralization, precipitation, flocculation, coagulation, settling and decanting, carbon absorption, and cartridge filtering. Washwater effluent is discharged to East Fork Poplar Creek under National Pollutant Discharge Elimination System (NPDES) monitoring.

Mop-waters received from tankers or poly tanks are strained. Oil is removed in the oil/water separator, placed in 55-gallon drums, and stored at the Organic Liquid Storage Area. The wastewater is held in the aerated oil skim tank. Sulfuric acid, ferric sulfate, and hydrated lime are added as needed in the reactor clarifier feed tank. The wastes precipitated by these chemicals are settled in the upflow clarifier with the addition of a polymer to enhance flocculation. The settled mop-water sludge from the clarifier is pumped to settlers and transferred to the West Tank Farm at the West End Treatment Facility via tanker for storage. Treated effluent from the clarifier is held in a collection tank; additional solids are removed in the Dynasand Filter. The rejects (solids) from the filter are returned to the reactor clarifier feed tank, and the filtered effluent is sent to a sump tank prior to discharge. In the direct discharge system, organics are removed from the combined wastewaters in carbon adsorption columns; the pH is adjusted as required with the addition of sulfuric acid. If necessary, the wastewater is retained in the effluent basins prior to final filtration, antifoam treatment, NPDES monitoring, and discharge to East Fork Poplar Creek.

Concentrated acidic or caustic wastes received in tankers or poly tanks are transferred to the acid storage tank or the caustic storage tank. Waste is then transferred to one of two process reactors, and ferric sulfate is added. If acidic, the waste is neutralized with hydrated lime, or if caustic, with sulfuric acid. The neutralized waste is transferred to one of four settlers where it combines with sludge from the PRTF and other CPCF treatment processes. Sludge from the settlers is pumped to a 5,000-gallon tanker and transported to the West End Tank Farm. Spent carbon from the carbon adsorption columns is transferred to East Tennessee Technology Park (ETTP) for storage. Spent cartridge filters from the final filter are also sent to ETTP.

West End Treatment Facility — The West End Treatment Facility (WETF), which includes the West Tank Farm (WTF) and the Magnesium Chip Dissolver (MCD), treats liquid nitric acid wastes, nitrate-bearing rinsewaters, mixed acid wastes, waste coolants/mop-waters, biodenitrification sludges, caustic wastes, and magnesium chips/shavings from Y-12 production operations. Waste materials are delivered to WETF in 5,000-gallon tankers and 600-gallon poly tanks; various small containers are taken to the WTF. The WETF operates under a Permit-by-Rule RCRA exemption under the Y-12 NPDES permit.

Waste materials are processed in three system groupings at the WETF complex: the Head-End Treatment Systems, the WTF, and the Effluent Polishing Systems. The Head-End Treatment Systems perform both neutralization and nutrient addition steps. Shipments consisting of neutral nitrate-bearing waste, as well as small quantities of acidic and caustic wastes, are received at the WTF. These wastes undergo biological denitrification (biodenitrification or BDN) and biological oxidation (bio-oxidation or BOD) in the WTF, and metals precipitation, coagulation, flocculation, settling, and decanting in the Effluent Polishing Systems. Sludge accumulated in the WTF tanks and the Effluent Polishing Systems is stored in Tank Farms 3 and 4 until a long-term storage or disposal option for this mixed waste can be developed or approved. The sludge, consisting mainly of calcium carbonate and biomass, is contaminated with uranium, chromium, nickel, and lead and also contains low concentrations of organic chemicals. Other solid wastes, spent activated carbon, sand filter contents, and spent filter cartridges are placed in drums and sent to ETTP for long-term storage/disposal.

The decanted layer from the sludge storage tanks at the WTF is continuously fed to the Effluent Polishing Systems for removal of trace amounts of uranium, heavy metals, and suspended solids through chemical processing and settling. The treated material is then filtered and discharged through an NPDES monitoring station into East Fork Poplar Creek.

The Head-End Treatment Systems consists of four subsystems: waste receiving, cyanide destruction, neutralization, and process support. Cyanide levels have never justified use of cyanide destruction; furthermore, this unit must be modified before it is put into service.

The BDN reaction occurs in an agitated anaerobic environment. Bacteria in the BDN tanks convert the nitrates and acetates to nitrogen and carbon dioxide. A slurry resulting from the BDN reaction goes to the bio-oxidation step where air injection enhances the formation of sludge, carbon dioxide, and water.

The Effluent Polishing Systems remove residual heavy metal and organics from the sludge decant liquid by sludge dewatering (not used yet), pH adjustment and clarification, and filtration. Sand followed by carbon adsorption is used in the filtration step.

Five 500,000-gallon tanks in the WTF serve as sludge storage. To reduce sludge generation and add storage capacity, the WETF Head End Modification Project (WETFHEM) will allow recycling of the WETF sludge for use as a biological feed. As a part of the Y-12 Plant-wide Production Waste Storage Facilities Project, additional sludge storage capacity will be added. Finally, the Y-12 Waste Minimization Program is helping to reduce generation by reducing wastewater generation.

The following assumptions are made to characterize waste generation data.

- Waste is either nonroutine or routinely generated. Nonroutine waste is identified as waste that is PCB contaminated, any waste generated by Environmental Restoration activities, and any waste identified as "legacy waste." All other wastes are routinely generated.

- Process waste waters are identified as all liquid wastes treated in existing onsite waste water treatment facilities.

- All wastes characterized as RCRA-hazardous are identified as Mixed-LLW, as presented in the Mixed Waste Inventory Report (MWIR), due to suspect and/or demonstrated radioactive contamination.

- Similarly, all PCB-contaminated wastes are presented as Mixed Toxic Substance Control Act (TSCA) material, excluding those PCB contaminated wastes that are also RCRA-Hazardous. These RCRA/PCB wastes are presented as Mixed-LLW, as presented in the MWIR.

- Sanitary waste generation includes those wastes managed in onsite industrial landfills and those sent to local commercial sanitary landfills. Asbestos waste is included in this category.

- Mixed TSCA waste generation includes "regulated" levels of PCB contamination (>50 ppm) as well as "managed" levels of PCB contamination (2-49.99 ppm).

Significant decreases in weapons production-related activities have impacted the waste stream across ORO facilities. The mission of Y-12 has changed from weapons production and assembly-oriented programs to disassembly, special materials storage and management, technology transfer and work for others, and stockpile capability evaluation. For example, Y-12 has had no high level waste (HLW), transuranic waste, or mixed transuranic waste over the past reported year (1995). The waste stream has been composed of low level waste, mixed low level waste, and TSCA regulated waste, each in solid and liquid forms.

<u>9212/EUO</u>

The waste stream and material recovery process is located in Building 9818 and the area surrounding or adjacent to 9818. Nitric acid and aluminum nitrate aqueous streams from the EU recovery operations in 9212 complex are processed to recover and reuse the nitric acid and most of the aluminum nitrate from in uranium processing. Aluminum nitrate not recovered is processed through a biodenitrification facility before disposal to the Y-12 Plant West End Treatment Facility.

Nitric Acid Recovery — The nitrate waste processing and nonenriched uranium material recovery facility is located in Building 9818 and in smaller buildings immediately adjacent to it, all of which are adjacent to Building 9212. Nitric acid is recovered from the condensate produced during chemical recovery evaporation steps and from the condensate produced from the vapor evaporator used for aluminum nitrate recovery. Vapor produced in a vaporizer enters the glass distillation equipment and is contacted with the flow of the liquid reflux system. The nitric acid in the vapor is absorbed into the liquid reflux stream. Temperature and specific gravity checks are used to control the nitric acid concentration. Vapors escaping the top of the still are condensed, collected, and discarded to Waste Treatment Operations. The product nitric acid is sparged with a flow of ozone to remove any chlorides that might have been concentrated through acid recovery. The nitric acid is pumped to a storage tank for reuse in enriched uranium recovery operations.

Aluminum Nitrate Recovery — Raffinate solution from primary solvent extraction is concentrated in a vacuum evaporator and transferred to a crystalizer tank. Condensate from the vacuum evaporator flows to a feed tank for nitric acid recovery. Aluminum nitrate crystals form in the raffinate solution that is supersaturated in aluminum nitrate in the vacuum evaporator. Once crystals exceed a certain percentage of the tank volume, they are separated from the solution by a centrifuge. The solution is recycled from the centrifuge to the crystalizer tank and overflows into a feed tank for biodenitrification. Crystallized aluminum nitrate solids from the centrifuge fall through a chute to a molten-salt tank where the solids are pumped to a molten-aluminum-nitrate tanks in the B-1 wing for reuse.

