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40430-PL-0010	0PCN1	APPROVED	SILO 3 RETREIVAL AND DISPOSITION NUCLEAR HEATH AND SAFETY PLAN	ATT: RAYER, DIANA L Project: 40430

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RECORD OF ISSUE/REVISION

NOTE: The main body of the Silo 3 N-HASP (prepared by Fluor Fernald staff) determines the operable effective date for the entire N-HASP package. The appendices provided by Jacobs Engineering are stand-alone components with their own revision numbers. Outside the annual revision process, a change in an appendix does not increase the revision number for the entire document; it is considered an N-HASP PCN.

EFFECTIVE DATE	PCN NO.	REV. NO.	DESCRIPTION
02-09-04		0	Initial issue of N-HASP to identify hazards, controls, and mitigators for Silo 3 retrieval and disposition.
03-19-04	1	0	PCNs for: (1) Section 1.2, *FCP Site History and Description*, to specify Silo 4 demolition; (2) Section 1.4, *Silo 3 Process Description*, to specify Silo 4 demolition and to clarify training plans for Silo 3 penetration; (3) Figure 1-1 to add charge tanks and specify shipping mode; (4) Section 6.0, *Management of Change*, to clarify when the Silo 3 Safety Basis Impact Screen (SBIS) is used, and to address the management of software change; (5) Table 8-23, *Radiological Hazard Controls*: *Radiological Access Controls: Access to Controlled Areas*, to specify the location of the Silo 3 control point and TLD storage, and to require workers not receiving TLDs to report to Silo 3 Rad Con for time-tracking while in the Controlled Areas; (6) Section 10.2, *Silo 3 System Safety Requirements*, to SBR-1 to clarify Silo 3 stack monitoring; to PR-3 to specify that IP-2 bulk bags/packages must be sealed before transfer outside of the Cargo Bay area; to PR-5 to remove operations procedures from the Implementation column; (7) Section 20, *References*, to update two references; (8) Appendix B to update two references; (9) Appendix C to clarify responsibilities for evaluating and revising manuals and procedures.

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1.0 INTRODUCTION

1.1 Purpose and Scope

This Silos project-specific Nuclear Health and Safety Plan (N-HASP) was developed to ensure that hazards have been identified and that controls or mitigators will be in place to support the safe operation of Silo 3 retrieval and disposition process. The Silo 3 N-HASP is being submitted to satisfy a commitment in the U.S. Department of Energy (DOE)-approved *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects,* 40000-RP-0034 [Ref. 1]. This N-HASP meets the requirements of Title 10 Code of Federal Regulations (CFR) 830.204, *Documented Safety Analysis* (DSA) [Ref. 2]; 29 CFR 1910.120 (b)(4), *Site Specific Health and Safety Plan* [Ref. 3]; and follows the general rules for HASP development as outlined in NS-0005, *Initiating, Reviewing, and Approving DOE-Approved SBDs* [Ref. 4].

The Silo 3 Retrieval and Disposition Project has been determined to qualify as a Radiological (RAD) Facility based on the analyses discussed in Appendix B, *Hazard Category Calculation*. Although Silo 3 inventory qualifies as nuclear Hazard Category 3 (HC-3). The retrieval and disposition activities and facilities qualify as RAD based on analytical consequences. Per DOE-STD-1120-98, *Integration of Environment, Safety and Health into Facility Disposition Activities* [Ref. 5], a RAD categorization/classification based on analytical consequences requires DOE approval. A more detailed discussion of the safety basis is provided in Section 5.0. Silo 3 System Safety Requirements are listed in Section 10.0.

This N-HASP is divided into two volumes. Volume One contains the standard requirements of a 29 CFR 1910.120 HASP, into which have been inserted sections addressing the Silo 3 System Safety Requirements and the Work Control Processes related to the Silo 3 process. Volume Two includes the analyses that support the Silo 3 DOE decision basis [i.e., Integrated Hazard Analysis (IHA), Hazard Category Calculations (HCC), Human Factors Evaluation (HFE), ALARA (As Low As Reasonably Achievable) Analysis, Environmental ALARA Analysis, Fire Hazards Analysis (FHA), Accident Analysis, and Health Physics Plan (HPP)]. These analyses were used to develop the Silo 3 System Safety Requirements that provide defense-in-depth. Together, Volumes One and Two comprise a DSA that meets the requirements of 10 CFR 830.204, *Nuclear Safety Management* [Ref. 6].

1.2 FCP Site History and Description

From 1952 until 1989, the Fernald site provided high-purity uranium metal products to support U.S. defense programs. Note: From 1952 until 1992, the site was called the Feed Materials Production Center (FMPC). Starting in 1992, the site was called the Fernald Environmental Management Project (FEMP). Recently, the site name was changed to the Fernald Closure Project (FCP). The FCP is operated by Fluor Fernald, Inc. (previously called Fluor Daniel Fernald, Inc.)

Uranium production halted in 1989 because of declining demand and a recognized need to commit available resources to environmental remediation. Former uranium operations at the FMPC site were limited to a fenced 136-acre tract near the center of the site known as the (former) Production Area. Large quantities of liquid and solid wastes were generated by the various FMPC production operations. Before 1984, solid and slurried wastes from FMPC processes were stored or disposed of in the Waste Storage Area (WSA). This area, located west of the production facilities, includes: six low-level radioactive waste (LLRW) storage pits; two concrete silos with earthen berms containing K-65 residues; one concrete silo containing metal oxides; one unused concrete silo; two lime-sludge ponds; a burn pit; a clearwell; and a solid-waste landfill. The WSA is part of Operable Units 1, 2, and 4. The former Production Area and WSA are fenced and closed to the general public. The remaining 914 acres of the site consist of forest, fields, wetlands, and pasture lands.

Operable Unit 4 (OU4) is a 5.8-acre area located on the western side of the site containing the following FCP facilities and associated environmental media:

- Silos 1 and 2 and their contents (also called K-65 Silos)
- Silo 3 and its contents (also called Cold Metal Oxide Silo)
- Silo 4 (formerly empty; now demolished)
- The decant sump (an underground tank and its contents)
- A portion of a concrete pipe trench and other concrete structures (currently being decommissioned)
- An earthen berm surrounding Silos 1 and 2
- Soils beneath and immediately surrounding the silos
- Perched groundwater in the vicinity of the silos
- Remainder of the Vitrification Pilot Plant (now known as the Silos Operations & Maintenance [SOM] building) and associated operations pad
- Associated abandoned underground utilities and foundations

PCN1

Silo 3 was constructed for the transfer and storage of "cold" 11e.(2) uranium processing byproduct material [as designated by the Atomic Energy Act (AEA) of 1954, as amended] generated through refinery operations at the FMPC site. The Silo 3 material is a by-product of uranium-bearing ore concentrate processing. The ore concentrates had been preprocessed through a uranium mill where a significant portion of the Ra^{226} and the gamma-emitting progeny were removed, and thus they were termed "cold" feed material. Silo 3 received metal oxide raffinates generated by all FMPC refinery operations from May 1954 until late 1957.

1.3 Silo 3 Structure, Contents, and History

1.3.1 Silo 3 Structure

Silo 3 was constructed in 1952 and is located south of the Waste Pit Area of the FCP property. Silo 3 is a free-standing, post-tensioned concrete, domed silo. It is approximately 80 feet in diameter and approximately 33 feet above ground level (apex). The floor system is approximately 17 inches of compacted clay, a 2-inch thick layer of asphaltic concrete, and an 8-inch layer of gravel, topped by 4 inches of concrete. Silo 3 does not have an underdrain system. The domed

After a soft-sided container is filled, the inner PVC liner is sealed by radio frequency, perforated, and detached from the fill chute at the perforation. The container is moved to the Package Staging Conveyor, where swipe sampling and surveys of the container assembly are performed. If no contamination is found, the container is then transported to the Cargo Container Bay, through an airlock, where it is closed and placed on a shipping pallet. The containers are surveyed to meet shipping requirements and staged for labeling. Once a container has been labeled, it will be loaded into an enclosed truck trailer using a forklift, and transported to a staging area for shipment off-site.

1.4.2 Cutting a Hole in Silo 3 for Mechanical Retrieval

Note: Hole cutting is a construction activity performed by construction labor and authorized by the PHAR. The Silo 4 mock access demonstration was performed during the construction of the retrieval facility. However, Silo 3 wall access will occur after the operations phase has begun because the plan calls for pneumatic retrieval of material behind the intended wall opening. Safety Basis Requirement 1 (Section 10) specifies a deliberate process for proceeding with the wall cutting. Therefore, there will be a short window of time when operations (authorized by this N-HASP) and construction work (authorized by the Silo 3 PHAR [Ref. 14]) will overlap.

Successfully cutting an opening in the Silo 3 wall large enough for mechanical retrieval may be critical to successful project operations if pneumatic retrieval cannot transport the most compacted waste. The project committed to a demonstration of the work steps for cutting such an opening. This demonstration (conducted on now-demolished Silo 4) was designed to verify engineering calculations, support detail vendor design, integrate multiple field activities, analyze observations, and generate lessons learned for subsequent documentation.

Design and preliminary strategies were developed through early collaboration with consultants, engineers, equipment vendors, and construction representatives, including supervisors and craftsmen. An independent structural consultant, considered an expert in reinforced concrete tank design, supported the detailed design. The project bulk powder consultant conducted modeling studies to predict material flow during scenarios that varied by material height at the time of cutting. The overall retrieval approach is documented in 40430-PL-0002, *Access and Retrieval Strategy for the Silo 3 Project* [Ref. 22]. The results of the Silo 4 demonstration are documented in 40430-RP-0028, *Silo 4 Mock-up Demonstration* [Ref. 23]. The following two subsections provide an overview of those results.

