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REMEDIAL DESIGN FOR SILOS 1 AND 2 HEEL REMOVAL AND DECANT SUMP TANK SLUDGE REMOVAL

Document No. 40710-RP-0046
January ___, 2004
Revision B

FERNALD
Environmental Management Project

Prepared Under U.S. Department of Energy
Contract No. DE-AC24-01OH20115

Revision	A				
Date	8/27/03				
Prepared By					
Checked By					
Approved By					

Revision Sheet			
Revision	**Date**	**Pages Affected**	**Reason for Revision**
A	8/27/03	ALL	Issued for Remedial Design
B			Revised in response to U.S. EPA/OEPA comments

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ACRONYMS

ALARA	As low as reasonably achievable
AWR	Accelerated Waste Retrieval
D&D	Decontamination and decommissioning
DOE	Department of Energy
FCP	Fernald Closure Project
IP	Industrial package
LSA	Low specific activity
NTS	Nevada Test Site
PPE	Personal protective equipment
RCS	Radon Control System
SWRS	Silos Waste Retrieval System
TTA	Transfer Tank Area
TWRS	TTA Waste Retrieval System

1.0 EXECUTIVE SUMMARY

This remedial design document describes the system design concept for Silos 1 and 2 heel removal and decant sump tank sludge removal. The heel is the waste that remains in the silos upon completion of bulk waste retrieval. The objective of heel removal is to clean the silos to acceptable levels for decontamination and decommissioning (D&D) operations. Debris removal from the silos will be performed during D&D.

The decant sump tank located between Silos 1 and 2 contains a sludge comprised of K-65 material. The objective of sludge removal is to clean the decant sump tank to acceptable levels for D&D. Debris will remain in the decant sump tank and will be removed together with the tank during D&D.

Several consecutive steps are included in the remedial design for silos heel removal and decant sump tank sludge removal. These steps are:

1. Silos heel removal using modified Hazleton pump with slurry module.
2. Silos heel removal using slurry jet pump with slurry module.
3. Decant ports cleaning.
4. Silos final water wash of interior walls and floor.
5. Blending or grouting of the residual heel to meet waste acceptance criteria &/or transportation requirements.
6. Decant sump tank sludge removal.

The approach taken for heel removal will be decision based. Although the equipment for all steps will be available at the start of heel removal operations for potential deployment if needed, it is not expected that all of these steps will be required to remove the heel successfully. After the performance of each step, an assessment will be made to decide whether performance of the next step is necessary. For example, the modified slurry pump may remove sufficient heel material in Step 2 so that deployment of the jet pump in Step 3 may not be needed. This step-wise approach provides for multiple contingencies, while avoiding the deployment of unnecessary equipment or the generation of excess sluice water with very low waste loading.

To determine the endpoint for heel removal, criteria to guide the decision-making process are required. The primary criterion for completion of heel removal is the ability to meet the prerequisites for initiation of decontamination and demolition (D&D) of the Silo 1 and 2 structures. One of the prerequisites to initiating D&D is the ability to isolate the silo structures from the RCS without causing environmental (fenceline) or onsite (workplace) radon levels to be exceeded. The RCS could be turned off (from treating silos radon) when the measured rate of radon emanation is less than a predetermined threshold value. The threshold rate is the rate such that were the emanation to enter the environment uncontrolled, the concentration of airborne radon at selected receptor points, and the estimated exposures calculated therefrom, would be within acceptable limits. It is at that point that the RCS could be shut off from controlling radon within the silos.

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The actual rate of radon emissions from the heel will depend upon the concentration of K-65 material remaining in the heel, and on the emanation characteristics associated with the residual. Modeling has been performed of radon emission from 8 inches of heel, assuming a 15% K-65 solids concentration in the residual. Based on those results, the impact to the FCP fenceline would result in an extremely low incremental radon concentration increase. This additional projected increase in radon concentration would be so low as to have minimal impact on the 0.5 pCi/l annual average fenceline limit specified by the Operable Unit 4 ARARs, and by proposed 10CFR834. This modeling is continuing to be reviewed and refined.

Even if the amount of residual reaches the level consistent with initiating D&D, further removal activities could be undertaken. The extent of these actions will depend upon:

- The ability of the heel material, after blending or grouting and packaging, to meet LSA-1 requirements for shipment;
- The amount of blended or grouted waste that would be produced and require offsite disposal;
- The operating status of treatment capability within the Silos 1&2 Treatment facility; and,
- The schedule for subsequent phases of the AWR project, i.e. the D&D efforts. Section 3.2 discusses the logic of the decision-making process to determine the final endpoint for heel removal.

Heel material will be removed from one of the silos (either Silo 1 or 2) following Steps 1 through 5, if the steps are needed, and then these steps will be repeated for removal of heel material from the other silo.

Systems and equipment (e.g., sluicers, pumps, piping, tanks, cameras, etc.) used by the Accelerated Waste Retrieval (AWR) Project for bulk waste retrieval will be used to support heel and sludge removal operations. Steps 1 through 4 will continue to use the existing sluicer modules to mobilize the heel material. The heel material removed from the silos will be transferred to the Transfer Tank Area (TTA) tanks for subsequent treatment in the Remediation Facility.

The final step will be implemented in the event that sufficient K-65 material could not be removed during heel removal Steps 1 through 4 to reach acceptable levels of residual heel material. Depending on the amount, if any, and characteristics (radionuclide concentration and dose, radon emanations) of any residual heel remaining in the silo, additional actions may be implemented prior to initiation of D&D. These final actions may include blending the residual with inert material, grouting or fixing it in place, or manual removal.

Removal of sludge containing K-65 material from the decant sump tank, will be performed by a contractor in accordance with a performance specification prepared for this scope of work. During meetings with commercial tank cleaning vendors, a concept to clean the decant sump tank was determined. The concept is a combination of mixing and pumping for several cycles to remove the sludge. Removal of the silo berm overlying the decant sump tank would increase the range of mixing and pumping technologies that could be the overlying berm to allow closer access to the decant sump tank would occur after bulk waste and heel removal operations were completed. The sludge removed from the decant sump tank may be transferred to the TTA tanks for subsequent treatment in the Remediation Facility, or the sludge may be treated separately by an alternative treatment that complies with Nevada Test Site (NTS) waste acceptance criteria and applicable transportation regulations.