Biodenitrification — Overflow from the aluminum nitrate crystalizer tank is subjected to biodenitrification. Nitrates in the feed solution are reduced through digestion by anaerobic bacteria. Calcium acetate is used as a nutrient for the bacteria. The solution and calcium acetate are transferred to a large bioreactor. Within the bioreactor, bacteria digest nitrate ions to form nitrogen and water and acetic acid to form carbon dioxide. The bacterial process leaves a biomass residue containing dead bacteria and heavy metal contaminants. The bacterial actions also produce sufficient calcium carbonate to cause precipitation of some metallic contaminants. The sludge formed from the precipitates and biomass is withdrawn from the bioreactor where it undergoes additional treatment by Waste Treatment Operations.

Section Review

1. *Place the appropriate letter in each blank to match the 10 programmatic elements with their corresponding missions.*

___ *Manufacturing Processes and Stockpile Support Systems Program*

___ *Nuclear Materials Management and Storage Program*

___ *Nuclear Packaging Systems Program*

___ *Weapons Receipt, Dismantlement, and Disposal Program*

___ *Material Recycle and Recovery Program*

___ *Stockpile Evaluation and Maintenance Program*

___ *Advanced Manufacturing, Design, and Production Technologies Program*

___ *Enriched Uranium Operations Process-Based Restart Program*

___ *Quality Evaluation and Surveillance Program*

___ *Facility Transition Program*

a. *Recycle and recover highly enriched uranium (HEU) and lithium-6 materials from process residues, dismantlement operations, and manufacturing processes.*

b. *Support maintenance and evaluation of the stockpile through manufacturing, process technology, and development support.*

c. *Achieve resumption of Enriched Uranium Operations in the Y-12 Plant.*

d. *Continue and accelerate the development and prototyping of advanced, cost-effective, environmentally-acceptable nuclear weapons production technologies and design.*

e. *Reduce the Defense Programs' footprint and landlord responsibilities by identifying and preparing facilities and related infrastructure for deactivation and safe shutdown.*

f. *Provide certified and economical packaging for transporting and storing radioactive and hazardous materials.*

g. *Receive, dismantle, and disposition retired weapon components and subassemblies from the stockpile.*

h. *Implement and maintain production processes and manufacturing information systems that are responsive to weapon component production requirements in support of the weapons stockpile and national security needs.*

i. *Receive, store, protect, and manage strategic and nuclear materials.*

j. *Provide evaluation, scheduled surveillance, enhanced surveillance, and testing of weapon components and assemblies to assess the integrity and life expectancy of the stockpile.*

2. *Select the primary buildings associated with:*
   - *Disassembly and Storage Organization (DSO)*
     9215 9720-5 9201-5 9204-4 9402-2E

   - *Depleted Uranium Operations (DUO)*
     9720-5 9720-6 9204-4 9215 9402-2 9201-5N

   - *Enriched Uranium Operations (EUO)*
     9720-5 9212 9206 9212 9215 9201-5N

   - *Special Materials*
     9204-2 9720-46 9201-5 9204-4 9402-2E

   - *Development Operations*
     9202 9731 9203 9212 9206 9212 9998

3. *Summarize the process overviews for:*
   - *Disassembly and Storage Organization (DSO)*
   - *Depleted Uranium Operations (DUO)*
   - *Enriched Uranium Operations (EUO)*

4. *What are the hazards associated with the work in these groups:*
   - *Disassembly and Storage Organization (DSO)*
   - *Depleted Uranium Operations (DUO)*
   - *Enriched Uranium Operations (EUO)*
   - *Special Materials*
   - *Development Operations*

5. *Summarize the safety features built into defense nuclear facility processes.*

6. *Characterize the Y-12 waste stream. Include the processes used in the primary Y-12 waste management/processing facilities. What are some ways the waste stream is changing or is expected to change?*

7. *Briefly describe the following waste stream processes:*
   - *Nitric Acid Recovery*
   - *Aluminum Nitrate Recovery*
   - *Biodenitrification*

II. East Tennessee Technology Park

The East Tennessee Technology Park (formerly known as the K-25 Site or the Oak Ridge Gaseous Diffusion Plant) was built during the World War II Manhattan Project to produce highly enriched uranium for use in nuclear weapons. The gaseous diffusion plant later produced low assay uranium for use as commercial nuclear power reactor fuel. Production ceased in 1985 and the plant was permanently shutdown in 1987.

The East Tennessee Technology Park (ETTP) mission is to reindustrialize and reuse site assets, i.e., facilities, equipment, materials, utilities, and trained workforce, through leasing of vacated facilities and incorporation of commercial industrial organizations as partners in the ongoing environmental restoration, decontamination and decommissioning, waste treatment and disposal, and diffusion technology development activities.

The ETTP defense nuclear facilities are:

- HEU process buildings K-25, K-27
- LEU process buildings K-29, K-31, K-33
- Decontamination Facility K-1420
- UF_6 cylinder storage yards

In this study guide, the UF_6 cylinder storage yards are treated as one facility but, more accurately, include K1066B, K1066E, K1066F, K1066J, K1066K, and K1066L.

HEU Process Buildings K-25, K-27

HEU K-25 and K-27 process buildings were originally designed and built to house a full-gradient cascade to yield uranium fully-enriched in ^{235}U to the weapon-grade level. The cascade enriched the ^{235}U isotope of uranium by the gaseous diffusion process that used uranium hexaflouride (UF_6) as the process gas.

Current activities in the HEU process buildings are limited. The ETTP Site Operations Division is responsible for maintaining the buildings and equipment to ensure continued safe confinement of residual uranium deposits in the process equipment and process lines. The Operations Division is also responsible for some of the vault areas, such as those that contain reactive lithium compounds, most of which are lithium hydroxide. The Deposit Removal Project (DRP) is an on-going demonstration project for removing uranium deposits from process equipment. The ETTP Waste Management Division (WMD) uses Buildings K-25 and K-27 to store hazardous, radioactive, and mixed wastes in containers pending shipment off-site for disposal.

K-25 and K-27 activities are managed by the Surveillance and Maintenance Operations (S&M) Department under the ETTP Operations Division. Monitoring and inspection of facilities is the major responsibility of the S&M Department. These responsibilities include asbestos inspection and mitigation, identification of leak sources, fire protection equipment inspections, and monitoring equipment removal or inspection.

Shutdown HEU facilities still contain large quantities of chemicals, tools, and equipment that supported uranium enrichment activities. Since the shutdown of the cascade operations, materials and equipment have been defined as surplus. Most coolant materials, lube oils, and some equipment have been removed from the site as surplus materials and shipped to other DOE facilities for use. Removal of surplus materials will continue for many years. Activities such as short-term storage of various materials removed from HEU buildings prior to shipping are typical surplus materials activities.

Waste Management Division (WMD) has responsibility for waste management activities at ETTP. Included is the responsibility for providing storage for waste (containerized RCRA, TSCA, fissile, PCB, and other LLW, as well as some fissile material not classified as waste) pending treatment and/or disposal. WMD activities include:

- Recombination (Bulking) of Waste — Drums of RCRA, TSCA, LLW, fissile, and mixed waste are stored throughout the basement vault areas. Periodically, some of these materials can be transferred into tanker trucks and transported off-site. These operations may require Unresolved Safety Question Determinations (USQDs) if not already covered by other safety basis documentation. If the materials are radiologically contaminated, Nuclear Criticality Safety Approvals (NCSAs) may also be required.

- Overpacking — As part of the normal inspection and surveillance program, WMD identifies any leaking or corroded storage containers. Corrective action includes overpacking and putting containers inside a larger container (e.g., putting a 55-gallon drum into a 85-gallon drum).

- Sampling — Sampling is required to determine the proper storage and/or disposal of waste. Containers are opened and samples taken for analytical processing.

- Storage Area Monitoring, Inspection, and Housekeeping — WMD performs weekly and monthly inspections of all containers and areas under their control. Inspections include but are not limited to inspection of container integrity, container labeling, and facility conditions.

- Container Staging — Containers (drums and ST-5 boxes) are staged for sampling, bulking, and segregation. Forklifts are used to unstack, stack, and transport the containers within the waste storage unit.

- Waste Tracking — WMD tracks waste containers using bar codes which are tracked by the ETTP Waste Tracking and Report System (TARS). The bar codes are added to the waste containers by operators as new containers are received from generators.