Mock Access on Silo 4

In preparation for the eventual access of the Silo 3 wall, a mock access was conducted on empty Silo 4 (since demolished). Silo 4 was built about the same time as Silo 3 by the same contractor, and had the same structural dimensions and characteristics (see Section 1.3.1). The main difference was that the Silo 4 concrete had severe freeze-thaw effects because it had been empty. However, based on the demolition of site water tanks (similarly constructed by the same contractor), the access plan was deemed feasible for Silo 3. The water tanks and Silo 3 are considered comparable in terms of good concrete quality. The added difficulty presented by good-quality concrete was factored into the observation of the Silo 4 demonstration.

A 20ft H x 15ft W opening is required for retrieving material with a remote-operated excavator. The access strategy calls for the intended wall opening to be cut into a grid pattern with a track-mounted wall saw. The outside surface of the silo wall was originally reinforced with post-tensioned wires encased in gunnite. Therefore, a concrete reinforcement frame was designed to maintain the structural integrity of the silos by maintaining the tension of the post-tensioning wires when cut, and preventing their release from the concrete. The design is conservative and provides a safety factor [Ref. 24].

The first step in the mock access was to cast-in-place the concrete reinforcement around the intended access opening. Next, some of the decant ports located on the silo wall were glove-bagged and removed because they interfered with the temporary cutting tracks and planned safety beams.

The plan calls for cutting the concrete in grid sections to facilitate removal and to reduce the amount of rubble that could get into the stored Silo 3 waste. There is also a concern that rubble and the large number of wires in the debris would foul the mechanical equipment in the retrieval bin. The grid plan also allows for concrete sections to be removed from top to bottom. This will be helpful if impacted material has to be removed as the opening is made.

A custom-designed curved tract was ordered to match the curvature of the silo. The track-saw automatically travels on the track and the depth of the cut is controlled by a tethered control. This allows the operator to maintain a safe work distance. The silo wall was scored in a grid pattern with a concrete wall saw to within one inch of the inside surface of the wall. It was determined that a cut of this depth would allow the concrete to be broken free and yet minimize worker exposure to Silo 3 material during the actual cutting. During the cutting, wedges were used to keep the sections stable.

During grid cutting, the severed wires and gunnite were removed. Horizontal beams were installed to prevent cut sections of the wall from falling on workers.

One reason the selected excavator was chosen was because it has an additional articulating joint. This provides a range of motion that allows it to work within the silo and adjoining excavator room. The machine can also articulate in a horizontal plane. This flexibility would support retrieval if only a portion of the wall can be removed due to material compacted behind the wall.

A mounting/lifting bracket was designed to be compatible with the excavator attachment mounting plate and was used for removal of some of the braces. This was found to be quicker and much safer than using a hoist, and could be done remotely. Different types of attachments were used to secure wall sections to the excavator, and those sections were successfully removed. Due to poor concrete quality, the sections fractured rather than remaining as whole sections. However, removal of concrete sections and testing of the excavator swing area within the footprint was demonstrated.

Due to the poor condition of the concrete, the rubble was placed within Silo 4 for later on-site disposal with the other demo debris. Silo 4 has since been demolished. Concrete will be disposed

of in the OSDF as part of the Silo 3 concrete waste stream, or in alternate disposal locations as specified in the Project Waste Identification and Disposition (PWID) report.

The Silo 4 demonstration showed that:

- the reinforced opening was appropriately designed and installed.
- a concrete track saw can be used to score the concrete prior to breaking the opening.
- the excavator can support field activities during the preparation steps of cutting the opening.
- a remote-operated excavator has the break-out force and maneuverability to work in the designed space for removing concrete.
- multiple (and available) tools and attachments are required to break the concrete free and handle pieces.
- the access and retrieval strategy approach is valid.

Silo 3 Access

Silos 3 and 4 were built in the same manner at the same time by the same contractor. They have the same structural dimensions and characteristics. The main difference is the less-degraded quality of the Silo 3 concrete. Based on demolition experience with site concrete water tanks built by the same contractor, Silos 3 and 4 have been determined to present equivalent challenges that can be accessed using the same strategy. Thus, the experience of the Silo 4 demonstration (i.e., reinforcing frame and grid cutting) is directly applicable to Silo 3. A Lessons Learned report was written following the Silo 4 demonstration [Ref. 25]. Detail design has incorporated any recommendations or changes through the project design change notice (DCN) process and safety basis impact screens (SBIS) and Unreviewed Safety Question (USQ) process.

It is a reasonable expectation that the project team associated with the Silo 3 wall cutting will include some of the same individuals who participated in the Silo 4 mock-up. All craft, supervision, and engineering support for Silo 3 penetration will receive training or briefings on the lessons learned, equipment, safety requirements, and work evolutions. Engineers familiar with the lessons learned and the Silo 3 cutting requirements will be made available during the training exercises.

If Silo 3 concrete sections meet the OSDF or WPRAP WAC, they will be removed and wrapped in plastic for staging in the thorium laydown area until disposal in the OSDF or WPRAP as part of the Silo 3 concrete waste stream. Silo 3 concrete that does not meet the OSDF or WPRAP WAC will be containerized and shipped as part of the existing NTS profile/shipping program for "process area waste." Such concrete will be placed directly in strong-tight containers (Sea/Lands).

A number of observations made during the Silo 4 demonstration will improve the Silo 3 access process:

- The vertical cuts through the post-tensioning wires caused delamination of the one-inch shotcrete layer, which affected the mounting of the track for the horizontal cuts. Steps were revised to completely remove the post-tensioning wires and shotcrete layer in the work area (no delaminating was observed past the reinforcing frame).

- After the first track-saw cut, it was easier to remove the cut wires using a hand-held saw. The track mounting was then reset after the shotcrete was removed. Additional track mounting brackets were identified as being needed. One section of scoring cut completely through the wall. On Silo 3, this would cause contamination of the work area. This demonstrated that the project must conservatively assume that a breach will occur and dress workers in appropriate PPE. In the event of a breach, the cut location can be temporarily sealed to contain the material. Additional measurements will be made after the track is reset to check clearances and adjust for silo curvature. Cuts will be made in three passes with the depth of the last cut to be adjusted.

- Installation of the wall braces was cumbersome at Silo 4 because there was no building on which to mount rigging (a manlift was used). For Silo 3, rigging can use the excavator roof structural steel. Improved brackets that braces could slide into would allow quicker installation and removal. A mounting/lifting bracket was designed to be compatible with the excavator attachment mounting plate and was used for removal of some of the braces. This was found to be a quicker and safer than using a hoist, and could be done remotely.

- Scoring of the concrete prior to removal resulted in defined boundaries for each section and allowed for control of the amount of concrete to be removed. The freeze-thaw effects on Silo 4 concrete caused the sections to fracture rather than remaining as whole sections; however, the fracturing remained within the grid. The mounting bracket for segment removal was used and demonstrated. Adjustments were made to the bracket installation work steps. The excavator handled the pieces within the design footprint of the excavator room. The selection of excavator attachments was demonstrated and an assessment of each piece was made.

- Measurements were made for the placement of the cable management system, tethered electric line, and closed-circuit television cameras. Cameras were not available to provide views of the far side from the control area. The operator walking and visually working with the machine was used to document the views and camera locations that will be needed during Silo 3 operations.

The following recommendations will be evaluated by engineering and will be incorporated, as appropriate, into the Silo 3 equipment, design, and work planning [Ref. 23]:

1. Revise the excavator cable management location. Locate camera mounting brackets on the excavator. Paint the boom in contrasting colors for depth perception.

2. Provide additional attachments, such as a modified bucket or tools to address variable concrete conditions, including removal of rubble in addition to whole pieces.

3. Modify the mounting bracket installation.

4. Procure additional mounting brackets and longer hydraulic hoses for the wall saw.

5. Design wall braces that can be remotely removed from the Silo 3 wall opening using the excavator. The brace design will account for live load of Silo 3 material behind the wall.

6. After the final brace design is received, revise the construction traveler to incorporate redline comments and revised work steps. (A construction traveler is a subcontractor-produced, FCP-reviewed/approved work plan that outlines how construction will perform work safely.)

7. Evaluate the need for vertical as well as horizontal braces.

8. Update the safety briefing on equipment and the construction traveler. Prior to initiating Silo 3 penetration, show that the activity can be performed as planned per the Operations Work Instructions specified in this N-HASP (TABLE 10-1, SBR-1).

1.4.3 Silo 3 Material Retrieval and Packaging Activities

This section provides a more detailed explanation of the operational steps of Silo 3 material retrieval and packaging.

<u>Pneumatic Retrieval</u>

Note: Prior to construction, the design of the pneumatic retrieval components will be evaluated against, and conform to, the Technical Safety Requirement (TSR) specified in Section 10.3. The pneumatic retrieval strategy has a demonstration plan [Ref. 26] for vacuum wand retrieval and will separately document the results.

The VWMS is installed on the silo dome beneath a fabric enclosure structure that provides protection from the weather. The VWMS consists of flexible hoses and metal tubes (vacuum wands) that will be inserted through the six existing silo dome manways. A motorized hoist will be used at each manway to assist operators in manipulating the VWMS hoses/wands. Video cameras to allow for remote viewing.

At each vacuum wand (and associated manway), an enclosure is provided with passive air supply (inlet) and process vent (outlet) hose connections. A coated fabric flexible boot is installed on the top of each enclosure to seal around the vacuum wand and prevent particulate emissions from the silo, particularly during times when the vacuum retrieval is not running.