2.0 BACKGROUND

Silos 1 and 2 are located at the U.S. Department of Energy (DOE) Fernald Closure Project (FCP) site near Cincinnati, Ohio. The silos presently contain K-65 material, a residue generated from processing high-grade uranium ores, which contains radionuclides including radium (the primary contaminant of concern). The silos also contain Bentogrout® caps, which cover the K-65 material to reduce radon emanation. The purpose of the Accelerated Waste Retrieval (AWR) Project is to retrieve the K-65 and Bentogrout® materials contained in the silos and transfer them to the Transfer Tank Area (TTA) tanks for staging prior to their transfer to the Silos 1 and 2 Remediation Facility for treatment.

The heel is the waste that remains in the silos upon completion of bulk waste retrieval. The objective of heel removal is to clean the silos to acceptable levels for decontamination and decommissioning (D&D) operations. Debris removal from the silos will be performed during D&D.

In addition to Silos 1 and 2, a nearby underground decant sump tank (9,000 gal capacity) contains approximately 1,000 gal of sludge comprised of K-65 material. The K-65 material was entrained in decant water and transferred to the decant sump tank during silo filling operations, which were accomplished using a slurry and decant process. The objective of sludge removal is to clean the decant sump tank to acceptable levels for D&D. The small amount of K-65 material in the sludge removed from the decant sump tank will be treated either in the Remediation Facility or separately by an alternative treatment. The alternative treatment would differ from the Remediation Facility's treatment process, but it would convert the sludge into a form that complies with the Nevada Test Site (NTS) waste acceptance criteria for disposal as well as with applicable transportation regulations. Debris will remain in the decant sump tank and will be removed together with the tank during D&D.

2.1 ALTERNATIVE SELECTED FOR SILOS 1 AND 2 HEEL REMOVAL

A workshop was held January 21–22, 2003, with a team of experts from DOE facilities and private industry to develop and evaluate alternatives for heel removal from the Fernald Silos 1 and 2. Constraints on silos heel removal were discussed first; brainstorming of alternatives followed; alternatives were refined next; and lastly, screening criteria were used to rate the alternatives. Additional background information can be found in *Silos Heel and Decant Sump Tank Sludge Removal Technical Report, Document No. 40710-RP-0037*.

The four highest rated alternatives from the workshop and their ability to be implemented with the existing Silos Waste Retrieval System (SWRS) were then examined. The results of this analysis are contained in *Silos 1 And 2 Heel Removal Alternatives, Document No. 40710-RP-0038*.

The recommendations from analysis of the heel removal alternatives include modification of the Hazleton pump to maximize its ability to remove heel material (by reducing its submergence requirements), and replacement of the Hazleton pump with a jet pump with its inlet located in the silo sump

2.2 METHOD FOR REMOVING K-65 MATERIAL FROM DECANT PORTS

Alternatives for removing K-65 material from the silo decant ports were also discussed in the workshop and were examined further in *Silos 1 And 2 Heel Removal Alternatives, Document No. 40710-RP-0038.* The recommended method for cleaning the decant ports depends on whether the silo berm is still in place when the work is conducted. If the silo berm is in place, the method involves removing the decant port weir boxes from the interior wall (shearing was later selected) and washing the piping and weir boxes with the sluicers. If the berm has been removed, the method involves cleaning the ports by flushing water from the outside of the silo through the weir and baffle assembly. In either case, the K-65 material and wash water will be removed from the silo in the same manner as heel material is removed.

2.3 ALTERNATIVE SELECTED FOR DECANT SUMP TANK SLUDGE REMOVAL

Alternatives for removing K-65 material from the decant sump tank were also discussed during the workshop. It was determined that discussions with commercial tank cleaning vendors would be valuable in developing a recommended approach. Meetings with five vendors were held May 28, 2003, to discuss their capabilities and ideas for removing K-65 sludge from the decant sump tank. The current strategy is to use a contractor to perform this scope of work. A performance specification will be prepared during preliminary design for the contractor scope of work. It is expected that the contractor will propose to use a combination of mixing and pumping, for several cycles, to clean the decant sump tank.

3.0 OVERVIEW

The scope of this document includes system design descriptions of the remedial design for Silos 1 and 2 heel removal and decant sump tank sludge removal. The heel and sludge removal operations will be accomplished in several steps, which are described in separate sections of this document.

3.1 SEQUENCE OF OPERATIONS

Several consecutive steps are included in the concept for silos heel removal and decant sump tank sludge removal. These steps are:

1. Silos heel removal using modified Hazleton pump with slurry module.
2. Silos heel removal using slurry jet pump with slurry module.
3. Decant ports cleaning.
4. Silos final water wash of interior walls and floor.
5. Silos blending / grouting.
6. Decant sump tank sludge removal.

It is expected that not all of these steps will be required to remove the heel successfully. The approach taken for heel removal will be decision based. After the performance of each step, an assessment will be made to decide whether performance of the next step is necessary. This step-wise approach provides for multiple contingencies. Equipment for each step will be available at the start of heel removal operations for potential deployment if needed.

Heel material will be removed from one of the silos (either Silo 1 or 2) following Steps 1 through 5, if the steps are needed, and then these steps will be repeated for removal of heel material from the other silo. Step 6, decant sump tank sludge removal, will follow the final step in heel removal, and will be preceded by excavation of a portion of the silo berm.