Environmental Restoration Division (ERD) is responsible for the DRP in the HEU facilities. The DRP involves removing target items such as pieces of pipe or equipment from existing locations; transporting the items to the DR room; confirming the uranium deposit mass by NDA measurements; removing deposits inside a glovebox; and packaging and storing deposits, wastes, and target items. Following interim storage in Building K-25, the removed deposits will be relocated to safe storage at the Y-12 Plant. Some items have deposits that will be removed using gaseous removal process. The gaseous removal process refluorinates the deposits to a gaseous state for removal via a trap.

HEU facilities present several safety risks to workers and/or the public. The risks stem from:

- Radioactive material
- Toxic material
- Reactive material

Radioactive material

The hazards associated with radioactive materials stem from three groups of material: radioactive deposits and material in fissile material storage areas, radioactive wastes, and radioactive contamination.

Large quantities of uranium deposits consisting primarily of uranyl fluoride remain in the process equipment inside buildings K-25 and K-27. The largest single deposits found in the process piping have deposit masses in excess of minimum critical masses for the deposit ^{235}U enrichments. Single deposits in excess of minimum critical masses were measured only in Building K-25.

In addition to uranium deposits, residual deposits from UF_6 feed materials produced from reactor returns were identified. The three isotopes of concern are ^{239}Pu, ^{237}Np, and ^{99}Tc. The ^{239}Pu and ^{237}Np fluoride compounds are not very volatile. Most of the materials would have remained in the feed cylinders or would have been deposited in the process equipment near the feed points. The quantities remaining in the cascade equipment are judged insignificant with respect to the uranium deposits.

The other radioactive material locations are in the Building K-25 fissile material storage areas. Though these inventories may vary, they are significant compared to the uranium deposits in the process equipment in the HEU buildings.

In addition to the radiotoxicity hazard of the uranium in the HEU buildings, the masses of many deposits substantially exceed the critical safe mass for the ^{235}U enrichments identified. Nuclear criticality is prevented by avoiding the introduction of a moderator to these large deposits. However, the possibility of accidental introduction of moderator and resulting nuclear criticality exists.

The storage vaults in the basements of buildings K-25 and K-27 are permitted for the storage of radioactive LLW. The vault storage configurations generally limit storage capacities to less than the permitted levels of waste. However, if the vaults are filled to permitted storage capacities, then significant quantities of uranium are present.

The HEU buildings and building penetrations are generally contaminated with uranium and most are designated as Contamination Areas (except some small clean or High Contamination Areas). Most of the uranium contamination in these buildings is fixed with very little removable in routinely accessible areas.

Toxic material

The health effects caused by the chemical toxicity of soluble uranium and technetium compounds found in these buildings are often greater than the radiological effects. Adverse health effects may result from acute exposure to inhaled or ingested soluble material. Insoluble uranium compounds are not present in significant quantities in these facilities.

The vault areas in buildings K-25 and K-27 are permitted to store hazardous wastes and RCRA-regulated materials in quantities up to the full permitted storage capacity of the facilities even though vault storage configurations limit the amounts actually stored. These materials are potentially toxic and/or corrosive, and may react with other stored waste.

Other toxic materials are PCB oils. PCBs are in:

- Capacitors
- Transformers
- Contaminated lube oil
- Contaminated waste

Additionally, PCB-contaminated oils have been found in process building ductwork. Low levels of PCB contamination in ductwork are expected in both HEU process buildings. Miscellaneous PCB-contaminated equipment is stored on the K-25 cell-floors.

Liquid fluorocarbon coolants also present a toxic threat to personnel in the HEU buildings. Liquid fluorocarbon coolants are stored in the basement vaults and could potentially be released to the area atmosphere. This release presents an asphyxiation hazard to building personnel because the HEU building ventilation systems are shutdown.

Reactive material

Building K-25 vaults contain drums of lithium compounds, primarily lithium hydroxide (LiOH). LiOH is soluble in water and produces a strongly alkaline solution. This material is toxic and corrosive.

LEU Process Buildings K-29, K-31, K-33

LEU process buildings K-29, K-31, and K-33 were originally designed and built to house the low enrichment part of the Oak Ridge Gaseous Diffusion Plant (ORGDP) cascade.

Current activities in the LEU buildings are limited and the facilities are scheduled to be turned over for D&D. The ETTP Operations Division occasionally removes process equipment and ships it to the operating gaseous diffusion plants (PGDP or PORTS) for reuse. Operations Division is also responsible for maintaining the buildings and equipment to ensure continued safe confinement of residual uranium deposits in the process equipment and process lines. The ETTP WMD uses buildings K-31 and K-33 to store mixed and low-level radioactive wastes in containers pending treatment or shipment off-site for disposal.

In the LEU facilities, buildings K-31 and K-33 are used by WMD to store drums containing soils contaminated with uranium or PCBs, LLW in ST-5 boxes, and removed PCB-contaminated electrical capacitors. Other WMD activities include recontainerization (bulking) of wastes, overpacking of waste containers, sampling of wastes and inspection of waste containers, and the staging (movement) of waste containers.

A fissile material storage area is located on the operating floor of Building K-31. The fissile storage containers hold UF_6. The stored fissile materials include relatively small quantities of uranium-contaminated materials and uranium compounds cleaned from piping and valves and larger quantities of UF_6 in partially filled containers.

S&M Operations responsibilities in LEU facilities include monitoring, inspecting, and correcting deficiencies that might otherwise affect the environment, jeopardize the public or site personnel's health and safety, or adversely affect national security due to the loss of classified technology or SNM.

Shutdown LEU facilities still contain large quantities of chemicals, tools, and equipment that supported uranium enrichment activities. Since the shutdown of the cascade operations, materials and equipment have been defined as surplus. Most coolant materials, lube oils, and some equipment have been removed from the site as surplus materials and shipped to other DOE facilities for use. Removal of surplus materials will continue for many years. Activities such as short-term storage of various materials removed from EU buildings prior to shipping are typical surplus materials activities.

LEU facilities also present several safety risks to workers and/or the public. These risks stem from:

- Radioactive material
- Toxic material
- Reactive material

Radioactive material

The hazards associated with radioactive materials stem from three groups of material: radioactive deposits and material in fissile material storage areas, radioactive wastes, and radioactive contamination.

Large quantities of uranium deposits consisting primarily of UO_2F_2 remain in the process equipment inside the three LEU buildings. The largest single deposits are located in process piping.

In addition to UO_2F_2 deposits, residual deposits from UF6 feed materials produced from reactor returns were identified. The three isotopes of concern are ^{239}Pu, ^{237}Np, and ^{99}Tc. The ^{239}Pu and ^{237}Np fluoride compounds are not very volatile. Most of the materials would have remained in the feed cylinders or would have been deposited in the Building K-33 process equipment near the feed points. The process equipment deposits were removed during facility upgrades for buildings K-31 and K-33.

Other radioactive material locations are in the Building K-31 fissile material storage areas. Though these inventories may increase, the inventory in the fissile material storage area will remain small compared to the uranyl fluoride deposits in the process equipment of each of the LEU buildings. As areas go through D&D, these areas will become fewer and fewer.

In addition to the radiotoxicity hazard of the UO_2F_2 in the LEU buildings, the masses of many deposits substantially exceed the critical safe mass for the ^{235}U enrichments identified. Nuclear criticality is prevented by avoiding the introduction of a moderator to these large deposits. However, the possibility of accidental introduction of moderator and resulting nuclear criticality exists.

The storage vaults in the basements of buildings K-31 and K-33 are permitted for the storage of radioactive LLW. The vaults contain drummed wastes from the decontamination of waste settling and holding ponds.

The LEU buildings contain large areas of radioactive contamination. Areas without significant contamination are designated nonradiological. Other areas are designated as Contamination Areas or High Contamination Areas. Most of the areas for the three LEU buildings are designated as Contamination Areas due to uranium contamination. The majority of contamination in these areas is fixed. Selected areas of the three buildings are designated as High Contamination Areas due to ^{99}Tc contamination. These areas are the north side of the Building K-33 operating floor, the west end of the K-31 operating floor, and the entire cell floor of K-29.

<u>Toxic material</u>

The principal identified toxic materials in the LEU Process Buildings are the radioactive materials identified above, and PCB oils. Significant quantities of PCBs are present only in K-33.

PCBs are in:

- Capacitors
- Transformers
- Contaminated lube oil
- Contaminated waste

Additionally, PCB-contaminated oils have been found in process building ductwork. Low levels of PCB contamination in ductwork is expected in both LEU process buildings.