In order to keep silo pressure from becoming too negative, the passive air supply (from a HEPA filter) will replace air displaced during pneumatic retrieval and process vent operations. The process vent connection will normally be used to provide slight negative pressure when vacuum wand sections are added and when the pneumatic retrieval (vacuum) system is not in operation.

A vacuum relief valve on the passive air supply piping will open at 3 inches water column (WC) vacuum in the event the HEPA filter becomes plugged or does not allow sufficient air flow to alleviate silo negative pressure.

In the event of a failure of the passive air supply and/or the vacuum relief valves, the fabric flexible boots around the wands should fail (thus relieving silo negative pressure) before a silo failure occurs. Additionally, there is a pressure transmitter on the silo dome to provide an alarm if the silo pressure becomes greater than 3 inches WC vacuum. The pneumatic system also has a low-

pressure switch on the blower inlet that will open a blower inlet relief valve, and a low-flow switch to shut down the blower in the vent of a plug in the pneumatic system or the passive air supply.

The PRS is contained in a steel beam/metal-sided building (the Process Building) adjacent to the silo. The PRS provides pneumatic, vacuum flow using rotary blowers. From the VWMS, the material/air stream enters the PRS baghouse collector, where material is separated from the air stream and fed by a screw conveyor and rotary airlock to the packaging screw conveyor. The air stream from the PRS baghouse collector passes through a cartridge filter, a high-efficiency particulate air (HEPA)/ ultra-low penetrating air (ULPA) filter, and rotary blower and is discharged via the Silo 3 exhaust stack. Material collected by the cartridge filter is fed by the same screw conveyor and rotary airlocks to the packaging screw conveyor.

Pneumatic retrieval will be performed to the extent practicable (i.e., as long as material can be safely and effectively removed by vacuum). Of significant importance is the use of the VWMS/PRS for removal of material from behind the silo wall, at the proposed access location, to permit safe wall opening for mechanical retrieval. The VWMS/PRS can be used prior to the MRS and in conjunction with it.

Mechanical Retrieval

The Mechanical Retrieval System (MRS) is housed in a robust concrete structure (Excavator Building) attached to the silo structure. When free-flowing material has been removed from the silo to expose the inside of the silo wall, and pneumatic retrieval is no longer practical, an opening will be cut into the exposed silo wall to enable the use of a mechanical excavator (see Section 1.4.2). Compacted material remaining behind the wall will not prevent initiation of wall removal.

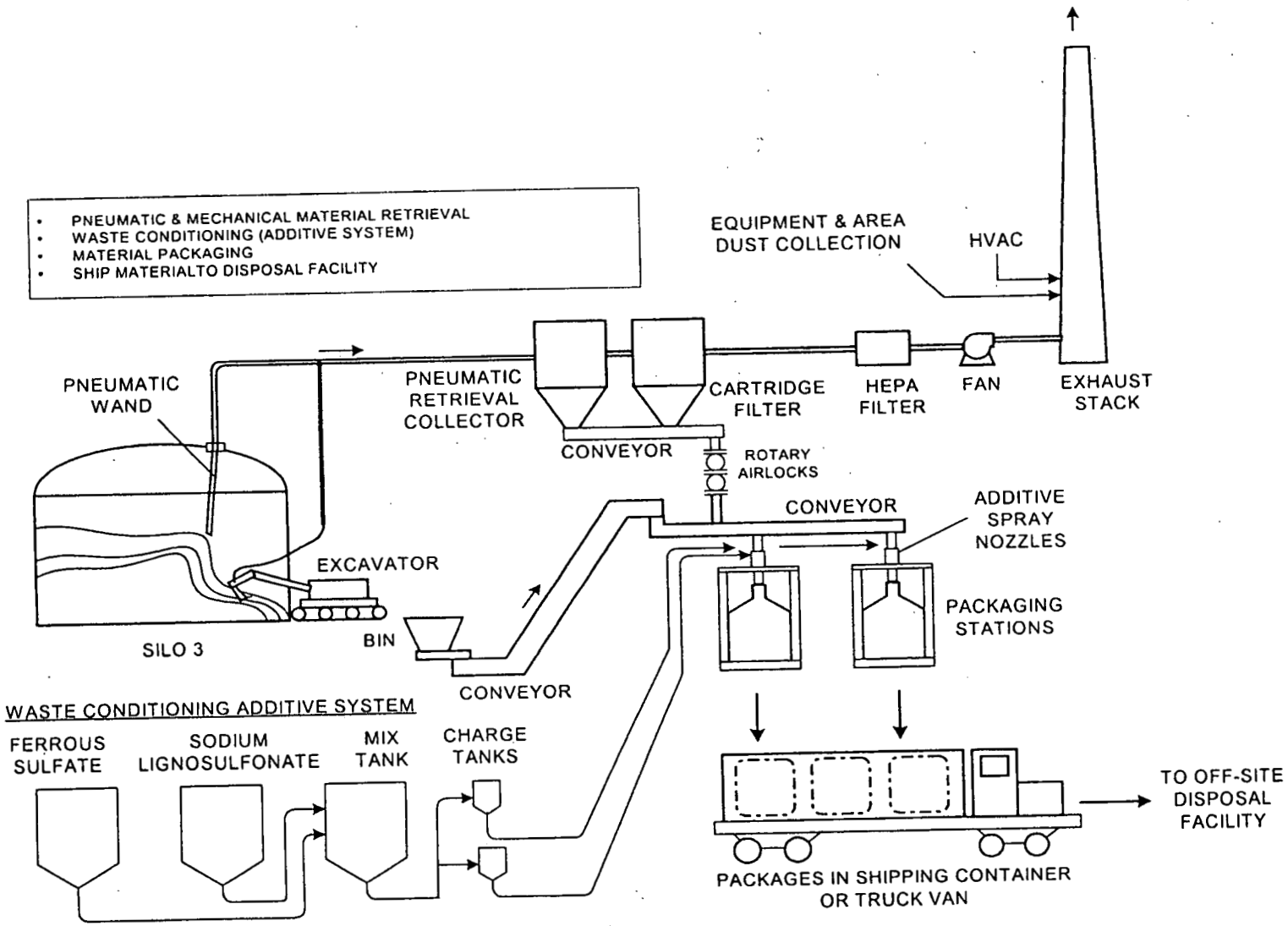
The selected excavator has an additional articulating joint. This provides a range of motion that allows it to work within the silo and adjoining excavator room. The machine can also articulate in a horizontal plane. This provides flexibility for supporting retrieval if only portion of the wall can be removed due to material impacted behind the wall.

The excavator can reach into the silo and loosen compacted material for vacuuming. Video cameras to allow for remote viewing. The excavator may also be used to manipulate the VWMS wand/hose to facilitate pneumatic retrieval. The remotely-operated excavator will enter the silo and dig into the waste pile. Removed material will be placed in a below-grade bin in the Excavator Room and then moved to the two packaging stations via four conveyors. Three of the conveyors are screw-type, and one is a pocketed sidewall belt conveyor. The last of the screw-type conveyors is common to the PRS.

Waste Conditioning

As the Silo 3 material is containerized, it will be conditioned by the addition of an aqueous solution to reduce dispersibility and metals mobility. The solution of ferrous sulfate, sodium lignosulfonate, and water will be sprayed onto the material in the fill chutes at the packaging stations. No credit was taken for waste conditioning in the hazard category calculations.

FIGURE 1-1: SILO 3 OPERATIONS FLOW DIAGRAM



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- Annually review and update the HASP[s], as necessary. If there are no significant changes required to the HASP[s], meet the annual update requirement via a letter to DOE stating there have been no significant changes.

The following commitment from the DOE SER 40000-RP-0034 has been identified by the Silo 3 Project as applicable to Silo 3:

- Fluor Fernald, Inc., must maintain the safety programs as described in the site Integrated Safety Management program description documented in PL-3081, *Safety Management System Description (SMSD)* [Ref. 33].

6.0 MANAGEMENT OF CHANGE

NOTE: With the approval of this Silo 3 N-HASP, Silo 3 personnel will no longer use the Silos Project Safety Basis Impact Screen (SBIS) for Silo 3 Project change issues. For Silo 3 changes, personnel will use the Silo 3 SBIS documented in this section. Changes to approved Silo 3 operating procedures, and approval of new Silo 3 operating procedures, must go through the review process specified in the site document control procedure, MS-2001. The Silos Project SBIS is still valid for Silos change issues outside the scope of any approved Silos N-HASP. PCN1

Since the Preliminary DSA (i.e., Silo 3 Preliminary Hazard Analysis Report (PHAR) [Ref. 14]) was approved, changes to the design or variations in construction from the design have been screened using the *Silos Project Safety Basis Impact Screen* (SBIS). Upon Silo 3 N-HASP approval, a *Silo 3 Safety Basis Impact Screen* must be completed: (1) for changes in design requiring a Design Change Notice (DCN) per an engineering procedure; (2) for new activities; (3) for maintenance alterations; (4) for changes to this N-HASP. The Silo 3 screen is shown in **FIGURE 6-1**. Both the Silos Project screen and the Silo 3 screen meet the requirements of NS-0008, *Safety Basis Documentation Review (SBDR) Process* [Ref. 45]. PCN1

A System Safety Analyst [SSA] must approve the impact screen. After DOE approval of this N-HASP, any change that results in a YES to any of the five questions on the Silo 3 SBIS will require further evaluation. Question 1 focuses on both nuclear safety and occupational safety (e.g., the Hazards Analysis could be affected by the introduction of a new chemical in the maintenance process, requiring further evaluation). Question 1 allows the screen originator to take an ISM approach to a potential hazard not previously identified. The evaluation will then provide input to the work plan or work permit used for the activity. Question 2 ensures that the System Safety Requirements are not affected by the change. Questions 3, 4, and 5 evaluate potential inadequacies, effects to nearby or adjacent facilities or activities, and changes in inventory of hazardous material.