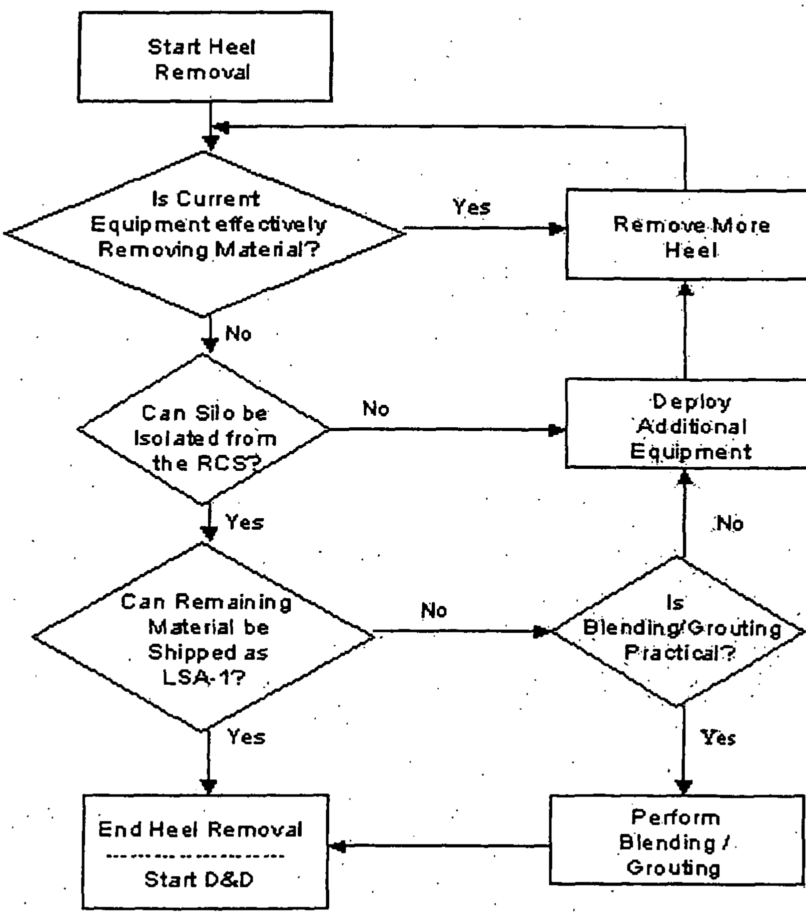
For bulk waste retrieval operations, each silo has its own dedicated equipment. For heel removal operations, each silo will still have use of this bulk waste retrieval equipment as needed. However, for new heel removal equipment, only one set of new equipment will be required because the equipment will be deployed sequentially. The new heel removal equipment will be deployed at one of the silos (either Silo 1 or 2), and then the equipment will be moved and deployed at the other silo. Simultaneous heel removal operations in both silos will not be possible because of electrical power and sluice water volume constraints. There may be a period of transition between bulk waste retrieval and heel removal operations. Equipment that will be required for heel removal after such a transition period will be maintained in a condition that will support its restart at a later date.

3.2 HEEL REMOVAL ENDPOINT

The existence of a heel cannot be proven or inferred definitively from the existing data. It is postulated that there may be a different kind of material encountered as the process of bulk slurry removal proceeds with depth into the silos. Compaction over time may have produced a material that is somewhat more refractory to removal than the bulk waste overlying it. It is also possible, however, that the heel may not even exist as a material whose mobilization characteristics are differentiable from the bulk slurry itself, therefore presenting a removal challenge no different from that of the bulk material. Therefore, rather than a closed, specific design, the project is proposing a flexible, observationally-based approach for the removal of the heel. Figure 1 depicts the logic for making decisions during heel removal operations.

FIGURE 1

DECISION-MAKING LOGIC FOR SILOS 1 AND 2 HEEL REMOVAL



The primary objective for the heel removal process is to clean the silos to acceptable levels for decontamination and decommissioning operations. The goal of each of the potential steps of heel removal is to transfer as much of the residual Silos 1 and 2 material to the TTA as is practical without proceeding beyond a point where large amounts of excess water is being generated with very small amounts of waste loading. Although the equipment for all steps will be available at the start of heel removal operations for potential deployment if needed, it is not expected that all of these steps will be required to remove the heel successfully. For example, the modified slurry pump may remove sufficient heel material in Step 2 so that deployment of the jet pump in Step 3 may not be needed. This step-wise approach provides for multiple contingencies, while avoiding the deployment of unnecessary equipment or the generation of excess sluice water with very low waste loading. As each of the potential heel removal steps reaches this point of diminishing return, an evaluation will be conducted to determine if deployment of the next heel removal step is necessary.

An operational definition of the "Heel" has been developed. When the Hazelton pump with the large (approximately 10" immersion) screen is no longer effective in removing slurry the "Heel" has been reached. To get to the heel, we intend to operate the Hazelton pump that is currently part of the bulk slurry removal process until, observationally, it is judged to be no longer effective in waste removal. This means: Conducting limited sampling over time of the slurry exiting the Slurry Module to determine the % solids of the exiting, pumped slurry; ascertaining the distance from the bottom of the Hazelton Pump intake screen to the floor of the silo; visually confirming that the Hazelton pump has not dug itself into a cone of depression.

The sluicing units (there are two to each silo) can be used to blast out any mounded materials and thus control any cone into which the Hazelton pump may dig itself. We are able to monitor the length of the hose immersion into the silo, thus knowledge of the hose extension and the relative datum of the silo floor relative to the bridge will provide knowledge of the height of the pump screen above the floor of the silo.

When we see that the solids levels in the exiting slurry are consistently low (nominally less than 15%), that the distance to the floor of the silo is approaching 12" and that the Hazelton pump has not dug itself into a cone of depression, the heel has been reached. Via the three cameras installed in the silo, we shall have visual access to the silo. Thus, we will be able to see the extent of removal.

At this point the rate of radon emissions from the remaining heel will be determined. The actual rate of radon emissions from the heel will depend upon the concentration of K-65 material remaining in the heel, and on the emanation characteristics associated with the residual. Modeling has been performed of radon emission from 8 inches of heel, assuming a 15% K-65 solids concentration in the residual. Based on those results, the impact to the FCP fenceline would result in an extremely low incremental radon concentration increase. This additional projected increase in radon concentration would be so low as to have minimal impact on the 0.5 pCi/l annual average fenceline limit specified by the Operable Unit 4 ARARs, and by proposed 10CFR834. This modeling is continuing to be reviewed and refined.

If the rate is acceptable, we will proceed to determine compliance of the material as an LSA-1 waste. If the D&D rubble containing heel material cannot be classified as LSA-1 waste, it would be classified as LSA-II waste, and an industrial package (IP) 2 container would be required for transport. An IP-2 container is an engineered container that must meet several criteria including a 3-ft drop test without the loss of any contents. It would either be necessary to package the D&D rubble in the container being used for the Remediation Facility (18-in. diameter opening), or a new IP-2 container would need to be designed, tested, and qualified. This would be impractical from both a cost and schedule basis.