Decontamination Facility K-1420

Decontamination Facility K-1420 was originally built to provide radiological decontamination, uranium recovery, and metal-plating process capabilities. Today, the building has a limited mission of some operations which include plating and compressor and valve rebuilding. The majority of the work in the facility is D&D. The K-25 Site Operations Division is responsible for maintaining the building and equipment to ensure continued safe confinement of residual uranium and neptunium deposits in the process equipment and process lines.

Building K-1420 is shutdown with minimal ongoing activities. The former decontamination process areas have been cleaned and are scheduled for private industrialization. One area of the facility, the Fluorination Tower Reactor Room and related process equipment, is retained by ORO for D&D. Current operations in the facility involve storage of containers of radioactive and contaminated liquid, sludge, and solid wastes; surveillance and maintenance; 90-day RCRA storage area management; periodic audits and inspections; and occasional decontamination work.

The K-1420 Decontamination and Uranium Recovery Facility presents hazards in addition to the routine hazards found in an industrial facility. These additional hazards include:

- Radioactive material
- Toxic material
- Reactive material

<u>Radioactive material</u>

The decontamination of gaseous diffusion process equipment resulted in uranium and neptunium contamination in equipment used for the decontamination and uranium recovery operations. Most of the building equipment is permanently shutdown but still in place with the exception of equipment used in current limited decontamination operations. The deposits of contamination are distributed among the process equipment, floor pans, and uranium recovery and oxide fluorination systems.

The tunnel area decontamination solution storage columns contain the largest mass of radioactive materials. The contents of the columns were removed and are planned for shipment to Y-12.

Other radioactive materials, including uranium deposits in pipe sections from Building K-1423 and miscellaneous drums and boxes are stored in the high bay area. The piping, fittings, and other mounted equipment storage is controlled by Nuclear Criticality Safety Approvals (NCSAs).

K-1420 was used for decontamination of equipment, hence, it contains radioactive materials. The major areas of the facility are posted as Contamination Areas, with the process/mezzanine, tunnel, roof, and calciner room posted as High Contamination Areas.

In addition to the radiotoxicity hazards, some enriched uranium deposits exceed minimum critical mass limits and potentially can achieve nuclear criticality. In general, nuclear criticality is prevented by combinations of several factors including Nuclear Criticality Safety Program requirements, critically safe geometry equipment, limited quantities of fissile materials in isolated equipment, and prevention of the introduction of a moderator to the deposits.

Toxic material

The toxic material in K-1420 includes uranium-bearing nitric acid solution that was drained from the storage columns and contained in 55-gallon drums in the fissile storage area in the high bay.

In addition to the nitric acid in the facility, nickel sulfate residuals may remain in piping and containers that were formerly used in the nickel plating process. These chemicals have been drained and the piping and containers are vented to the atmosphere.

A 600-gallon tank contained hydrochloric acid and a 200-gallon tank contained sodium hydroxide. Both tanks are drained and vented to the atmosphere. The other toxic materials in K-1420 are residual mercury in the mercury recovery equipment and solid wastes stored in the RCRA 90-day accumulation area.

Reactive materials

The nickel plating processes used various chemicals including acetone, hydrochloric acid, isopropyl alcohol, nickel chloride, nickel nitrate, nitric acid, perchloroethylene, potassium hydroxide, and sulfuric acid. Nickel chloride, nickel nitrate, and nickel sulfate are known carcinogens. Since the suspension of operations, the chemicals have been drained from the system, and the system vented to the atmosphere. Nickel sulfate was the primary chemical used in the process, and the most hazardous of the chemicals used.

UF_6 Cylinder Storage Yards

The UF_6 cylinder storage yards serve as long-term storage areas for steel cylinders containing depleted, normal, or enriched UF_6. The mission of the cylinder storage yards includes storage of cylinders containing normal or enriched UF_6 until they are eventually relocated to an operating gaseous diffusion plant for disposition and long-term storage of other UF_6 cylinders.

The cylinder storage yards were built to support gaseous diffusion plant operations. The yards stored UF_6 cylinders filled with depleted assay UF_6, normal assay UF_6 Feed material, and enriched assay UF_6 product material. Since enrichment operations were terminated in 1985, the filled UF_6

product cylinders and most of the UF_6 feed cylinders have been shipped off-site to the operating gaseous diffusion plants. Current operations consist of shipping the remaining feed cylinders to the operating diffusion plants and storing depleted assay UF_6 cylinders and empty and nearly empty cylinders containing residual quantities of UF_6 until plans for ultimate disposition of these cylinders are finalized and implemented.

Cylinder yard operations include confinement of UF_6 in cylinders during storage, handling, and transfer. Other operations include performing routine inspections and performing maintenance and repair operations on stored cylinders and yards.

For the East Tennessee Technology Park Site cylinder yards, there are two reasonably potential accidents that present a real hazard to workers (but not the public) from operation of the yards: a release of solid/gaseous UF_6 to the atmosphere and a cylinder yard fire. Since the yards do contain fissionable material, nuclear criticality is possible but is not likely due to the amounts of material and the operations involved.

The potential for a release of solid/gaseous UF_6 to the atmosphere can begin through any of several plausible scenarios, e.g., cylinder corrosion, pressurized/nonpressurized cylinder valve leak or shear, pressurized/nonpressurized cylinder impact/drop, or a cylinder welding accident. Whatever the initiating accident catalyst, the hazards involved are due to the possible inhalation of radiological and toxic materials.

The principal hazard in the cylinder yard operations is UF_6 , which is a radiological and toxic material. The ^{235}U component is also a potential nuclear criticality hazard. The nature of storage process in the cylinder storage yard operations precludes a criticality from occurring. The amount of UF_6 in the cylinder storage yards is limited and is expected to lower as more and more cylinders are relocated to other gaseous diffusion plant sites. When UF_6 reacts with water, uranyl fluoride and HF are produced. Uranyl fluoride is also a radioactive and toxic hazard. The concerns for uranyl fluoride are the same as for UF_6 , except for the capability of generating HF, and the hazards associated with uranyl fluoride are not as limited by the controlled amount of UF_6 . HF is extremely irritating, corrosive to the skin and mucous membranes, and may cause death for prolonged exposures.

Technetium-99, plutonium, and neptunium are present in the yards in trace amounts and do not contribute significantly to the chemical or radiological effects of a UF_6 release. These elements are contaminants that infiltrated the cascades and migrated through the diffusion process with the UF_6 . Additional amounts will not be added to the cylinder yard inventories.

A cylinder yard fire, though extremely unlikely to occur, presents hazards to workers not just due to the nature of fire itself but because of the threat of leading to a fire-induced rupture of a UF_6 cylinder. The most likely initiating sequence for this accident begins with a vehicle accident.

During operations associated with cylinder handling/storage, the potential exists for fires to occur. Cylinder storage yards are exposed to combustible materials from handling equipment that could cause significant fires if no mitigation were provided. The only mitigation source for these facilities is the on-site fire department. Small fires can be caused by welding operations, electrical failures, and vehicle accidents. The significant fire hazards are diesel fuel, gasoline, and lubricants used in vehicles in the vicinity of the UF_6 cylinders.

The UF_6 cylinders have been tested in various fire conditions and failure due to fire occurs in just over 10 minutes, usually due to hydraulic failure or valve leakage. The time of failure and mode of failure vary with the size of cylinder tested. It is important to note, however, that fire fighting actions may successfully extinguish a fire prior to cylinder rupture, but not always. The fire department must decide whether to fight the fire or not based on the potential risks to the fire fighting personnel. Once the cylinder has failed, the hazards of concern are the same as those identified in the above release of solid/gaseous UF_6 to the atmosphere.

Because of the significant amount of time that must elapse before a fire becomes fully established to rupture a cylinder, facility workers should have sufficient time to evacuate the immediate area and avoid significant exposure. Due to the location of the cylinder yards and the distance to site boundaries, in neither case is there a reasonable threat to the public.

Safety

As with other DOE defense nuclear facilities, East Tennessee Technology Park relies upon established conduct of operations (as well as other administrative controls) for maintaining control of facility evolutions and to enhance the safety margin for facility personnel, site properties, the general public, and the environment. Additionally, and again like other DOE facilities, there are engineered safety features built into the facilities themselves.