When a change or deviation requires further evaluation, either the change will not be implemented or work on the affected portion of the facility will remain suspended until an evaluation has been completed and attached to the impact screen. This screen package will then go to the Silo 3 PM for review and approval.

Because the silos themselves are HC-3 facilities, when proposed changes have the potential to affect the Silos, positive impact screens will be evaluated using USQ process per NS-0002, *Unreviewed Safety Question (USQ) Determination and Safety Evaluation System* (USQD/SE System) [Ref. 46]. Potential SBR/PR violations that affect the Silos will be evaluated using the Safety Analysis Evaluation Process listed in NS-0002. PCN1

All completed Safety Basis Impact Screens or USQD/SEs will be evaluated annually by Nuclear and System Safety (N&SS) staff for inclusion into this N-HASP to ensure that each document is complete and up-to-date.

Surveillances will be performed by N&SS staff and approved by the N&SS Manager to ensure that the project Safety Requirements are being implemented and the safety basis is being kept up-to-date.

Readiness activities will include a review of the SBIS process to ensure that the DCNs that were performed against the PHAR were properly incorporated into this N-HASP.

Software Management of Change

The Silo 3 Project uses the process outlined in MS-1040, *Software Quality Assurance* [Ref. 47], to classify, develop, verify, and validate software that may have an impact on nuclear safety. This process applies to software currently in use, proposed for use as well as software that is purchased, developed in-house, licensed from a commercial vendor for customized use, obtained from another site, or developed or customized by a vendor or subcontractor. PCN1

FIGURE 6-1: SILO 3 SAFETY BASIS IMPACT SCREEN (SBIS)

Description of Activity/Design Change:

Work Plan/ Design Doc. No.:	**Change Originator:**
SBIS Originator:	**SBIS Date:**

1	Will the proposed change affect any parameters used in calculations supporting the Hazard Analysis as documented in the Silo 3 N-HASP? ☐ **YES** ☐ **NO** / **EXPLAIN:**
2	Will the proposed change affect any of the System Safety Requirements in the Silo 3 N-HASP? • Safety Basis Requirements (SBRs)? • Process Requirements (PRs)? ☐ **YES** ☐ **NO** / **EXPLAIN:**
3	Does the proposed change identify a potential inadequacy (e.g., new accident, hazard) in the Silo 3 N-HASP or any potential reduction in any SBR? ☐ **YES** ☐ **NO** / **EXPLAIN:**
4	Does the proposed change affect the activities or requirements of a nearby or adjacent facility or activity operating under a different safety basis (e.g., Silos 1 & 2, RCS, TTA)? **NOTE: IF** a proposed change can potentially affect the Silos, **THEN** a USQD/safety evaluation must be completed per NS-0002 (Unreviewed Safety Question (USQ) Determination. ☐ **YES** ☐ **NO** / **EXPLAIN:**
5	Does the proposed change result in a change in the inventory or amount of hazardous material? ☐ **YES** ☐ **NO** / **EXPLAIN:**

IF the answer to ANY of these questions is **YES, THEN:** (1) update the analysis; (2) determine whether the change will put the project or affected project outside the safety envelope; (3) incorporate any mitigators or controls into the work plan/permit; (4) attach the updated analysis to this impact screen. **IF** the change will result in a higher hazard categorization, **THEN** a USQ must be performed per NS-0002 and submitted to the SRC, the Fluor Fernald President, and the DOE for concurrence.

6	Per this SBIS, the proposed change ☐ **DOES** ☐ **DOES NOT** impact the Silo 3 safety basis.

Signature: _____ **Date:**
System Safety Analyst

SSA: Are there descriptive changes not requiring analysis, but requiring inclusion in the annual update? ☐ **Y** ☐ **N**

NOTE: IF there is an impact to the safety basis, **THEN** the Project Manager's signature is required.

Signature: _____ **Date:**
Silo 3 Project Manager

7.0 HAZARDS ASSESSMENT

The hazards assessment associated with this N-HASP will focus on the activities necessary to support operations and maintenance of Silo 3. To date, fourteen Silo 3 operations tasks have been identified for routine performance by Fluor Fernald maintenance and operations personnel, and one by construction personnel (#15):

NOTE: The hazards associated with these tasks may act as initiators for potential nuclear accidents; if so, they are addressed in Appendices A, B, and G.

1. Truck transport of empty containers and containerized additive materials
2. Receipt of Silo 3 bulk chemicals
3. Manipulation of the Pneumatic Retrieval System (PRS) vacuum wand and hose
4. Maneuvering of the Mechanical Retrieval System (MRS) remote control vehicle
5. Conditioning and packaging of retrieved waste
6. Loading of containerized material
7. On-site transportation of containerized waste materials
8. Maintenance of the Pneumatic Retrieval System (PRS), Air Handling Systems, and Process Vent System
9. Maintenance of motorized vehicles
10. Maintenance of conveyors, feeders, and packagers
11. Maintenance of cranes
12. Maintenance of Waste Additive System and Wastewater System
13. Maintenance of Plant/Breathing Air System
14. Shift-by-shift surveillance of Silo 3
15. Cutting a hole in the Silo 3 wall structure (Note: This is Construction work)

The identified hazards listed below are based on the potential exposure of personnel to the Standard Industrial Hazards, chemical hazards, and radiological hazards posed during Silo 3 operations and maintenance activities. A brief description of the expected hazards and their associated controls are provided in Section 8.0. A Hazards Control Matrix is presented in Section 9.0. This matrix identifies the above tasks in conjunction with their hazards and their controls/ mitigators. The matrix forms the basis for employee briefings.

1. Slips, trips, and falls
2. Noise
3. Housekeeping
4. Illumination
5. Ergonomics
6. Head impact
7. Pinch/Crush Points
8. Ladders
9. Hand and power tools
10. Electrical
11. Hazardous energy
12. Hoisting and rigging
13. Confined space
14. Flammable material
15. Hot work
16. Compressed gas
17. Biological
18. Environmental
19. Heat and cold stress
20. Heavy Equipment
21. Radiological
22. Chemical

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
5	Area Air Monitoring: Occupational air monitoring for radionuclides will be performed in accordance with RM-0020 [Ref. 53] and the project-specific Occupational Air Monitoring Plan.
6	An ALARA Analysis was completed for Preventative Maintenance Tasks (see Appendix D of this N-HASP).
7	Airborne Radioactivity Areas: If average radon concentrations and airborne particulate levels exceed 10 percent of the DAC, an Airborne Radioactivity Area will be established and appropriate respiratory protection equipment will be established, as prescribed in the RWP for the area/task. Air sampling and/or radon monitoring will continue, as necessary, to determine the extent and duration of the Airborne Radioactivity Area. Airborne Radioactivity areas no longer exceeding 10 percent of the DAC will be down-posted.
8	Completed waste packages will be surveyed before they are placed in the Sea/Lands to determine if there is surface contamination.
Radiological Access Controls: Access to Controlled Areas	
1	Unescorted access to Silos Project Controlled Areas or Radiological Areas requires a minimum of Radiological Worker training.
2	All workers shall be briefed on the contents of each RWP or Safe Work Plan. Workers shall sign an acknowledgment form to signify their understanding of RWP or Safe Work Plan requirements.
3	Before passing the access control point (access point from the uncontrolled area to the controlled area), workers shall check their HAZWOPER Mod 2 training qualification by reviewing their pink card. If their training qualification has expired, they shall contact their supervisor or training coordinator. Radiological Control Dosimetry will provide Exclusion Lists to supervisors of personnel delinquent in bioassay submission.
4	Access into the Silo 3 facility is primarily through the Silo 3 Control Point Trailer (T-205). The primary location for TLD storage is the RCS Operations and Maint. Building (94A).
5	If personnel are assigned TLDs, they shall obtain them before reaching the Controlled Area Workers not assigned TLDs must report to Silos Radiological Control for time-tracking while in the Controlled Areas.
6	Personnel assigned TLDs must wear them while in the Controlled Areas.
7	TLDs shall be worn on the outside of the workers' clothing (non-PPE), facing forward, between their waist and shoulders.

TABLE 8-23: RADIOLOGICAL HAZARD CONTROLS	
8	Visitors may be allowed to enter the Controlled Area upon approval of Radiological Control with a properly trained and cognizant escort.
9	If a worker's training or bioassay is insufficient or out-of-date, access to the controlled area without an escort will be denied.
10	When exiting a Category I Controlled Area, workers shall perform whole body monitoring, (preferably with a personal contamination monitor [PCM]), and monitor personal items with a hand-held frisker.
Radiological Access Controls: Access to Contamination Area	
1	Workers shall sign the appropriate RWP for entry into a contaminated work area.
2	Workers shall obtain the prescribed PPE clothing and respiratory protection equipment, enter their badge number and the respirator serial number into the access control computer, show evidence of being respirator-fit, go to the dressing area, and don the prescribed PPE.
3	When wearing protective clothing so that no skin is exposed (i.e., full anti-Cs and a respirator), the worker's TLD must be worn underneath the protective clothing.
4	When protective clothing requirements allow skin to be exposed (e.g., no respirator), the TLD must be worn on the outside of the anti-Cs.
5	Before entering the Contamination Area, workers shall contact an RCT for assignment of personal air samplers and airflow testing of the powered air-purifying respirators (PAPRs) (if worn). The following conditions apply to persons wearing personal air samplers: • When changing work areas, workers must sign in on the appropriate RWP and verify they are wearing PPE in compliance with the RWP for the new area. If the worker must change PPE before moving to the new job area, the worker must exit the Contamination Area and go through the appropriate steps for re-entry, wearing the correct PPE for the new area. The worker will be assigned a different personal air sampler. • Personal entry into Contamination Areas must be through the established control point.
Exiting Contamination Areas	
1	Whenever their protective clothing is compromised, or when non-water-resistant anti-Cs get wet, or sweat has penetrated protective clothing, workers shall always leave a Contamination Area and doff anti-Cs at the appropriate control point.
2	Workers shall sign out on the RWP upon exiting through the access control point.