Next, the amount of residual heel material would be assessed to determine if it would be practical for blending or grouting to achieve LSA-1 criteria and/or disposal facility waste acceptance criteria, which would involve adding an amount of inert material that would be sufficient to reduce the concentration of radionuclides to meet the necessary criteria. The additional inert material would need to be reasonably homogeneously mixed with the K-65 material for it to be classified as LSA-1 waste. If blending / grouting were impractical, then additional equipment would be deployed for further heel removal operations.

Assuming that further removal is either required or desired, the large screen would be removed from the Hazelton pump and replaced with an essentially flat screen. This action will force the Hazelton pump to remove waste down to a level of about 1-2". Again, the determination of the effectiveness of the removal of waste would proceed much the same as above: Limited sampling, visual observation. The radon emission rate and the compliance of a blended or grouted waste with LSA-1 limits are again determined. When, observationally, the altered Hazelton pump is no longer effective in removing waste, the need to proceed to the next contingency will be evaluated.

If judged necessary, the use of a jet pump will be implemented. The Hazelton pump within the Slurry Pumping module will be removed and replaced with a jet pump. The intake of the jet pump will be placed at the bottom of the sump located on the silo floor where the conical grading converges near the floor's center. By sluicing toward the sump we expect to be able to make further removal progress. As for the previous contingencies, we need to determine the effectiveness of the jet pumping operation. Limited sampling and visual observation will be employed to determine when the pump is no longer effectively removing silo material.

When the jet pump is no longer effective in waste transfer its operation will be discontinued. Depending on the amount, if any, and characteristics (radionuclide concentration and dose, radon emanations) of any residual heel remaining in the silo, additional actions may be implemented prior to initiation of D&D. These final actions may include blending the residual with inert material, grouting or fixing it in place, or manual removal.

At the end of this phase and depending upon the status of the berm removal, the decant ports will be removed. Sluice water will be directed to remove accumulated waste from the displaced weir boxes and the exposed ports they formerly covered. Continued sluicing of the floor of the silo and use of the jet pump in the sump will be employed to remove the waste liberated from the decant weirs and ports.

Finally at whatever point the removal of heel is completed, the Silos interiors will be washed down with the sluicers, and preparations will be made to initiate D&D.

3.3 AWR SUPPORT SYSTEMS

The following systems, provided by the AWR Project for bulk waste retrieval, will be used to support heel and sludge removal operations.

3.3.1 Silos Waste Retrieval System (SWRS)

SWRS will use the technique of "past practice sluicing" to retrieve and transfer bulk waste material from the silos. The SWRS sluicers and their corresponding sluicer modules will be used during Steps 1 through 5 of silos heel removal for mobilizing heel material, rinsing debris, and washing the silo walls. The SWRS Hazleton slurry pump will be modified (to reduce submergence requirements) and used during Step 1 of silos heel removal operations to remove heel material from the silo and transfer it to the TTA tanks. The SWRS slurry module will be used during Steps 1 and 2 to house and deploy heel removal pumps. Other SWRS equipment, such as the bridge monorail hoist, the diverter valve enclosure, and the diverter valve enclosure winch will also be used during heel removal operations. The double-contained 4-in. diameter transfer pipeline will be used for transferring heel material to the TTA tanks.

Three closed-circuit television video cameras with lights, which will be deployed through risers in each silo roof to provide an overall view required to maneuver and control in-silo equipment during SWRS, will also be used during heel removal operations.

3.3.2 Transfer Tank System

Heel material removed from the silos will be transferred to and staged in the transfer tank system storage tanks before it is ultimately transferred, using the TTA Waste Retrieval System (TWRS), to the Remediation Facility for treatment.

3.3.3 TTA Waste Retrieval System (TWRS)

During heel removal operations, the TWRS slurry/decant pumps will be used to provide sluice water to the silo sluicers, in the same manner as during SWRS operations. Sluice water will be recycled from the TTA tanks, where a settling and decant process will be used to recover the water.

3.3.4 Radon Control System (RCS)

The RCS provides ventilation and reduces radon concentrations in the silos and other tanks containing K-65 material and residues. During heel removal operations, it will provide ventilation through the silos. The present project schedule allows for the RCS to be in operation during the cleanout of the Decant Sump Tank. At present, no other systems for ventilation of the Decant Sump tank have been planned or identified as necessary. If there appears to be a need for additional ventilation capability, a requirement to provide a portable system (e.g. a package carbon adsorption air unit) will be incorporated into the specification for the contractor selected for Decant Sump tank cleaning.

3.3.5 Process Water System

Process water from three makeup water tanks will be supplied during heel and sludge removal operations as needed. Clean water will be required to decontaminate heel removal equipment and other items as they are retracted from the silos. The process water system can provide high-pressure (3,000 psi) water for decontamination operations. Process water may also be used in Step 5 for accomplishing the final water wash of the silo interior walls and floor. After use, the water will be transferred to the TTA tanks for subsequent treatment in the Remediation Facility.

3.3.6 Breathing Air System

Breathing air is available for personnel entering the equipment modules for maintenance and other activities (e.g., Steps 1 and 2 retrofit). Breathing air would be provided by the existing breathing air system.

3.4 EQUIPMENT TESTING AND OPERATIONAL TRAINING

Prior to the introduction of new heel removal equipment into the silos, equipment testing will be performed. Present plans call for an equipment test period of approximately one-month duration followed by a training period of approximately three months. During the training period, operators will simulate various aspects of the heel removal operations. The testing and training will be carried out on the same Fernald Test Stand that will be used to test equipment for bulk waste retrieval. The testing and training will be preceded by development of testing and training plans and will lead to the finalization of heel removal procedures.

4.0 SILOS HEEL REMOVAL USING MODIFIED HAZLETON PUMP WITH SLURRY MODULE

The first step in the silos heel removal sequence of operations is to use the existing bulk retrieval system to the maximum extent possible with the Hazleton vertical, centrifugal slurry pump, which will be modified to achieve additional depth. The slurry pump will be modified for heel removal after reaching its limit for bulk retrieval, which is dictated by the initial height of the pump stand and submergence requirements.