<u>HEU, LEU, K-1420</u>

The ETTP Radiation/Criticality Accident Alarm System (RCAAS) alerts personnel in the vicinity of a nuclear criticality accident to evacuate the area of excessive radiation, thus limiting the potential exposure of on-site personnel. RCAAS monitors all ETTP buildings and storage areas that normally contain enriched materials in forms and quantities of potential nuclear criticality concern. These areas include:

- HEU facilities K-25 and K-27
- LEU facilities K-29, K-31, and K-33
- RDF K-1420

The RCAAS consists of gamma-detection cluster units at specified locations and their associated controls, annunciation, power, and monitoring systems. The central control and monitoring panel at the Site Central Control Facility in Building K-1650 is continually monitored by the Plant Shift Superintendent (PSS) or shift operations personnel.

The accident analysis for the ETTP cylinder storage yards shows the potential for significant consequences if a large UF_6 release occurred. Although several physical features and administrative programs for the ETTP cylinder storage yards contribute to defense-in-depth against a large UF_6 release, there are no active preventive or mitigative systems, structures, or components that meet the definition of safety class SSCs. The cylinder storage yards do use design features and components that can be identified as safety significant because they are considered significant to worker safety and to defense-in-depth. These items are:

- UF_6 cylinders
- UF_6 cylinder lifting equipment
- UF_6 cylinder chocks

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 is 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, 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.

UF_6 Cylinders

The cylinder chocks are designated as safety-significant for cylinders that are improperly stacked (i.e., subjected to an “upper tier stacking defect”). The chocks prevent loss of cylinder from rolling/falling due to an earthquake or any other jarring action.

Waste Streams

The ETTP WMD uses HEU Buildings K-25 and K-27 to store hazardous, radioactive, and mixed wastes in containers pending shipment off-site for disposal. Since the facility process systems are all shutdown, the wastes include legacy waste and those generated from DRP and decon and decommissioning activities inside the building. These wastes include uranium-contaminated wastes, PCB-contaminated wastes, RCRA hazardous materials, mixed wastes, and electrical equipment containing PCB oils.

As previously mentioned, shutdown HEU facilities contain large quantities of chemicals, tools, and equipment that supported uranium enrichment activities. Since the shutdown of the cascade operations, materials and equipment have been defined as surplus. Most coolant materials, lube oils, and some equipment has been removed from the site as surplus materials and shipped to other DOE facilities for use. Removal of surplus materials will continue for many years.

The WMD uses LEU Buildings K-31 and K-33 to store mixed and low level radioactive wastes in containers pending treatment or shipment off-site for disposal. The LEU processes are also shutdown so the facility wastes include legacy waste and waste generated from decon and decommissioning work and waste generated from the removal of process equipment for reuse at the other operating gaseous diffusion plants. These wastes include uranium-contaminated, solidified pond sludge in drums, PCB-contaminated soils in drums, capacitors containing PCB oils stored in ST-5 boxes, and uranium-contaminated solids (LLW) in ST-5 boxes.

Like the HEU facilities, shutdown LEU facilities today contain large quantities of chemicals, tools, and equipment that supported former uranium enrichment activities. Since the shutdown of the cascade operations, materials and equipment have been defined as surplus. Most coolant materials, lube oils, and some equipment has been removed from the site as surplus materials and shipped to other DOE facilities for use.

Decontamination Facility K-1420 housed decontamination, uranium recovery, and metal plating processes, all of which generated radioactive wastes. These wastes, along with a small quantity of waste from ongoing decon activities, constitute the majority of K-1420 wastes. The facility stores uranium-contaminated nitric acid process solutions contained in storage drums. Current D&D activities in the building include the removal and disposition of large quantities of radiologically-contaminated process equipment and the decontamination of the building surfaces and surrounding soils. Radioactive contamination is removed or stabilized to reduce source terms and decrease the worker risks to lower hazards. D&D also includes abatement activities that facilitate compliance with environmental, health, and safety requirements.

Section Review

1. *Identify the current defense nuclear facilities at ETTP.*

2. *How has the mission changed for the ETTP facilities?*

3. *Summarize the process overviews for:*
    - *HEU buildings*
    - *LEU buildings*
    - *K-1420*
    - *Cylinder storage yards*

4. *What are the hazards associated with the work in these areas?*

5. *Characterize the ETTP defense nuclear facility waste stream in regards to the primary composition. How is this waste generated?*

III. OAK RIDGE NATIONAL LABORATORY (ORNL)

ORNL is responsible for the development of new energy sources, technologies, materials, and the advancement of knowledge in the biological, computational, environmental, radiochemical, physical, and social sciences.

As a DOE multi-program laboratory, ORNL conducts basic and applied research and development to advance the nation's energy resources, environmental quality, scientific knowledge, educational base, and industrial and economic competitiveness. ORNL's core competencies are:

- Energy production and end-use technologies
- Advanced materials synthesis, characterization, and processing
- Biological and environmental science and technology
- Neutron-based science and technology
- Computational science and advanced computing
- Instrumentation, manufacturing, and control technologies (an emerging core competency shared with the Oak Ridge Y-12 Plant)

ORNL has three defense nuclear facilities:

- Building 3019 — Radiochemical Development Facility (RDF)
- Building 7830 — Melton Valley Storage Tanks (MVSTs)
- Gunite tanks

The RDF is a Manhattan Project vintage building that has received numerous upgrades and modifications over the years. During the building's 50-year history, the RDF has been the site for development and operation of several methods for nuclear fuel processing (e.g., PUREX, THOREX, Flouride Volatility).

The MVSTs provide storage capacity for the ORNL Liquid Low Level Waste (LLLW) System and include tanks W-24 through W-31.

The Gunite tanks were originally used for the collection, storage, neutralization, and transfer of the aqueous portion of the radioactive and/or hazardous chemical wastes produced as part of the normal facility operations at ORNL. All 15 tanks (8 at the North Tank Farm, 6 at the South Tank Farm, and Tank 11) no longer receive wastes and are considered out of service.

Building 3019 — Radiochemical Development Facility (RDF)

The mission of the RDF is to serve as the National Repository for ^{233}U. To accomplish this mission, the RDF maintains the following capabilities:

- Physically handle multi-kilogram quantities of ^{233}U
- Process multi-kilogram quantities of ^{233}U and enriched uranium in gloveboxes and/or

shielded storage cells

Other processes that can be performed at Building 3019 include storage of ^{233}U, uranium acid dissolution, ion exchange separation, physical separation of raw material, oxidation of material, and three uranium disposition processes (dry melt blending, aqueous nitrate blending, and dry mix processing).

The key operations processes that can be performed at the RDF include:

- Handling multi-kilogram quantities of ^{233}U
- Processing multi-kilogram quantities of ^{233}U

<u>Handling multi-kilogram quantities of ^{233}U</u>

Radioactive material is received and transferred generally by two methods depending on final destination of the material. Material can be received/transferred at the North loading dock area where it can be moved into Building 3019 or into the Building 3100 Storage Vault. Material can also be received/transferred at the Penthouse Crane Bay on the south side of Building 3019 and moved directly into the Penthouse.

Prolonged physical handling operations are conducted by using remote handling devices to maintain the containers at least three feet from the worker. Operations in close proximity to the materials are allowed for very brief periods or on low radiation level containers. For containers with higher radiation levels, physical handling operations are conducted using heavily shielded transfer casks and shielded confinement cells. Shielded transfer casks are mechanically operated locally and moved using cranes.

<u>Processing multi-kilogram quantities of ^{233}U</u>

Processing activities with multi-kilogram quantities of ^{233}U can be performed in gloveboxes and/or shielded confinement cells. Glovebox activities can be performed in the following spaces:

- Room 201
- Rooms 22, 26, 29, 110, 112, 113, 114, 142, 144, 145, 150
- Building 3100 glovebox room

Activities within shielded confinement cells were intended to be conducted in process cells 1 - 7. The equipment in cells 3, 5, 6, and 7 are technically in a stand-by condition but it is doubtful that any of this equipment would ever be used to process radioactive material again. Cell 4 is dedicated to storage and is a High Radiation Area.

Processing activities in gloveboxes and/or shielded confinement cells are limited by worker radiation protection regulations and the established safety envelope. Processing activities include a diverse range of chemical reactions and physical processes:

- Dry melt blend processing
- Aqueous nitrate blending
- Dry powder blending/Dry mix processing
- Uranium solids dissolution
- Precipitate and filtration
- Ion exchange separation
- Physical separation of raw material
- Weighing and NDA of material
- Thermal disassociation
- Oxidation of material (high temperature furnace/smelters)
- Material packaging
- Waste immobilization
- Material sampling/characterization

The principal radioactive materials processed within the RDF include natural thorium, natural or depleted uranium, and fissile uranium containing varying concentrations of ^{235}U and/or ^{232}U, neptunium, and plutonium. Typically small amounts of transuranium elements, fission products, and other radionuclides are sometimes present as impurities in the metals, alloys, oxides, and other compounds that are received and subsequently processed at the RDF.