10.2 Silo 3 System Safety Requirements

The matrix in **TABLE 10-1** has been developed to identify Silo 3 System Safety Requirements, reference the origin of the requirements, and identify the method(s) of control and implementing document(s), as appropriate. These System Safety Requirements are provided for Defense-in-Depth. Table 10-1 is the requirements matrix pursuant to the DOE-approved *Decision Basis Document Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Projects,* 40000-RP-0034 [Ref. 1]. Table 10.1 identifies the requirements of the written site safety and health program and project specific requirements that relate to system safety and are relied upon for maintaining the safety envelope.

As identified in Appendix G, *Silo 3 Accident Analysis*, there are no safety class or safety-significant components associated with the Silo 3 Retrieval and Disposition Project. This is based on the fact that Silo 3-initiated accident scenarios do not yield consequences that would exceed on-site dose limits, nor was any mitigation credit taken for these systems, structures, and components in the consequence analysis. However, SBRs and PRs were developed around some components to provide defense-in-depth.

TABLE 10-1: SILO 3 SYSTEM SAFETY REQUIREMENTS

SBR, PR	Requirement	Basis/Source	Implementation
SBR-1	Wall cutting activity, for mechanical retrieval, must be authorized by updated documentation, including but not limited to an Unreviewed Safety Question Determination (USQD) and Operations Work Instructions.	Although consequences are analyzed in this document as EBA-2 (see Appendix G), the wall cutting activity is authorized in the Silo 3 PHAR [Ref. 14] and the work will be done by Construction.	• NS-0002 • Management assessment
PR-1	The Silo 3 stack monitoring capability will be maintained within defined operability parameters, with established action level thresholds and operating limits. Operating data from the particulate filtering system (i.e., pressure differential) can be relied upon during maintenance events on the stacks samplers.	Public and Worker Protection, Environmental Protection Agency (EPA) Required	• 40000-PL-012, *Silos Engineering Project Execution Plan* (i.e. Silos Design Change Notice) • Operations procedures • Routine calibration and maintenance • Routine inspections • Engineering design

TABLE 10-1: SILO 3 SYSTEM SAFETY REQUIREMENTS			
SBR, PR	**Requirement**	**Basis/Source**	**Implementation**
PR-2	Individual IP-2 bulk bags shall not exceed 7000 lbs. gross weight.	EBA-4 (App. G) Test Report for IP-2 Container Testing [Ref. 65]	• Operations procedures • Routine inspections • Engineering design • Routine calibration and maintenance
PR-3	Verify that IP-2 bulk bags/packages are sealed before transfer outside of the Cargo Bay area.	Shipping requirement	• Operations procedures • Routine inspections • Engineering design • Routine calibration and maintenance
PR-4	Visually inspect the flexible fabric boot on each vacuum wand for verification of integrity (i.e. in place, no holes).	Public and Worker Protection, Containment	• Operations procedures • Routine inspections • Engineering design
PR-5	During pneumatic retrieval operations, a vacuum relief valve must be installed on Silo 3, set to -3.0 inches of water, with alarm indication.	Dome Failure, protect Silo Dome TSR	• I-TAB • Routine inspections • Engineering design • Routine calibration and maintenance

PCN1

PCN1

10.3 Silos Project Technical Safety Requirement (TSR)

Technical Safety Requirements (TSRs) are the limits, controls, and related requirements necessary for the safe operation of a nuclear facility and, as appropriate for the work and the hazards identified in the documented safety analysis for the facility, includes management controls, use and application provisions, and design features, as well as a basis appendix. TSRs are subject to 10 CFR 830, Subpart B [Ref. 6].

The Silos Project has one TSR (see **TABLE 10-2**). There are no TSRs in support of the Silo 3 Retrieval and Disposition Project. However, planned Silo 3 operations and activities will be conducted within the umbrella of the Silos safety basis.

32. 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals; Explosives and Blasting Agents;* Final Rule, Code of Federal Regulations, OSHA; February, 1992

33. PL-3081, *Safety Management System Description (SMSD);* Fluor Fernald

34. DOE Policy 450.4, Safety Management System Policy, Department of Energy; October 15, 1996

35. 48 CFR 970.5204-2, *Department of Energy Acquisition Regulation (DEAR) Clause*, Department of Energy; June, 1997

36. Fernald Closure Contract DE-AC24-010H20115; November, 2000; Conformed: June 11, 2003

37. RM-0016, *Management Plan*, Fluor Fernald

38. CT-2.1.1, *Construction Project Planning and Construction Invitation for Bid/Request for Proposal (IFB/RFP) Preparation*, Fluor Fernald

39. 40000-PL-0013, *Silos Construction Health and Safety Plan*, Fluor Fernald; December 11, 2001

40. DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, DOE; May, 18, 1992

41. *Safety Evaluation Report* [SER] *for Implementation of 10 CFR 830 Safe Harbor Requirements for the Silos Project, 40000-RP-0034*, DOE; July 2, 2002

42. DOE-STD-1120-98, *Integration of Environment, Safety, and Health into Facility Disposition Activities*, DOE Standard; May, 1998

43. RM-0012, *Quality Assurance Program*, Fluor Fernald

44. SH-0028, *Occurrence Reporting*, Fluor Fernald

45. NS-0008, *Safety Basis Documentation Review (SBDR) Process*, Fluor Fernald

46. NS-0002, *Unreviewed Safety Question (USQ) Determination and Safety Evaluation Systems*, Fluor Fernald

47. MS-1040, *Software Quality Assurance*, Fluor Fernald

48. RM-0021, *Safety Performance Requirements Manual;* Fluor Fernald

49. 29 CFR 1926.56, *Illumination*, Title 29 Code of Federal Regulations, Part 1926, Subpart 56, OSHA; July 1, 2002

50. 29 CFR 1926.150, *Fire Protection*, Title 29 Code of Federal Regulations, Part 1926, Subpart 150, OSHA; July, 2001

51. OP-0004, *Fluor Fernald Lockout Tagout Program;* Fluor Fernald

52. RM-0045, *Fluor Fernald Hoisting and Rigging Manual;* Fluor Fernald

53 RM-0020, *Radiological Controls Requirements Manual*

54. 10 CFR 835, *Occupational Radiation Protection*, Title 10 Code of Federal Regulations, Part 835, DOE; July, 2001

55. 40 CFR 302, *Designation, Reportable Quantities, and Notification*, Title 40 Code of Federal Regulations, Part 302; DOE; current edition

56. 40 CFR 355, *Emergency Planning and Notification*, Title 40 Code of Federal Regulations, Part 355; DOE; current edition

57. WSRC-TR-2000-00523, Rev. 0, *Characterization of Fernald Silo 3 Waste*, Westinghouse Savannah River Company; December, 2000

58. 40700-RAD-0002, *Silo 3 Material Airborne Control Limit Calculation*; Fluor Fernald; January, 2000

59. 40430-RP-0025, Silo 3 Conditioning Report, Fluor Fernald; February, 2003

60. 10 CFR 850, *Chronic Beryllium Disease Prevention Program*, Final Rule; Title 10 Code of Federal Regulations, Part 850; December 8, 1999

61. QA-0001, *Fluor Fernald Nonconformance Identification and Tracking System,* Fluor Fernald

62. SH-1006, *Event Investigation and Reporting*, Fluor Fernald

63. QA-0021, *Administration and Conduct of Standard Startup Review SSR Activities,* Fluor Fernald

64. DOE-1411-96, *Authority and Responsibilities for Safety Documentation and Startup Authority of Operations, Facilities, and Activities, at the Fernald Environmental Management Project,* Letter Jack R. Craig to John Bradburne, DOE; October, 1996

65. 0202615-010 MHF, *Test Report for Fernald Environmental Project Silo 3 IP-2 Container Testing*, Prepared by Logistical Solutions for Fluor Fernald; October, 2003

66. 40000-H&S-0001, Rev. 2, Technical Safety Requirements Document for the Operable Unit 4 (OU4) Silos, Fluor Fernald; July, 2003

67. TQP-067, *Silos Project Training and Qualification Program Description*, Fluor Fernald

68. DOE Order 5480.20A, *Life-Cycle Training Requirements for DOE Nuclear Facilities*, DOE, February, 1997

69. RM-0043, *FEMP Training Implementation Matrix*, Fluor Fernald

70. 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*, Title 29 Code of Federal Regulations, Part 1910, Subpart 120, OSHA; July, 2001

71. RM-0055, *FEMP (Fernald Environmental Management Project) Access;* Fluor Fernald

72. OSHA 29 CFR 1910.1200, *Hazard Communication* (Chemicals) Title 29 Code of Federal Regulations, Part 1910, Subpart 1200, OSHA; July 1, 2001

73. RPR 1-1, *Respiratory Protection Program*, Fluor Fernald

74. SPR 12-14, *Hazardous Noise Exposure*, Fluor Fernald

75. SPR 3-1, *Fall Protection and Prevention*, Fluor Fernald

76. *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices,* American Conference of Governmental Industrial Hygienists (ACGIH) (most recent annual edition)

77. 29 CFR 1910, *Occupational Safety and Health Standards,* Title 29 Code of Federal Regulations, Part 1910, OSHA; current edition

78. *The IESNA Lighting Handbook*, Ninth Edition, Illuminating Engineering Society of North America, 2000