The SWRS pump stand extension and intake screen will be removed and replaced with a "suction saver" intake screen to initiate heel removal operations. Pump modifications are described in greater detail in Section 4.1.1. The intake screen will be the shortest Hazleton recommends based on the minimum screen open area needed for minimum recommended pump flow. Theoretically, with this configuration, minimum submergence can be reduced to 1-1/2 to 2 in. Flow will need to be reduced when the bottom of the screen is blocked during this type of operation to minimize cavitation. Cavitation will be indicated in the control room by sudden reduced flow, surging flow, reduced current draw on the pump motor, or a combination of all three. This modification increases risk of damage to the pump since it may tend to cycle between cavitation and no cavitation. The reduced flows might also result in slurry transfer pipe plugging. Reduction in the slurry solids content and close attention to pump operation will greatly minimize these risks. It is expected, based on conversations with the pump manufacturer, that the level of damage sustained by the pump will not significantly reduce pump performance, much less cause pump failure, during the amount of time the pump will be operated in this configuration. The pump damage, if any, would be sustained only during the latter phases of operation when the bottom of the pump screen is resting completely on the bottom of the silo. This will occur only during the final pump down of the slurry. An insignificant amount of damage is expected in the short duration of this operation.

The thickness of the heel would reach about 5 in. in the vicinity of the pump with the standard inlet screen and pump feet after removal of the SWRS pump stand extension. With the planned modifications, the heel thickness should be reduced to approximately 1.5 in. Results will be dependent on the techniques that operating personnel employ during operation of the SWRS sluicers and the modified SWRS slurry pump when the heel thickness approaches the theoretical minimum.

Sluicing with the existing SWRS sluicers will be continued to mobilize the heel material following modification of the SWRS slurry pump. When the modified slurry pump reaches its limit for heel retrieval, it will be removed from the silo and slurry module. A jet pump will then be deployed through the slurry module to be used in Step 2 (Section 5.0). The jet pump's inlet will be positioned in the silo sump for improved heel removal efficiency.

4.1 SYSTEM DESCRIPTION

The first step in the silos heel removal sequence of operations is to use the modified SWRS slurry pump with the existing slurry module. This system is almost the same as the bulk waste retrieval system; the only change is modification of the existing slurry pump.

The major equipment components for this step are:

Silo 1 Sluicer Module 1 (SLC-11-203)

Silo 1 Sluicer Module 2 (SLC-11-204)

Silo 1 Slurry Pump (PMP-11-201)

Silo 1 Slurry Module (SLR-11-201)

Silo 2 Sluicer Module 1 (SLC-11-205)

Silo 2 Sluicer Module 2 (SLC-11-206)

Silo 2 Slurry Pump (PMP-11-202)

Silo 2 Slurry Module (SLR-11-202)

All these equipment components will exist for bulk waste retrieval. The existing slurry pumps will be modified for heel removal operations.

4.1.1 Slurry Pump and Slurry Module

The Hazleton slurry pump is a vertical, centrifugal-style, submersible pump. It has a strainer screen mounted under and around the pump feet, ahead of the pump suction, to limit the size of material entering the pump. Oversized objects would lodge in the pump impeller and cause damage to the pump. The pump will be modified for heel removal operations by removing the pump stand and reducing the screen opening area. The SWRS pump stand is designed by Hazleton to maintain pump inlet clearance dimensions during SWRS operations yet allow minimum pump inlet clearances for heel removal. This has been achieved by reducing the pump foot height and installing spacers integral to the SWRS pump stand and intake screen.

Prior to heel removal activities, the pump will be raised into the slurry module and the SWRS pump stand will be replaced with the suction saver screen. Activities required to complete replacement are limited to removal of the pump inlet spray ring and removal and replacement of the pump stand and intake screen. Replacement of the pump stand and intake screen is achieved by removing and replacing only three attachment bolts. The modification may take as long as one shift to complete because the work will occur within the slurry module with personnel wearing personal protective equipment (PPE).

The slurry pump will be used to transfer heel material out of the silo and to the TTA tanks, and will operate at about 200 psi and 350 gpm. The slurry pump has a variable speed drive to control flow rate. The elevation of the slurry pump can be adjusted along the entire vertical profile of the silo by a chain hoist.

The slurry pump will be deployed through the center riser into the silo from the existing slurry module. The module is a sealed steel structure that provides secondary containment. The slurry module is located in the center of the silo and is supported by the bridge structure. The module is about 8 ft wide by 19 ft long by 15.5 ft high and weighs about 20,500 lb. The module contains the equipment needed to allow the pump to be operated with minimal or no routine personnel access. This equipment includes a chain hoist, one hose reel to hold the pump discharge hose, one hose reel for the high-pressure water supply hose (for the pump inlet spray ring), one cable reel to hold pump power wiring, one cable reel for instrumentation cable, and piping/hoses and valves to direct flows.

A decontamination spray ring, supplied with high-pressure water (3,000 psi) from the high-pressure water pump, will be used whenever the slurry pump is retracted into the module. Process water will be available to the module as a backup to sluice water for flushing the slurry line following a transfer. In addition, process water will be available to back-flush the slurry pump. Both of these backup provisions are implemented using jumper hose connections.

4.1.2 Sluicers and Sluicer Modules

Two SWRS sluicers with sluicing nozzles, deployed from two sluicer modules, will be used to mobilize the heel material in each silo. Each sluicer is supplied with sluice water by the TTA decant pumps. The sluicers will use low to medium pressure (about 150 psi), high volume (about 250 to 300 gpm) sluice water to dislodge heel material, form a slurry, and convey heel material to the intake of the slurry pump. Whether one or two sluicers are operated, the total sluicing flow rate is fixed, with a maximum total flow of about 300 gpm, to maintain a water balance in the silo.

A mast supports the sluicer nozzle, sluice water supply hose, and power and control cables. The mast hoist (cable-type hoist) in each of the sluicer modules can adjust the nozzle assembly elevation. Additional sections of mast can be attached to enable the sluicer nozzles to be positioned at lower elevations.

The sluicer modules provide secondary containment. They are located on either side of the slurry module and are supported by the silo bridge structure. The sluicers are deployed through risers along the silo's perimeter at 0° and 180° and approximately 50 ft apart. Each sluicer module is about 6 ft wide by 10 ft long by 20 ft high and weighs about 13,500 lb.

Each sluicer module is equipped with a decontamination spray ring, supplied with high-pressure water (3,000 psi) from the high-pressure water pump, which will be used whenever a sluicer and/or mast is retracted into the module.

