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Technical Qualification Program

OAK RIDGE OPERATIONS OFFICE DEFENSE NUCLEAR FACILITIES

Study Guide

Y-12

Developed by the
OAK RIDGE OPERATIONS OFFICE
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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*