79. 602-5024, *Industrial Hygiene Air Sampling Program,* Fluor Fernald

80. EM-0020, *Building Emergency Procedure,* Fluor Fernald

81. EM-0030, *Silos Area Emergency Procedure,* Fluor Fernald

82. DOE Order 232.1A, *Occurrence Reporting and Processing of Operations Information*, DOE; July, 1997

83. DOE M 232.1-1A *Occurrence Reporting and Processing of Operations Information,* DOE Manual; July, 1997

84. DOE Order 4330.4B, *Maintenance Management Program*, DOE; February 10, 1994

85. ED-12-4015, *Performance Grading*, Fluor Fernald

86. MT-0003, *FEMP Work Request/Order Procedure*, Fluor Fernald

87. RM-0012, *Quality Assurance Program (QAP)*, Fluor Fernald

88. 10 CFR 830, *Nuclear Safety Management*; Subpart A, *Quality Assurance Requirements;* Title 10 Code of Federal Regulations, Part 830; DOE; January 10, 2001

89. DOE Letter DOE-0359-03, FEMP Quality Assurance Program, DOE; May 5, 2003

90. 40000-QA-0001, Rev. 1, *Quality Assurance Job Specific Plan for the Silos Project*; Fluor Fernald; October 9, 2002

91. DOE Order 414.1A, *Quality Assurance*, DOE; July 12, 2001

EXECUTIVE SUMMARY

The Silo 3 Retrieval and Disposition Facility is classified as a Radiological (RAD) facility with Low chemical hazards, since the largest potentially releasable inventory does not result in significant localized consequences, due to the low specific activity of the material.

The most severe radiological and chemical hazards from the Integrated Hazards Analysis (IHA), Appendix A, were selected for modeling to determine the hazard category. Several scenarios were analyzed for consequences and the most significant potentially releasable inventory is a result of a silo failure during wall cutting.

The RAD hazard classification was determined after analyzing both radiological and chemical hazards. This is shown in Section B-3.0.

The radiological analysis considered three parameters, total activity of the various radionuclides, total activity that could be reasonably released via bounding scenario, and dose to onsite and offsite personnel.

The chemical analysis considered two parameters, the quantities of the various hazardous chemicals present, and the concentrations that would be generated during the bounding accident. Whereas five hazardous chemicals could be released in quantities exceeding the corresponding Threshold Planning Quantities, the airborne concentrations that would result are lower than the applicable Emergency Response Planning Guides. This is because of the low concentrations of the hazardous components in the bulk material. The "Low" chemical hazard category specified is conservative.

B-1.0 INTRODUCTION

The purpose of this hazard categorization is to ensure that the appropriate level of hazard baseline documentation and approval authority is assigned to the project based on the severity of the hazards that may be encountered.

This document establishes the hazard category designation for the Silo 3 facility in accordance with DOE-STD-1027-92 [Ref. 1] for the following activities: PCN1

- Retrieval of material from Silo 3
- Packaging of the material in storage bags for placement into cargo containers
- Storage of cargo containers that are awaiting shipment

The hazard baseline for the activities preceding retrieval has been documented separately in RMR-0445-0056-002, the Silo 3 PHAR [Ref. 2]:

- Continued storage of material in Silo 3
- Routine maintenance and upkeep of Silo 3, support equipment, and surrounding grounds
- Continued design, procurement, construction, and system operability testing of new facilities and/or existing facilities in support of Silo 3 final remediation

B-1.1 Previous Analyses

The preliminary hazard category for Silo 3 storage was first documented in FEMP-2337, *Preliminary Safety Analysis Report (PSAR) for Operable Unit 4* [Ref. 3]. The preliminary hazard categorization of HC-2 was determined by comparing the total inventory of Silo 3 radioactive materials to the threshold quantities listed in DOE-STD-1027-92 [Ref. 4]. In accordance with DOE-STD-1027-92, the PSAR established the final hazard category for Silo 3 as HC-3, based on the hazards analysis.

Subsequent safety basis documents continued to document Silo 3 storage as HC-3, including the *Hazards Analysis Report (HAR) for Operable Unit* 4 [Ref. 5], and the *Preliminary Hazard Analysis Report for Silo* 3 [Ref. 2].

B-1.2 Segmentation

The Silo 3 structure houses the entire inventory of hazardous materials associated with current Silo 3 activities, processes, and operations. Therefore, the "facility" considered for hazard categorization is limited to the Silo 3 structure and its contents. The concept of independent facility segments is applied *within* a facility where facility features preclude bringing hazardous materials together or causing harmful interaction from a common severe phenomenon. Therefore, the Silo 3 structure constitutes a single segment, authorized by the PHAR.

The Hazard Category Calculation documented here establishes that the Silo 3 Retrieval and Disposition Project consists of two additional segments with respect to safety analysis for future project configurations. Therefore, there are a total of three facility segments:

1. Silo 3 - analyzed and authorized in PHAR
2. Process Building - analyzed and authorized in this N-HASP
3. Interim Storage Area (ISA) - analyzed and authorized in this N-HASP

The Process Building consists of a process area containing material handling and bag-out facilities, the Excavator Room, the Excavator Service Room, and the Cargo Container Bay. The building is adjacent to Silo 3, and connects to Silo 3 through the batch type retrieval mechanisms (pneumatic and mechanical). After construction of the building and operation of the pneumatic retrieval system for initial removal of waste material, an opening will be cut in the silo to provide direct access to the remaining contents by mechanical retrieval

TABLE B.3-1: PRELIMINARY HAZARD CATEGORIZATION

Radionuclide	Silo 3 Radionuclide Inventory (Ci)	HC-3 Threshold (Ci)	HC-2 Threshold (Ci)	Fraction of HC-3 Threshold	Fraction of HC-2 Threshold
Ac-227	3.4	0.042	4	7.99E+01	7.80E-01
Ac-228	1.5	940	430,000	1.57E-03	3.42E-06
Bi-210	12.6	320	150,000	3.94E-02	8.41E-05
Bi-212	1.3	2,000	430,000	6.65E-04	3.09E-06
Bi-214	14.0	8,200	430,000	1.71E-03	3.26E-05
Fr-223	0.0	8,200	430,000	5.75E-06	1.10E-07
Pb-210	12.6	0.36	2,200	3.51E+01	5.74E-03
Pb-211	3.4	6,200	430,000	5.41E-04	7.80E-06
Pb-212	1.3	320	430,000	4.16E-03	3.09E-06
Pb-214	14.0	8,200	430,000	1.71E-03	3.26E-05
Po-210	12.6	1.9	350	6.64E+00	3.61E-02
Pa-231	2.3	0.2	55	1.14E+01	4.13E-02
Pa-234	0.0	1,520	430,000	4.77E-06	1.69E-08
Pa-234m	6.4	1,520	430,000	4.24E-03	1.50E-05
Ra-223	3.4	62	3,800	5.41E-02	8.83E-04
Ra-224	1.3	200	9,900	6.65E-03	1.34E-04
Ra-226	14.0	12	55	1.17E+00	2.55E-01
Ra-228	1.5	12	55	1.23E-01	2.68E-02
Th-227	3.4	32	55	1.05E-01	6.10E-02
Th-228	2.7	1	92	2.71E+00	2.94E-02
Th-230	218.3	0.62	89	3.52E+02	2.45E+00
Th-231	0.4	12,000	430,000	3.54E-05	9.87E-07
Th-232	3.1	0.1	18	3.05E+01	1.70E-01
Th-234	6.5	2,800	430,000	2.31E-03	1.50E-05
U-234	6.3	4.2	220	1.49E+00	2.85E-02
U-235/236	0.4	4.2	240	1.01E-01	1.77E-03
U-238	6.5	4.2	240	1.54E+00	2.69E-02
Rn-220	3.0	2	55	1.49E+00	5.42E-02
Rn-222	14.0	10	260,000,000	1.40E+00	5.38E-08
Total (Ci)	370				
Mass (lbs)	7.99E+06				
			Sum of the Fractions	526	4.0

B-3.2 Final Hazard Categorization

The potentially releasable inventory (PRI) is the amount of radioactive or hazardous material that can be released and present a respirable hazard.

B-3.2.1 Material at Risk

The material at risk (MAR) is the inventory of Silo 3 material in each segment. As shown in TABLE B.2.1, the radiological inventory in Silo 3 is 370 Ci, the inventory in the Process Building and Cargo Container Bay is 5.64 Ci. The inventory in the ISA is contained in DOT shipping containers which are analyzed and authorized in the *Test Report for Fernald Environmental Project Silo 3 IP-2 Container Testing* (Doc. No. 0202615-010 MHF). PCN1

The MAR for the silo failure during wall cutting will be reduced from the total Silo 3 inventory because some material has been removed from the vicinity of the wall cut before performing the wall cut operation. For analysis purposes it was assumed that 25 percent of the original silo material volume has been removed before the collapse.

B.3.2.2 Potentially Releasable Inventory

The PRI is that portion of the MAR source term released external to the facility. It is a function of the accident, the release fraction or rate, and the facility leak path factor.

Solids Released

The silo failure during wall cutting (EBA-2 in Appendix G) results in the release of solids. The configuration of the remaining silo material is such that the angle of repose from the floor area at the wall opening to the high solids level at the center of the silo is less than 45 degrees. Material release at the time of collapse would result from material falling toward the collapsed region. The material spilling out of the collapsed region would be minimal and it is conservatively assumed that 1 percent of the silo MAR, at the time of collapse, spills outside the silo, into the below ground-level excavator room. The solid mass released is 7.99×10^6 lb x 0.75 x 0.01 = 59,930 lb.