Cameras with lights, located in three risers on each silo dome, will be used to view the progress of the sluicing and heel removal operations.

4.2 SYSTEM OPERATION

Initially, one sluicer nozzle stream will be directed as close to the slurry pump inlet as possible to create a slurry pool and form a cavity for slurry to flow into. The modified slurry pump will be lowered into the cavity and started. The sluicer will then begin pushing heel material toward the pump while avoiding close contact with the pump inlet. Cavitation and loss of pump prime can occur when sluice water impinges on the pump intake screen. Typically, one sluicer will be operated at a time, and the sluicers will be alternated as needed. Both sluicers could be operated at once to attempt to mobilize certain "dead zones" of heel material.

5.0 SILOS HEEL REMOVAL USING SLURRY JET PUMP WITH SLURRY MODULE

The second step in the silos heel removal sequence of operations is to use a slurry jet pump, with its inlet located in the silo sump, in combination with the existing slurry module after the modified Hazleton pump has been removed from the module. The slurry jet pump can continue to operate until the silo sump is pumped nearly dry. Therefore, the slurry jet pump is expected to be able to retrieve almost all of the heel material that can be moved by the sluicers to the silo sump (to a thickness in the sump of about ¾ in.).

5.1 SYSTEM DESCRIPTION

This heel removal step uses a slurry jet pump, with its inlet located in the silo sump, with the existing slurry module. A slurry booster pump will be installed in the slurry module to transfer the heel material to the TTA storage tanks.

The major equipment components for this step are:

Silo 1 Sluicer Module 1 (SLC-11-203)

Silo 1 Sluicer Module 2 (SLC-11-204)

Silo 1 Slurry Module (SLR-11-201)

Silo 2 Sluicer Module 1 (SLC-11-205)

Silo 2 Sluicer Module 2 (SLC-11-206)

Silo 2 Slurry Module (SLR-11-202)

Slurry Jet Pump (PMP-11-301)

Slurry Booster Pump (PMP-11-302)

The sluicer and slurry modules will exist for bulk waste retrieval. The primary reasons for selecting the jet pump for this application include its lighter weight, compact size, limited need for additional support equipment for operation, absence of moving parts within the pump, ability to function without cavitation while solids are agitated at the pump suction, control of discharge slurry density to some degree, and ability to remove solids down to a thickness of approximately ¾ in. The white paper titled *Pump Selection for Silos 1 and 2 Heel Retrieval*, included as Appendix A of *Silos 1 And 2 Heel Removal Alternatives, Document No. 40710-RP-0038*, provides additional information on selection of the jet pump.

The slurry jet pump will be deployed from the existing slurry module, located in the center of the silo. The slurry jet pump body will be positioned adjacent to the silo sump, which is slightly offset from the silo's center. The jet pump will be designed with an inlet extension that will reach into the sump. The pump will be supported from the same chain hoist that was used by the centrifugal slurry pump to provide the capability for remote vertical adjustment. The lift chain and pump hoses will be threaded through smooth sleeves and/or pulleys, which will be attached to the slurry module support steel with hand operated "come-alongs" or similar tensioning devices. After deployment of the jet pump into the silo through the central access riser, the tensioning devices will be used to draw the hoist chain and pump hoses to the edge of the central riser. This will position the pump adjacent to the silo sump. Additional cables may need to be attached to the pump and routed to the module for adjustment of the pump inlet location.

The slurry jet pump will use sluice water as its motive force at approximately 175 gpm and 150 psig. In passing through the jet pump, the motive force water will entrain the slurried heel material. The suction flow rate of the slurry jet pump will be approximately 155 to 175 gpm. The discharge pressure of the jet pump is conservatively estimated to be about 23 psig. The slurry jet pump will transfer the heel material as a slurry to the slurry booster pump mounted within the slurry module. The slurry booster pump is anticipated to be a 60 HP centrifugal pump. The slurry booster pump will transfer the heel material slurry to the TTA storage tanks through the existing 4-in. diameter transfer piping system. The slurry jet pump will provide approximately 330 to 350 gpm at about 4 psig pressure to the booster pump inlet.

The slurry jet pump will be equipped with an agitator ring with multiple water nozzles. The nozzles will emit water jets in a turbulent manner around and adjacent to the pump inlet to improve heel material mobilization. The water jet nozzles are rudimentary in design and use large diameter orifices (1/8 in. to 1/4 in. diameter), which have little risk of plugging. The nozzles will use the same sluice water as used for the jet pump motive force. The agitator nozzles are designed for use only when the jet pump flow falls below normal and agitation is desired or deemed necessary by operating personnel.

The slurry jet pump is submersible and its inlet can be run dry without damage to the pump. Due to the nature of the pump design and operation, flushing the slurry discharge line is accomplished either by allowing the pump to run until the sump is nearly empty or by raising the pump out of the slurry, eliminating the slurry inlet stream. The sluice water supply fluid then flushes the line because no more slurry is entering it. Process water will be available to the slurry module as a backup to sluice water for flushing the slurry line following a transfer. In addition, process water will be available to back-flush the booster pump. Both of these backup provisions are implemented using jumper hose connections. The slurry module decontamination spray ring, supplied with high-pressure water (3,000 psi) from the high-pressure water pump, will be used to clean the jet pump whenever it is retracted into the module.

Two SWRS sluicers will be used to mobilize the heel material in each silo. Lower flow sluicer nozzles will be used (¾ in. nozzles will be replaced) since the jet pump requires sluice water for operation. The nozzles are designed to maintain sluicing effectiveness with the reduced flow. Each sluicer is supplied with sluice water by the TWRS slurry/decant pumps. The sluicers will operate at approximately 100 gpm and 150 psig, if used one at a time while the slurry jet pump is operating.

Each sluicer module is equipped with a decontamination spray ring, supplied with high-pressure water (3,000 psi) from the high-pressure water pump, which will be used to clean the equipment whenever a sluicer and/or mast is retracted into the module.

Cameras with lights, located in three risers on each silo dome, will be used to view the progress of the sluicing and heel removal operations.