The major safety risks to facility workers, aside from the typical industrial environment safety risks, are due to the nuclear materials being processed and stored. These materials present radiological (fissionable and radioactive materials) and chemical (toxic, corrosive, and reactive materials) hazards. There are no major safety risks to the public from the processes or storage of materials in the RDF.

Radiological

There are two major isotopes of concern for uranium at the RDF: ^{232}U and ^{233}U. Because of the isotope half-life and the half-life of the decay daughters, ^{232}U is the greater source of radiation and presents the greater hazard. ^{233}U is considered fissile while ^{232}U is only considered fissionable. Because ^{233}U is readily fissile, care must be taken in the design of process equipment and procedures to avoid criticality.

Uranium and its compounds present biological hazards through ingestion and inhalation. Chemical toxicity appears as kidney damage and acute necrotic arterial lesions. Soluble uranium compounds (e.g., uranyl nitrate) pass easily through the body resulting in little damage from ingestion of relatively large amounts to be absorbed. Insoluble compounds have a highly toxic effect to the lungs in the form of irradiation. Some compounds associated with certain forms of uranium can also be toxic, such as hydrogen fluoride with the uranium fluorides.

Chemical

Pure uranium is a heavy metal that exists as silver-white or black crystals. It is highly toxic and a radiation hazard. When in the form of a solid or dust, it can be a dangerous fire hazard when exposed to heat or flame. Uranium dust can also be an explosion hazard when exposed to flame in the presence of oxygen.

Uranium metal can react vigorously, even violently, with oxidizing agents. Large solid pieces are fairly stable but will corrode on the surface. Corrosion of uranium metal has negative consequences. First, it converts a cohesive metal solid to a dispersible oxide dust. Second, under wet conditions, it can lead to a fire or explosion hazard or container pressurization due to hydrogen evolution.

UO_2 is stored in the RDF and is the most common compound used in reactor fuels (in a compressed pellet form). In a very fine powder, UO_2 is potentially pyrophoric.

UF_4 and UF_6 are stored in the RDF. UF_4 is nonvolatile and was used in the Molten Salt Reactor Experiment. UF_6 is volatile, meaning it is highly reactive with water and moist air, forming uranyl fluoride and releasing hydrogen fluoride both of which are chemically toxic. Inhalation and ingestion of UF_6 are acutely serious health threats. UF_6 must be stored in gas-tight, corrosion-resistant canisters.

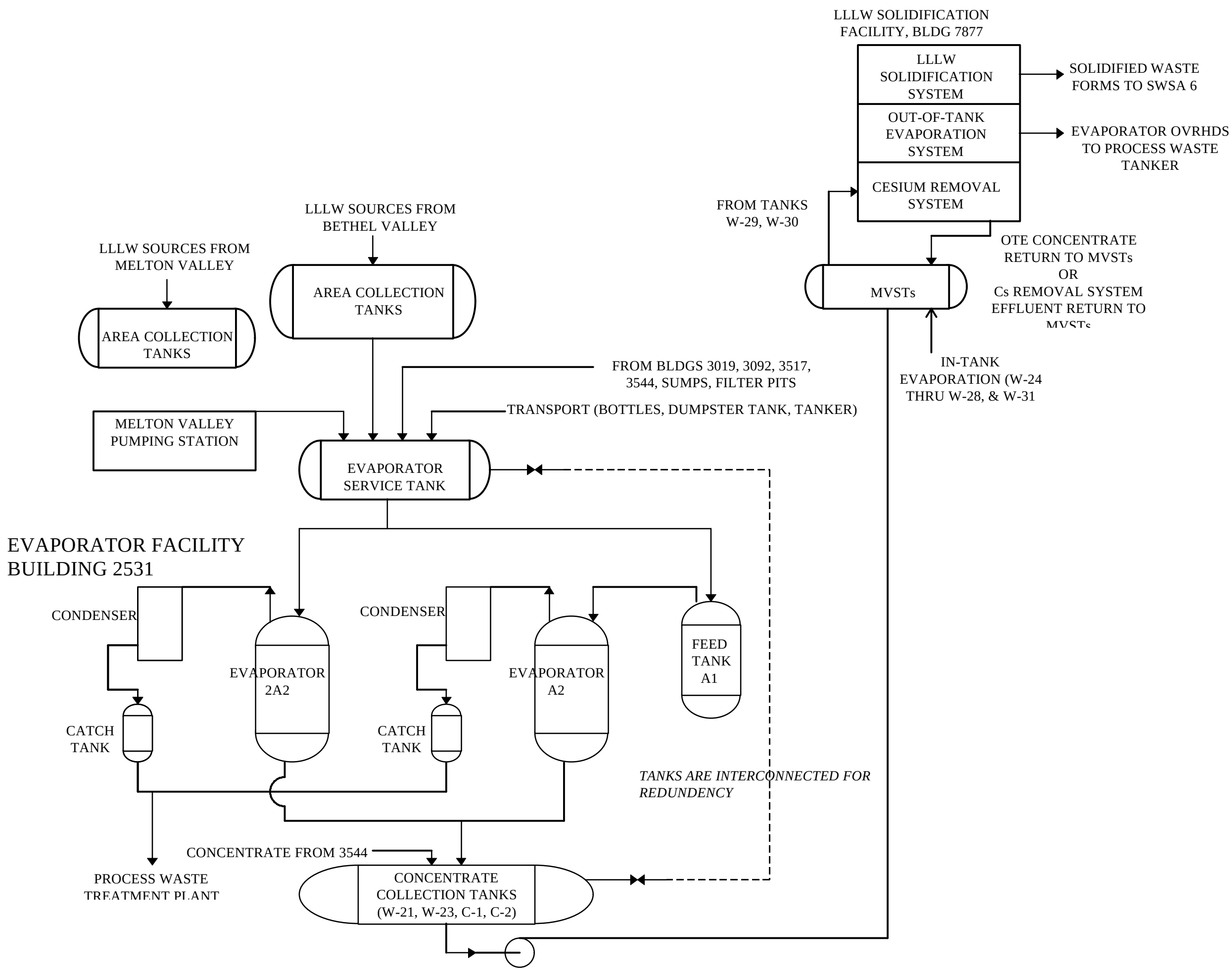
Building 7830 — Melton Valley Storage Tanks (MVSTs)

Eight 50,000-gallon underground storage tanks are the MVSTs. The function of these tanks is to provide storage capacity for the ORNL LLLW System. The LLLW System provides collection, volume reduction, and storage of ORNL LLLW for facilities that generate LLLW. The system's primary purpose is to contain the LLLW and prevent release of radioactive contaminants to the ground or air and minimize, to the extent possible, exposure to on-site personnel.

System Overview

The MVSTs are basically one component of a larger operating system. In general terms, the LLLW System collects, neutralizes, concentrates, and stores aqueous radioactive waste solutions from various ORNL sources (see following figure). The sources of these waste solutions are contaminated sinks and drains in research and development laboratories, radiochemical pilot plants, and nuclear reactors located in both Bethel and Melton valleys (Oak Ridge area of Tennessee).

LLLW Waste Simplified Flow Diagram



The waste solutions are discharged from the source buildings to a series of collection tanks, each located near the source building. The stainless steel tanks are of various capacities ranging from 500 to 15,000 gallons. Nineteen of the collection tanks are located in Bethel Valley and four are located in Melton Valley. Each collection tank is equipped with liquid level instrumentation and a filtered vent to the atmosphere or to the Central Off-gas System.

The waste solutions, which accumulate in the collection tanks, are periodically transferred to one of the three 50,000-gallon stainless steel storage tanks (usually W-22) near the evaporator building. These tanks are enclosed in underground, stainless steel-lined concrete vaults. A network of 2-inch and 3-inch diameter stainless steel pipelines buried directly in the ground connects the collection tanks to a 6-inch diameter double-contained stainless steel collection header that directs flow to the evaporator storage tanks. Transfer is made by pumps or steam jets.