Solids released as a result of the other EBAs are significantly less than those released in EBA-2 (see Appendix G for details). Therefore EBA-2 is the scenario evaluated for hazard categorization purposes.

B-5.0 REFERENCES

1. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports,* DOE; September, 1997

2. RMR-0445-0056-002, *Preliminary Hazards Analysis Report for Silo 3*, Rocky Mountain Remediation Services; January, 2000

3. FEMP-2337, Rev. 0, *Preliminary Safety Analysis Report (PSAR) for Operable Unit 4,* Parsons Engineering; Fernald Environmental Management Project; April, 1994

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8. 10 CFR 830, *Nuclear Safety Management*, Code of Federal Regulations, Title 10, Part 830; DOE; January 10, 2001

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18. EPA-5201/1-88-020, Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, U.S. Environmental Protection Agency; 1998

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21. WSRC-MS-92-206, Rev. 2, *Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in DOE Facilities*, Westinghouse Savannah River Company; March, 1995

22. DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE; December, 1994

PATH FORWARD

At the beginning of final design for the Silo 3 Project, the design engineers were provided with a Human Factors Engineering Design Checklist and design criteria. Design engineers used the checklist to ensure that constraints and recommendations of human factors engineering were included in their design of components and systems. The checklist and criteria assisted design engineers in designing equipment in accordance with human capabilities and limitations.

This Human Factors Evaluation (HFE) was prepared as an appendix to this Silo 3 N-HASP for the request for DOE approval to perform Silo 3 operations. A complete and final HFE requires a thorough review of the human/machine interfaces of all systems within the Silo 3 Project.

As the construction of the Silo 3 Project progresses, the manufacturers' manuals for major equipment will become available. Silos Project personnel evaluate manuals to provide procedure and training guidance. A System Safety Analyst (SSA) reviews all Technically Operationally Significant (T/OS) procedures. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise during actual implementation. PCN1

C-1.0 INTRODUCTION

This HFE is an assessment of factors important to the safe operation of the Silo 3 Project. The HFE goal is to address stress, ergonomic, procedural, design, and training issues, with a resulting reduction of risk to workers, the public, and the environment due to operator errors. The adequacy of controls has been evaluated based on specific engineering design details. The HFE focus is on the new facility design and pays particular attention to remote operations. The purpose of this HFE is to demonstrate that human factors are adequately considered for Silo 3 Project operations.

According to DOE-STD-3009-94 [Ref. 1], the primary "... emphasis is on human-machine interfaces required for ensuring safety function of safety structures, systems, and components (SSC's) that are important to safety." There is no human-machine interface with safety-significant SSCs in the Silo 3 retrieval and disposition process. Therefore, the emphasis of this evaluation was shifted to activities that could cause unnecessarily high exposures to hazardous/radioactive materials, but still less than those necessary to cause significant local effects, consistent with the concept of As Low As Reasonably Achievable (ALARA). In addition, emphasis is placed on minimizing physical dangers to personnel (i.e., strains or falls) in the course of performing project activities.

C-1.1 Silo 3 Description

The Fernald Closure Project (FCP) Operable Unit (OU) 4 includes four silos: Silos 1 and 2 (also known as the K-65 Silos), Silo 3, and Silo 4. Silos 1 and 2 contain radium-bearing residues from pitchblende ore processes. Silo 3 contains dry uranium oxide and other metal oxides. Silo 4 is empty and has never been used. Silo 3 was built in 1952 and is a free-standing, pre-stressed concrete, domed silo. It is 80 ft. in diameter and the top is about 36 ft. above ground level. The floor system is constructed of seventeen inches of compacted clay, a 2-in.-thick layer of asphaltic concrete, and an eight-inch layer of gravel topped by 4 in. of concrete. Approximately 5,088 yd^3 of metal oxide material reside in Silo 3. The predominant radionuclide of concern is thorium-230, which is produced from the natural decay of uranium-238.

Silo 3 contains metal oxide material generated from the operation of the former Feed Materials Production Center (FMPC), now known as the FCP. Raffinate streams from the FMPC's solvent extraction process were de-watered using rotary vacuum filters. The filtrate streams were then processed through evaporators, and the evaporator concentrates were further processed using either a spray calciner or a rotary calciner. From plant start-up through the mid-1950s, a spray calciner processed the concentrates. Approximately 35 percent of the Silo 3 material is believed to have come from this process. Because of operational difficulties with the spray calciners, a rotary calciner process was implemented. In this process, the evaporator concentrates were transferred to a drum dryer, and finally, to a rotary calciner. The calciner removed residual liquids and converted the metal nitrates to metal oxides. The resulting fine powdered metal oxides were pneumatically transferred to Silo 3 for storage. Transfer of all materials into Silo 3 continued until 1957.

C-1.2 Human Factors Evaluation

The primary objective of human factors engineering is to improve human performance through enhancements in the work environment and human-machine interface (HMI) [Refs. 2 and 3]. Enhancements to the work environment and HMI reduce human errors and their consequences and lead to the following:

- Increased productivity
- Lower costs
- Better product quality
- Decreased equipment and property damage
- Improved program schedules
- Personal job satisfaction
- Further improvements in the safe operation and maintenance of project facilities

Human factors safety guidance provided in DOE-STD-3009-94, Chapter 13 [Ref. 1] refers to the following:

- Allocation of control functions to personnel versus automatic devices
- Staffing and qualification of operating crews
- Personnel training

- Preparation, validation, and use of written procedures to guide operations
- Surveillance and maintenance
- Design of the human-machine interface to build on strengths and protect against the susceptibility to human error in operating crews

HFEs are performed on project designs, operations, activities, procedures, plans, training programs, and other applicable documents and activities with a graded approach. The extent of the graded approach is determined by the following criteria:

- Requirements of the applicable DOE Orders and implementation guidance documents
- Magnitude of the risk being addressed
- Relative importance of the subject matter to the assurance of safety
- Risk and cost evaluation

C-1.3 Evaluation Methodology

A generalized checklist of human factors requirements and criteria was used to evaluate whether the applicable human factors requirements were being met (see ATTACHMENT 1). This checklist (based upon an HFE performed for the OU4 Hazard Analysis Report) [Ref. 4] was assessed for the Silo 3 Operations Phase (see ATTACHMENT 2).

The checklist was provided to appropriate design engineering personnel for review and completion. These individuals reviewed the project against the checklist, indicating whether the design incorporated each requirement. A comment column was provided to allow for further explanation. The checklist has been completed on the basis of final design information (see ATTACHMENT 1). The checklist may be revised, if necessary, based on information gained during construction, procedure development, acceptance testing, and training.

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Following receipt of the manufacturers' manuals, Silos Project personnel evaluate manuals to provide procedure and training guidance. A System Safety Analyst (SSA) reviews all Technically Operationally Significant (T/OS) procedures. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise from the actual implementation.

C-2.0 SILO 3 PROJECT DESCRIPTION

Access and retrieval of the Silo 3 material will be accomplished by both pneumatic and mechanical systems [Ref. 5]. Before material retrieval is initiated, radon concentrations in the silo headspace will be reduced to acceptable levels. In preparation for mechanical retrieval, a reinforced concrete framework will be installed on the east silo wall, and a section of the silo wall will be removed.

The Pneumatic Retrieval System (PRS) involves vacuuming material through the existing manways on the Silo 3 dome. Material is removed from the eastern side of the silo to allow for wall-cutting activities. Pneumatic retrieval continues from the manways until it is no longer effective or practicable due to either inaccessibility by the pneumatic wand or a

reduction in material flowability. The PRS then transfers material to the Process Building [Ref. 6].

In addition to pneumatic retrieval, a Mechanical Retrieval System (MRS) is used to access and remove the compacted material. An opening is cut in the silo wall to enable mechanical retrieval. A remotely-controlled mechanical excavator transfers Silo 3 material to a bin located in the Excavator Room. The retrieval bin discharge feeder is variable speed, which controls the flow rate of material from retrieval to packaging. All downstream conveyors are single-speed, and are designed to operate at capacities equal to or greater than the maximum capacity of the retrieval-bin discharge feeder. An inclined conveyor transfers the material to the Process Building. Once the Excavator is in full operation, a water-misting system may be employed for dust suppression and stabilization of the working face of the Silo 3 material [Ref. 6].

The Container Management System allows personnel in the Process Building to perform the following functions:

1. Prepare bags and packaging frames for filling.
2. Dispense Silo 3 material from the Feed Conveyor into bags.
3. Add waste conditioning chemicals.
4. Perform swipe sampling and labeling of bags.
5. Convey filled bags into the Cargo Bay for loading.

Lighting will be provided near each of the closed circuit television (CCTV) cameras. Cameras will be provided at the following locations to support access and retrieval: at the Silo 3 north wall; inside the silo dome; on the ceiling above the retrieval bin; and in the excavator room. In the Silo 3 Area, a 20-in. color monitor is located on top of Silo 3 to be used by the vacuum wand management system (VWMS) operator. A controller will be used by the vacuum wand operator to control pan/tilt and zoom of the Silo 3 cameras. A 20-in. color monitor will be in the observation room to be used by the excavator operator. The Operations Support Trailer has two 20-in. color monitors that can view any of the cameras [Ref. 7].

All equipment used for the Silo 3 Project includes control system hardware and a control approach typical of those used in conventional industrial material handling and packaging operations. The control philosophy is based on a combination of automated functions (where applicable) and actions by local operators. Many of the operations, particularly in the Packaging Area, require continuous operator actions and control input on a local basis.

Operator interface is based primarily on local operation with input via local push buttons and hand switches. A primary hand control station is provided at each of the two Package Loading Stands. Other control stations are provided, as required. These control stations are suitably configured for manipulation by operators who are in a standing position alongside the associated equipment.