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5.2 SYSTEM OPERATION

The slurry jet pump will initially be deployed in a vertical position in the same location as the centrifugal slurry pump. After entry into the silo, the pump hoist chain and hoses will be drawn to the edge of the central riser opening. This will position the pump close to the location of the silo sump. Once in position, the pump will be lowered to rest on the heel material. Slurry and water will be pumped out to a minimum depth of approximately ¾ in. at the jet pump inlet. The sluicing nozzles will then be used, either one at a time or in unison, to move heel material to the jet pump inlet. Sluicing effectiveness will be improved for this step, as compared to the step using the modified Hazleton pump, since the water layer over the heel material can be reduced to a minimum by the jet pump without concern for losing pump prime or causing cavitation.

Typically, one sluicer will be operated at a time, and the sluicers will be alternated as needed. However, both sluicers could be operated at once to attempt to mobilize greater volumes of heel material. As the heel level in the silo decreases, the slurry jet pump will be periodically lowered into the silo. The sluicer nozzles will also be manipulated to increase heel removal effectiveness, using their pan, tilt, and elevation control capabilities to control sluicer angle of attack. The normal operating flow rate of sluice water will be approximately 100 gpm in this step.

The combination of sluicing and pumping will remove the heel material as slurry. Water will enter the silo through the sluicers at about 100 gpm and leave through the slurry jet pump. The combined sluice water/heel removal rate from the silo will range from about 155 to 175 gpm. This will result in a net heel removal rate of about 55 to 75 gpm. The slurry jet pump is powered by sluice water. The jet pump requires approximately 175 gpm of sluice water to move the slurry out of the silo. The total discharge flow out of the silo to the slurry booster pump will range from 330 to 350 gpm.

The pump will be lowered, as heel removal from the sump rapidly progresses, until the pump inlet reaches the bottom of the sump or downward movement is halted by debris or dense solids. Heel material will be directed toward the sump by the sluicers until heel removal effectiveness is deemed marginal. The pump's water nozzle-type agitator will be used during these activities when necessary.

6.0 DECANT PORTS CLEANING

One of two methods will be used for cleaning any held-up K-65 material from the silo decant ports. If the silo berm is in place at the time of this step, then the ports will be sheared from the silo interior wall, fall to the silo floor, and be washed using the sluicer nozzles. If the berm is removed prior to this step, then each port will be cleaned by flushing water from the outside of the silo through the weir and baffle assembly. In either case, the K-65 material and wash water will be removed from the silo in the same manner as heel material will be removed. Decant ports cleaning will overlap Step 3 operations (or possibly start during Step 2) so that the K-65 material contained in the decant ports can be removed together with the heel material.

6.1 SYSTEM DESCRIPTION

The major equipment components for this step are:

Guided Ram Weight (for first method only)

Silo 1 Sluicer Module 1 (SLC-11-203)

Silo 1 Sluicer Module 2 (SLC-11-204)

Silo 2 Sluicer Module 1 (SLC-11-205)

Silo 2 Sluicer Module 2 (SLC-11-206)

Slurry Jet Pump (PMP-11-301)

Slurry Booster Pump (PMP-11-302)

Hydraulic Power Unit (HPU-11-201)

With the exception of the guided ram weight, these equipment components are identical to those used during heel removal. The sluicer modules will exist for bulk waste retrieval. The other equipment will be deployed during heel removal.

6.2 SYSTEM OPERATION

In this step, one of two methods will be used for cleaning the decant ports. The method selected will depend on whether the silo berm is in place at the time of this step, and consequently, whether the ports can be accessed from the interior or exterior of the silos.

The first method will be used if the silo berm is in place. This method uses a guided ram weight dropped through a 36-in. penetration in the silo dome directly above the decant ports. The ram will shear the ports from the interior walls, and the metal weirs and baffles will be allowed to fall to the silo floor. A full-scale demonstration of the guided ram weight is planned prior to implementation of this method in the silo.

In the first method, both the sheared pieces and the pipes in the silo wall will be washed with water using the sluicer nozzles. The decant ports are located on the east and west walls of each silo, and therefore, they are close to the sluicers (located east and west of the silo center). This will facilitate cleaning of the decant port piping in the silo walls following shearing of the weir boxes.

The second method will be used if the silo berm has already been removed. This method cleans each decant port by flushing water from the outside of the silo through its weir and baffle assembly and into the silo. The silo sluicers will not be needed for flushing the ports.

For either method, the K-65 material removed from the decant port components and the wash water will be removed from the silo in the same manner as heel removal using sluicing and pumping. Decant port cleaning will overlap final heel removal operations so that the K-65 material contained in the decant ports can be removed together with the heel material.

7.0 SILOS FINAL WATER WASH OF INTERIOR WALLS AND FLOOR

Before turning the silos over for D&D operations, heel removal will include a final water wash of the silo interior walls and floor. If, after completion of this step, the amount of K-65 material remaining in the silos is an acceptable level, then this will be the last step of heel removal. If K-65 material in excess of acceptable levels still remains in the silos, then the heel removal grouting system will be implemented (see Section 9.0).

The final water wash of the silo interior walls will be accomplished using the two SWRS sluicers, which were used previously during bulk waste retrieval and other steps of heel removal. The water from the washing process will be collected in the silo sump and pumped to the TTA tanks using the jet pump with its inlet in the sump and the booster pump in the heel retrieval module. Debris remaining in the silo will have previously (during Step 3) been moved to one location near the silo wall and rinsed with the silo sluicers Debris removal from the silos will be performed during D&D.

7.1 SYSTEM DESCRIPTION

The major equipment components for this step are:

Silo 1 Sluicer Module 1 (SLC-11-203)

Silo 1 Sluicer Module 2 (SLC-11-204)

Silo 2 Sluicer Module 1 (SLC-11-205)

Silo 2 Sluicer Module 2 (SLC-11-206)

Silo 1&2 Heel Retrieval Module (ENC-11-201)

Slurry Jet Pump (PMP-11-301)

Slurry Booster Pump (PMP-11-302)

Hydraulic Power Unit (HPU-11-201)

These equipment components are identical to those used during Step 3 of heel removal. The sluicer modules will exist for bulk waste retrieval.

7.2 SYSTEM OPERATION

During the silo washing operation, the sluicers will be directed at the silo walls, starting at the top, moving in a grid-like pattern from side to side, and then moving downwards. The sluicers will operate at approximately 100 gpm and 150 psig, if used one at a time while the slurry jet pump is operating. The slurry jet pump will be operated to remove the wash water from the silo, and the slurry booster pump will assist in transferring the wash water to the TTA tanks. The entire washing operation is expected to take approximately four hours for each silo, based on a reasonable washing rate for the interior silo surface area.