Waste from the storage tanks is transferred to one of two evaporators where the aqueous solution is routinely concentrated by a factor of 20 to 30. The radioactive concentration of the condensate is less than the feed solution concentration by a factor of 10^4 to 10^5. When the specific gravity of the concentrated waste reaches the desired concentration, the contents are cooled and then sent to a 50,000-gallon stainless steel receiving tank. There are three 50,000-gallon service tanks and two 50,000-gallon backup storage tanks, C-1 and C-2. Each tank can be configured for incoming storage or outgoing storage.

The concentrate stored at the evaporator is periodically pumped to one of eight 50,000-gallon stainless steel tanks located in Melton Valley near the hydrofracture site. These tanks, the MVSTs, are essentially identical to the evaporator storage and receiving tanks and are enclosed in underground stainless steel-lined concrete vaults. The process operations associated with the MVSTs include air sparging, liquid level monitoring, tank transfers, and content sampling. Transfer of the evaporator tank contents to the MVSTs is through approximately 6,000 feet of double-contained stainless steel pipe. This pipe is buried underground and is protected by heat tracing and liquid leak detection instrumentation.

The major safety risks to workers and the public resulting from operations at the MVSTs stem from the tank contents. The MVSTs contain:

- Fissionable materials — > 250 g of ^{235}U fissionable equivalent mass in the form of dissolved, suspended, and settled out solids in up to 150,000 gallons of LLLW supernatant and sludges

- Radioactive materials — Up to 400,000 gallons of LLLW supernatant and sludges in the form of dissolved, suspended, and settled out solids in an aqueous solution

- Toxic/corrosive/reactive materials — Up to 400,000 gallons of LLLW supernatant and sludges in the form of primarily sodium/potassium nitrate solution containing a variety of laboratory and process chemicals

These materials become a real concern in the event of a tank overfill or rupture. Tank overfills at the MVSTs may result from component failure of the tank isolation valve, tank level instrumentation failure, or operator errors. When the tank overfills, the liquid would most likely flow through the tank ventilation inlet duct and be released from the ventilation inlet by spilling to the ground. An airborne release of radioactive materials is initiated by the free fall liquid spill which continues until the overfill is detected and flow of liquid to the tank is terminated. At latest, the overfill would be detected during the daily check of facilities required by the OSRs (operational safety requirements). Until the leak is detected and terminated, on-site personnel and off-site receptors are exposed to airborne radioactive materials.

Gunite Tanks

The 15 Gunite and associated tanks (GAAT) were originally used for the collection, storage, neutralization, and transfer of the aqueous portion of the radioactive and/or hazardous chemical wastes produced as part of the normal facility operations at ORNL. The term ‘Gunite’ is used with the tanks due to the construction process used for some of the tanks. As previously mentioned, the eight tanks at the North Tank Farm, six tanks at the South Tank Farm, and Tank 11 are no longer receiving wastes and are considered out of service. The North Tank Farm includes tanks W-1, W-1A, W-2, W-3, W-4, W-13, W-14, and W-15. The South Tank Farm includes tanks W-5 to W-10.

The tanks were built in the 1940s and have since been removed from service because of age and changes in liquid waste system needs and requirements. Though the tanks are no longer receiving wastes, some of the tanks contain between several hundred and several thousand gallons of LLLW and sludges. The tanks that have been successfully emptied require periodic pumping to the LLLW system for removal of tank inleakage.

The key operations processes performed at the GAAT are limited because the tanks are inactive. Ongoing surveillance and maintenance activities include weekly site inspections, tank inventory level monitoring, dry well monitoring, off-gas system monitoring (Tank W-1A only), and radiological surveys. Additionally, a treatability study is underway to assess the feasibility of emptying the tanks containing LLLW and sludge.

The GAAT Treatability Study involves the demonstration of sludge removal techniques and equipment for use in other waste storage tanks throughout the DOE complex. Sludges will be dislodged and transferred between tanks. A technique known as confined sluicing, which uses a high pressure, low-volume water jet integrated with a jet pump, is used. The deployment method for the confined sluicing uses a remotely operated vehicle; basically, a robot. The tracked vehicle, equipped with a plow type blade, is used to position and manipulate the confined sluicing equipment and to move sludge around the tank with the blade. The sludges will be sluiced out of the tanks and eventually transferred to the MVSTs.

Though the GAAT contain both radiological and hazardous materials, safety analysis identified no major safety risks to workers and the public resulting from operations at the GAAT.

The primary safety systems and features at the GAAT for preventing or mitigating operational accidents include tank level monitoring conductivity probes, off-gas system, and concave shaped cement pads under the tanks. Surveillance and maintenance activities are performed to ensure the conductivity probes provide an accurate indication of tank inventory levels. The off-gas systems include a HEPA filter for Tank W-1A and Stack 3039 for the South Tank Farm. Stack 3039 provides constant ventilation and maintains a negative pressure on the South Tank Farm tanks to prevent the buildup of hydrogen gas. Hydrogen gas presents a potential explosion hazard. The concave cement pads under the tanks collect any leakage from the tanks and provide a reliable indication of tank integrity.

Safety

The primary safety systems and features relied upon to reduce the risks associated with the operation of the RDF include:

- Hot cell structure, and
- Glovebox/Manipulator box structure, glovebox off-gas filtration, and ventilation duct system

The hot cell structure provides confinement during and following the design basis earthquake and large building fires. Additionally, the cell structure provides shielding from penetrating radiation associated with postulated criticality events.

The glovebox/manipulator box structure, glovebox off-gas filtration, and ventilation duct system includes the glovebox/manipulator box structure along with the glovebox off-gas (GBOG) header and duct system leading from manipulator boxes or gloveboxes up to and including one stage of HEPA filtration. Nuclear facility ventilation systems are designed to draw air from clean (or potentially cleaner) areas to areas of potentially higher contamination. All exhaust ventilation paths through potentially contaminated areas are passed through HEPA filters and air quality monitors before being released to the atmosphere. The GBOG system is designed to provide a volumetric flow of air (via filtered air inlets to gloveboxes) through the gloveboxes at low differential pressure.

Though not designated as safety-related equipment, Building 3019 is also equipped with a standby electrical power system, fire protection systems, and a criticality accident alarm system (CAAS) for facility safety.

The MVSTs have four features designed to prevent or mitigate accidents:

- Building 7830 facility structure
- Tank construction
- Secondary containment
- Tank level instrumentation

These structures and components are not designated as safety class SSCs but remain important to safety at the MVSTs.

The Building 7830 facility structure and the tank construction function to prevent leaks of LLLW in the event of earthquakes, vehicle impacts, and construction impacts.

The MVSTs have a secondary containment constructed of stainless steel lined vaults. The line vaults are capable of containing 100% of the respective tank contents (50,000 gallons for each tank W-24 through W-31). The secondary containment aids in the prevention of a release of LLLW should the primary containment be breached.

The tank level instrumentation functions in various ways to prevent or mitigate the effects of a leak. With the tank level monitoring system in service, a change in level indication could be an early sign of a system leak. The system also aids operators in monitoring tank level so as to prevent the inadvertent overfilling of a storage tank or alert an operator to a system misalignment during a solution transfer.

Again, though the GAAT contain both radiological and hazardous materials, safety analysis identified no major safety risks to workers and the public resulting from operations at the GAAT.

Waste Streams

Liquid waste streams for ORNL are generated as the result of laboratory experimentation, material processing, and groundwater in-leakage into the facility. Miscellaneous liquid waste streams, such as leaks to the cell floor sumps, are sometimes generated and are transferred into collection tanks. Waste solutions are sampled and analyzed to determine concentrations of fissile materials. If fissile materials are present in the waste, but their recovery is not economically feasible, the fissile materials are denatured (to provide criticality safety) and the solutions are transferred to the ORNL LLLW System.

Solid materials are generated as a result of laboratory equipment and routine facility operations. Contaminated solid wastes usually consist of gloves, shoe covers, small tools, obsolete equipment, and piping. These items are usually sealed in plastic bags and collected in metal containers. When filled, the containers are transferred to the ORNL Solid Waste Areas.

As previously mentioned, the sources of waste solutions to the LLLW System, and ultimately to the MVSTs, are contaminated sinks and drains in research and development laboratories, radiochemical pilot plants, and nuclear reactors located in both Bethel and Melton valleys. The waste is concentrated in the evaporators and transferred to the MVSTs for holding. From that point, the waste can be directed through one of three paths or in some combination of the Cesium Removal System, the Out of Tank Evaporator System, or the LLLW Solidification System.