The Silo 3 training program will include training on systems overview, facility operations, and field training. Field training will consist of system walkdowns, on-the-job training (OJT), training evaluation standards, completion of operator qualification cards, and assisting in the Silo 3 Construction Acceptance Test (CAT), where possible. Operators who are not able to participate in the CAT will receive OJT where they work side-by-side with experienced, qualified operators.

The Silo 3 operations and field training courses will provide training on the Silo 3 computer terminal and each of the PC screens. Nomenclature and labels on the screens will be coordinated with training materials and procedures to ensure that ergonomic and human factors engineering are implemented as designed. Operator aids will also be built into the PC screens as appropriate to assist the operators in their timely, reliable performance of safety functions.

C-2.2 Silo 3 Maintenance

Human factors engineering principles have been incorporated into the design of Silo 3 equipment and its maintenance (see ATTACHMENT 1). The Silo 3 final design has been reviewed to examine the provisions for maintenance of Silo 3 equipment. Adequate space for accessing and performing maintenance on each piece of Silo 3 equipment has been verified. In addition, adequate space is available to implement radiation protection practices developed pursuant to the radiological work permit (RWP) program (e.g., containments, step-off pads, and temporary shielding).

Maintenance personnel will be qualified in accordance with their craft Training and Qualification Program Description that includes practical evaluation. Maintenance personnel will receive pre-job and RWP briefings, as required.

The manuals for each piece of Silo 3 equipment requiring maintenance will serve as the starting point for development of Silo 3 maintenance procedures. Maintenance Work Instructions (MWIs) are then prepared and approved. MWIs will be validated and verified by a systematic walk-through with as-built equipment. Maintenance personnel will be briefed for each maintenance task, including equipment specifications, maintenance requirements, maintenance instructions, the need for special tools, and safety precautions. Radiation dose rates and potential radioactive contamination will be considered in preparing the MWI for each task to ensure that the work can be done while wearing the needed personal protective equipment (PPE). Specific requirements for dosimetry, shielding, and stay-time limitations will be provided through the RWP process.

Physical stress factors in the work environment for maintenance personnel are not expected to be unusual. Noise, temperature, and humidity within the Silo 3 Process Building should not cause any discomfort to workers that could affect their ability to perform maintenance work. PPE, such as protective clothing and respirators, will be provided as necessary and as specified by RWPs.

C-2.3 Human Factors Evaluation Results

A systematic and thorough evaluation of the HMI related to the construction, operation, and maintenance of equipment and facilities associated with the Silo 3 Project was performed based on the specific engineering design details available at this time. Each of the following four important elements are incorporated into the design, with the requirements proportional to their importance to safety:

- provisions for communication and operator aids to support timely, reliable performance of safety functions
- layout and design of controls and instrumentation, and provisions for labeling that apply the principles of ergonomics and human engineering
- work environments including physical stress, need for protective clothing and equipment, noise levels, temperature, humidity, distractions, and other factors bearing upon the physical comfort, alertness, and fitness of workers
- staffing considerations (e.g., minimum staffing levels, overtime restrictions, facility status turnover between shifts, procedures, and training)

ATTACHMENT 3 lists the industrial safety and human factors requirements applicable to the Silo 3 Project.

C-3.0 CONCLUSIONS

A preliminary HFE has been performed based on the available design information. As construction is completed and the procedures are ready for issue, the procedures will be re-evaluated. The finalized procedures will be incorporated into the training program and the HMI will be fully evaluated. Additional evaluations will be performed following dry-runs, walk-downs, and start-up testing so that procedures can be revised as necessary. Further refinements can be performed as lessons learned arise during actual implementation.

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This HFE demonstrates that the essential elements are, or will be, in place to ensure that the important human factors issues have been addressed for the operation and maintenance of the Silo 3 Project.

By the incorporation of these concepts into the project design, plans, procedures, and training, the potential for human error resulting in adverse safety consequences is minimized.

ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
8	Do procedures address the personal protective equipment required when performing routine and/or nonroutine tasks?	Yes	Conduct of Operations; Radiological Work Permits
H. Training (Subcontractor)			
1	Are new employees trained in the hazards of the processes?	Yes	Project-Specific Health and Safety Plan; Operations and Maintenance Safe Work Plans; site training; Quality Assurance Program Plan.
2	Do operators and maintenance workers receive adequate training in safely performing their assigned tasks before they are allowed to work without direct supervision?	Yes	Project-Specific Health and Safety Plan; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training
3	Does operator and maintenance worker training include training in appropriate emergency response?	Yes	Operations and maintenance worker training; site training
4	Do operators practice emergency response while wearing emergency protective equipment?	Yes	Performed by Emergency Response Teams
5	Do operators practice emergency response during extreme environmental conditions (e.g., at night or when it is very cold)?	N/A	Performed by Emergency Response Teams
6	Are periodic emergency drills conducted?	Yes	Contingency Plan and Emergency Response; Operator training
7	Are emergency drills witnessed by observers and critiqued?	Yes	Contingency Plan and Emergency Response

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ATTACHMENT 1: HUMAN FACTORS EVALUATION CHECKLIST			
SILO 3 OPERATIONAL PHASE (SYSTEMS OPERABILITY TESTING, READINESS ASSESSMENT, RETRIEVAL)			
ITEM	QUESTION	RESPONSE*	COMMENT/GOVERNING DOCUMENT
8	Does a periodic refresher training program exist?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training; daily safety meetings; Quality Assurance Program Plan.
9	Is special or refresher training provided in preparation for an infrequently performed operation?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations and maintenance training; site training; daily safety meetings; Quality Assurance Program Plan.
10	When changes are made, are workers trained in the new operation, including an explanation of why the change was made and how worker safety can be affected by the change?	Yes	Project-Specific Health and Safety Plans; Operations and Maintenance Safe Work Plans; Operations procedures; Operations training; Quality Assurance Program Plan
11	Are operators and maintenance workers trained to request assistance when they believe they need it so safely perform a task	Yes	Operations and maintenance training; Quality Assurance Program Plan
12	Are operators and maintenance workers trained to report near misses as part of the incident investigation program?	Yes	Operations and maintenance training; Safety Incident Report Program
13	Are operators trained to shut down the process when in doubt about whether it can continue to operate safely?	Yes	Operations training; Quality Assurance Program Plan, stop work authority

* Response options = Yes, No, Not Applicable (N/A)

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ATTACHMENT 3: INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS

The following industrial safety and human factors concerns are standard for industrial operations. Silo 3 Project personnel from multiple disciplines evaluated Silo 3 activities in terms of these concerns, and used a graded approach to determine the appropriate implementation.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
Procedures/Safe Work Plans		
1	Written procedures are developed, reviewed by all applicable disciplines including operations and safety, and issued for all operating phases (i.e., normal operations, temporary operations, emergency shutdown, emergency operation, normal shutdown, and startup following a significant change/modification shutdown or after an emergency shutdown).	The procedures were developed, reviewed, and approved per Fluor Fernald site requirements documented in MS-2001.
2	Safe operating limits are determined and documented providing consequences of deviating from limits and actions to take when deviations occur.	Safe operating limits are established. Automatic action is taken by the PLC when parameters start to go outside those limits. In order to change a setpoint, an engineering evaluation, including safety impact, is required.
3	A procedure change control process/system is implemented to ensure that all procedures remain current and accurate (i.e., they reflect the way in which the work is actually performed).	Procedures are maintained per Fluor Fernald site requirements documented in MS-2001.
4	A formal mechanism is implemented for correcting human factors deficiencies identified by the operators (e.g., modifications to controls or equipment to better meet operators' needs).	Design changes are completed per the DCN/RCI process.
5	Procedure format and language is reviewed and revised to ensure that they are easy to follow and understand.	Procedures were drafted by the subject matter expert, and formatted and edited by a technical writer to ensure clarity. Procedure development included walkthroughs with affected personnel.

ATTACHMENT 3: SILO 3 PROJECT INDUSTRIAL SAFETY AND HUMAN FACTORS REQUIREMENTS		
ITEM	**REQUIREMENTS**	**IMPLEMENTATION**
6	A process/system for document control, updating procedures, distributing revisions of procedures, and ensuring that workers are using current revisions of procedures is implemented.	Procedure maintenance is done per site requirements documented in MS-2001. A training program and required reading program have been established.
7	Procedures and/or work permits will prescribe the personal protective equipment (PPE) required when performing routine and/or non-routine tasks.	FCP Work Permits and Radiation Work Permits, which include a PPE sheet, are established for routine activities and developed prior to any new activity.
8	Before initial implementation and any subsequent significant revision of any Technical - Operationally Significant (T/OS) project procedures, they are evaluated by a qualified System Safety Analyst for human factors concerns and modified as necessary to ensure accordance with the requirements of this HFE.	The project uses a multi-disciplined team to review and evaluate procedures. This includes a qualified System Safety Analyst who evaluates for human factors concerns and ensures implementation of human factors requirements.
Training (Employees and Subcontractors)		
1	Training is developed, implemented, and evaluated according to the applicable requirements of DOE Order 5480.20A and implemented in training policies, requirements, and procedures.	The training is developed, implemented, and evaluated per site training requirements.
2	Pre-job briefings, safety meetings, and tool box discussions are conducted in addition to, not in lieu of, the required training.	In addition to training, pre-job briefings, safety meetings, and tool box discussions have been conducted and documented with rosters.
3	To qualify as training, an activity requires a method of evaluation and/or performance demonstration to be successfully completed by the trainee(s).	All training has been conducted per site training requirements.
4	Employees and subcontractors are trained in the hazards of the processes, conditions, and equipment used in the work they are to perform.	All workers have trained per site training requirements. In addition, briefings have been performed addressing project-specific hazards.

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