8.0 SILOS BLENDING / GROUTING

In the event that sufficient K-65 material could not be removed during heel removal steps 1 through 5 to reach acceptable levels, then a blending/grouting system will be deployed. This system will consist of contractor supplied and operated equipment for mixing the K-65 material remaining in the bottom of the silo, in place, with grout or other inert material. A performance specification for the blending/grouting work will be prepared during preliminary design.

If unacceptable amounts of K-65 material remain in a silo after the final water wash step is completed, the blending/grouting system will be deployed. The amount of material to be blended will be sufficient to reduce the concentration of radionuclides to ensure that the resulting waste material will meet LSA-1 criteria for shipment.

8.1 SYSTEM DESCRIPTION

The major equipment component for this step is:

Grouting Skid (SKD-11-201)

The grouting system is based on contractor supplied and operated equipment that provides turbulent mixing of a small amount of K-65 material remaining in the bottom of the silos with grout or other inert material. K-65 material previously on the silo walls and ceiling would be washed off by the sluicers prior to this step and would be present on the floor of the silo. Assuming that about ½ in. of dry K-65 material remained, about 365 yd^3 of inert material would be blended with the heel material in order to meet LSA-1 criteria. The resulting blended/grouted material would be approximately 2 ft deep in the 80 ft diameter silo.

The concept is based on grouting demonstrations with simulated residual wastes in test tanks at DOE sites (see Ref. 2 – 5). It has been demonstrated that the grout can be uniformly mixed with the residual material to produce a reasonably homogeneous product. The demonstrations have included use of grouting tools designed for tanks as large as 85 ft in diameter.

The concept for the contractor-supplied system is based on equipment contained on three truck trailers. The first trailer would contain storage bins and blending equipment for dry materials (e.g., cement and fly ash). The second trailer would contain a batch system for blending the pre-mixed dry materials with a bentonite/water mixture. The bentonite will be pre-hydrated with process water to form a 3% bentonite gel (3 lb bentonite in 100 lb water). The pre-mixed cement and fly ash would then be blended with the bentonite gel to produce a batch of grout. The third trailer will contain high-pressure pumps, hoses, and connections to introduce the grout into the silos. The grout will be rapidly pumped into the silo with sufficient force so that the grout will mix with the K-65 material to form a reasonably homogeneous product. If the K-65 material were hardened onto the bottom of the silo, sufficient force to scarify the silo floor would be required to enable the K-65 material to be mixed with the grout. The three-trailer system will be deployed near the silo on the gravel pad used previously for bridge construction. After completion of grouting the first silo (either Silo 1 or 2), the system will be moved and deployed near the second silo.

The grouted waste material will be removed from the silos during D&D operations. Therefore, it is preferable for the grouted waste material to have a lower strength than the silo walls and floor. It is estimated that a grout containing about 10-20% cement and 80-90% fly ash, mixed together with 3% bentonite gel in water, will be satisfactory for this application. The bentonite is added to prevent the grout from producing bleed water after setting. The grout formulation will take into account the water present with the residual heel material.

The grouted waste material will be removed during D&D by the same methods used for the silo walls and floor. It is anticipated that a hoe ram (jackhammer on a track hoe) and/or a hydraulic shear will be used for demolition and that a shovel attachment will be used for removing rubble and filling shipping containers (likely lined rail cars).

8.2 SYSTEM OPERATION

It is expected that the contractor supplied and operated grouting system will require about a one-week set-up period per silo and that the grouting process will take about one day per silo to complete.

9.0 DECANT SUMP TANK SLUDGE REMOVAL

Removal of sludge, expected to contain K-65 material, from the underground decant sump tank will be performed by a contractor. The goal is to remove all visible sludge from the tank prior to its disposal. A performance specification is being prepared for use to procure the services of a subcontractor whose objective will be to remove the sludge to this level. Even if the subcontractor is successful in removing all visible sludge, there will be a residual remaining that is expected to present a radiological hazard to D&D workers thus necessitating implementation of a plan for the minimization of worker exposures and releases of radon to the working environment.

During previous meetings with commercial tank cleaning vendors (see Section 2.3), a concept to clean the decant sump tank was determined. The concept is a combination of mixing and pumping for several cycles to remove the sludge. Removal of the silo berm overlying the decant sump tank would increase the range of mixing and pumping technologies that could be used, and therefore, may be advantageous prior to contracting for this work. Removal of the overlying berm to allow closer access to the decant sump tank would occur after bulk waste and heel removal operations were completed.

9.1 SYSTEM DESCRIPTION

The major equipment components for this step are:

Tank Cleanout Skid (SKD-11-202)

Decant Sump Tank Pump (PMP-11-303)

Several different approaches may be used to clean the decant sump tank, depending on the contractor selected. The concept will likely first use a mixing technology such as a water nozzle or pulse mixer to mobilize the sludge. Some water will likely be added to the tank to dilute the sludge to a pumpable mixture. After the sludge is sufficiently mixed, then the slurry will be pumped out of the decant sump tank. This water addition, mixing, and pumping cycle will be repeated several times until the tank is sufficiently cleaned. A water nozzle may be needed to rinse the tank walls, depending on the amount of residual sludge that is acceptable for tank removal during D&D operations.

The slurry from the decant sump tank can be transferred directly to the TTA tanks using the 2 in. transfer line that will be installed for SWRS operations. Rather than transferring the sludge to the TTA tanks for subsequent treatment in the Remediation Facility, the sludge may be treated separately by an alternative treatment. The alternative treatment would convert the sludge into a form that complies with NTS waste acceptance criteria for disposal as well as with applicable transportation regulations. The slurry from the decant sump tank could also be transferred to a transport truck (vacuum or other type) prior to treatment. The contractor may elect to use the pump that will be installed in the decant sump tank for SWRS operations, or may provide an alternate pumping system.

9.2 SYSTEM OPERATION

The tank cleaning contractor is expected to be able to clean the decant sump tank within about a day. A set up time of about a week will likely be needed to deploy the mixing and pumping equipment.

10.0 REFERENCES

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