The wastes involved contain fissionable nuclides (such as ^{233}U, ^{235}U, and $^{239\text{-}241}P$) and are therefore mixed with nonfissionable materials (e.g., ^{238}U, ^{232}Th).

LLLW Solidification Facility — The ORNL Waste Management and Remedial Action Division (WMRAD) LLLW Solidification Facility , Building 7877, houses operations to solidify the supernatant in the MVSTs. In general, each tank contains a soft crusty sludge covered by an alkaline, high-nitrate supernatant of variable volume. Both the sludge and supernatant contain Alpha- and beta-gamma-emitting radionuclides. The purpose of the solidification operations is to reduce the volume of LLLW stored in the MVSTs to provide storage volume for more waste. Previously, the wastes from the MVSTs were mixed with grout and injected into the ground at the Hydrofracture Facility. However, this method is no longer an acceptable course of action.

Out of Tank Evaporator System — The Out of Tank Evaporation method uses a single effect, shell and tube, vacuum evaporator unit installed in one-half of the bay area of Building 7877, to concentrate the supernatant from the MVSTs. The main components of the system include a feed tank, concentrate/recycle tank, distillate tank, evaporator, separator, condenser, heating and cooling systems, and local and remote control panels.

The GAAT are all inactive and therefore have no major waste streams. When the GAAT Treatability Study is underway, the LLLW and sludges associated with the tanks will be transferred to the MVSTs for storage and eventual handling through the LLLW System. GAAT contents are stored wastes from ORNL operations (e.g., Building 3019) and include chemical process waste, high radioactive metals, and fissionable materials (e.g., tritium and various isotopes of cesium, plutonium, uranium, and neptunium).

Section Review

1. *Identify the current defense nuclear facilities at ORNL.*

2. *How has the mission changed over recent years for the ORNL defense nuclear facilities?*

3. *Summarize the process overviews for:*
   - *Bldg. 3019*
   - *MVSTs*
   - *Gunite tanks*

   Include a sketch of the LLLW System to clarify your explanation.

4. *What are the hazards to the workers and general public from these facilities?*

5. *Characterize the ORNL defense nuclear facility waste stream in regards to the composition. How is this waste treated?*

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?*

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.

<u>Downblending Activities</u>

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.

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<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.*

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ATTACHMENT — Review Exercise

The reader is encouraged to use this review tool and refer to the guide as needed to determine the correctness of responses. A review key may be obtained by contacting ORO Training and Development Division.

Y-12 — Oak Ridge, Tennessee

1.1 List the ten programmatic elements that utilize the Y-12 defense nuclear facilities and together support national Defense Program missions. (5 points)

1.2 Place the appropriate letter in each blank to match the five Y-12 functional organizations with their corresponding organizational missions. (5.0 points)

____	Disassembly and Storage Organization	a.	Advanced development, process development, and process support for the nuclear weapons complex.
____	Depleted Uranium Operations	b.	Salvage and recycle lithium including wet chemistry processes, metal production, powder production, parts production, machining, and storage for weapon production.
____	Enriched Uranium Operations	c.	The production, special production, test assemblies, disassembly, material verification/accountability, and container refurbishment and storage.
____	Special Materials	d.	Manufacture weapon components from depleted uranium, depleted uranium alloys, and non-uranium metals such as steel and aluminum.
____	Development Operations	e.	Process highly enriched uranium safely into usable uranium products or into forms suitable for storage.

1.3 Describe the Chip Processing Operation performed in EUO (1.5 point).

1.4 Explain the three major categories for safety risks to workers and the public resulting from operations at Y-12 EUO facilities. (3.0 points)

Senior Technical Safety Managers only

1.5 List six Y-12 waste treatment facilities used to process Y-12 waste. (1.5 points)

East Tennessee Technology Park — Oak Ridge, Tennessee

1.1 Name the seven ETTP defense nuclear facilities. (3.5 points)

1.2 Describe the types of materials stored in the HEU facilities at ETTP. (2.0 points)

1.3 The safety risks to ETTP workers from the storage of radioactive materials comes from what three groups of material? (1.5 points)

1.4 List the three primary safety systems and features used in UF_6 storage yards for preventing or mitigating operational accidents. (1.5 points)

Senior Technical Safety Managers only

1.5 Characterize the waste streams from ETTP Decontamination Facility K-1420. (2.0 points)

Oak Ridge National Laboratory — Oak Ridge, Tennessee

1.1 List the ORNL defense nuclear facilities and their corresponding mission(s). (3.0 points)

1.2 List the primary safety systems and features of the MVSTs for preventing or mitigating operational accidents. (1.5 point)

1.3 Sketch and label the process flow path for the MVSTs. (5.0 points)

Senior Technical Safety Managers only

1.4 Characterize the waste processed by the LLLW Solidification Facility (Building 7877) and the function of the process facility operations. (2.0 points)

Paducah Gaseous Diffusion Plant — Paducah, Kentucky

1.1 Complete the following: The PGDP defense nuclear facilities consist of ______________ ____________ yards (0.5 point) and ___________ _______________ and _________________ ____________________ storage building (0.5 point).

1.2 Other than cylinder storage, list four operations performed PGDP in the storage yards (1.0 point).

1.3 Explain the major safety risks to workers and the public resulting from UF_6 at gaseous diffusion plants (2.5 points).

1.4 The _____________ ___________ __________________ __________________ is designed to detect gamma radiation levels that would result from the minimum criticality accidents of concern at PGDP (1.0 point).

Senior Technical Safety Managers only

1.5 Select from the list below DOE's largest LLW contributor at PGDP. (1.0 point)

a. Operation of the gaseous diffusion plant and ancillary systems.

b. Abandoned-in-place equipment no longer critical to the site's mission.

c. Construction/ demolition rubble such as dirt, concrete, and gravel generated primarily by environmental restoration and D&D activities.

d. Legacy waste from operation of the Paducah molten metal reactor.

Portsmouth Gaseous Diffusion Plant — Portsmouth, Ohio

1.1 Place the appropriate letter in each blank to match the seven PORTS defense nuclear facilities with their corresponding facility mission. (3.5 points)

___	Storage Cage X-326L	a.	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.
___	Special Nuclear Material Storage X-345	b.	Storage for 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).
___	Oxide Conversion Area X-705E		
___	Bulk Non-UESA Storage Building X744G	c.	Store miscellaneous equipment and materials, including various hazardous or contaminated materials in drums, crates, cars, trailers, and mobile tankers.
___	UF_6 Cylinder Storage Yards X-745-C, E	d.	RCRA waste storage facility and includes areas for unloading, sampling, and staging areas for wastes prior to shipping.
___	Recycle and Assembly Building X-7725	e.	Storage unit for hazardous waste such as high-assay uranium-bearing materials, asphyxiants, mixed wastes, technetium-bearing material, asbestos, and PCBs.
___	Recycle/Assembly Storage Yard X-7745R	f.	Temporary and long-term storage of cylinders filled with solid UF_6.
		g.	Served as an oxide conversion facility from 1967 until 1978.

1.2 Fill in the blanks. Concerning PORTS downblending activities, the HEU feed rate is controlled to ensure that there is no more than _____ kg of ^{235}U in __________ wt % ^{235}U enriched uranium in ________________ _________________________ components of the system during routine operations. (2.0 points)

1.3 Describe three material access area (MAA) access controls used to protect workers and safeguard SNM at PORTS. (1.5 point)

1.4 Complete the following: CAAS detects ______________, provides a distinctive, ________________ signal that will alert personnel to _________________ the areas that are potentially affected, and provide sufficient information to a central remote location for initiation of emergency response activities.

Senior Technical Safety Managers only

1.5 List the three principal sources of low-assay LLW generated at PORTS. (1.5 points)

1.6 Match the following wastes to the PORTS originating source. **Not all** originating sources on the right necessarily apply. (1.5 points)

___ Waste contaminated with ^{99}Tc / greater-than-class C LLW	a. Generated at PORTS by fabrication and maintenance activities, major equipment repair, metal machining, welding, instrument repair, field maintenance, and environmental restoration.
___ Mixed hazardous wastes	b. Coolant from high temperature gas-cooled reactor
___ Liquid mixed radioactive wastes	c. Spent ion exchange resins
	d. Spent solvents, sludges, discarded commercial chemicals, PCB-contaminated wastes, and metal machining and cutting fluids from fabrication, maintenance operations, and chemical operations
	e. Nitric acid and aluminum nitrate aqueous streams from the EU recovery operations in the 9212 complex

1.7 List the six major sources of hazardous wastes are generated at PORTS (3.0 points)