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**FUNCTIONS AND REQUIREMENTS
FOR
105-KE BASIN SLUDGE RETRIEVAL AND PACKAGING**

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to define the overall functions and requirements for sludge retrieval and packaging activities to be performed in the 105-KE Basin at the U.S. Department of Energy (DOE) Hanford Site, in southeastern Washington State. These activities will accomplish sludge removal from the basin, reduce associated health, safety and environmental impacts to as low as reasonably achievable (ALARA) levels, support the ultimate disposition of sludge, and place sludge in containers for removal from the basin.

Sludge, and the clouding due to sludge, interferes with basin operation and maintenance activities. Consolidating the sludge, particularly from the various pits and discharge chute, into containers, will free the operators to perform work more efficiently. Once packaged the sludge can then be more easily managed within the basin. These containers will stage the sludge until it is transported out of the basin.

Sludge packaging will also reduce the risk of releasing sludge to the environment by adding another layer of containment.

1.2 SCOPE

The scope of this document is to provide the functions and requirements for sludge retrieval and packaging in 105-KE Basin.

This document describes the top level functions and functional requirements for the overall activities and tasks to be performed. Detailed design requirements for the specific equipment items shall be included in the engineering work plan documents for each equipment item. The work plans shall also specify the equipment performance requirements and specify how the performance of the equipment will be evaluated during cold and hot tests.

1.3 DESCRIPTION OF PLANNED SLUDGE ACTIVITIES

The overall plan is to design sludge retrieval and packaging equipment required to support Spent Nuclear Fuel Project objectives. Any sludge retrieval and packaging equipment used in the basin that has not been previously qualified to be operated in the basin, shall first be cold tested in the 305 building test facility and approved for use in the basin. The following functions and requirements describe the equipment, its function and its functional requirements as required to perform the sludge retrieval and packaging activities and interface with the selected transportation system.

1.4 DEFINITIONS

1.4.1 Basin

This term is used herein as an abbreviation for the 105 K-East Basin storage pool.

1.4.2 Terminology

- Shall: Denotes a requirement
- Should: Denotes a recommendation
- Will: Denotes an assumption

1.4.3 Function

A function is the description of the task that is to be performed. It is not to describe the device in any manner, but may establish some of the parameters within which it must perform.

1.4.4 Functional Requirement

A functional requirement is an outside limiting factor which must be considered or incorporated into the design of the device which must perform the specified function; it is not a preference. These statements use "shall" or "should."

2.0 GENERAL REQUIREMENTS FOR SLUDGE RETRIEVAL AND PACKAGING ACTIVITIES PERFORMED IN THE BASIN

2.1 BASIN REQUIREMENTS

In addition to the specific functions and requirements specified in the following sections, the sludge activities performed in the basin shall meet all applicable safety and environmental requirements, and shall meet all 105-KE Basin Conduct of Operations requirements. Each of the activities performed in the basin shall be analyzed to assure that they meet all applicable requirements given in this section.

1. Maintain radiation exposure to workers at ALARA levels. Any new activity not covered in the review of the ALARA plan for the pilot run (Vargo 1994) shall be reviewed and approved.
2. All sludge retrieval and packaging operations shall be criticality safe by maintaining all transferred sludge configurations and mixtures sub-critical as specified in WHC-SD-NR-CSER-008. Conditions not specified in CSER-008 shall be reviewed and controlled per WHC-CM-4-29.

3. All operations performed in the basin shall comply with the current basin Operational Safety Requirements (OSR).
4. All new activities in the basin shall be reviewed for Unreviewed Safety Questions (USQ).
5. All support and development activities in the basin shall be evaluated for impacts to the existing KE Basin safety authorization (WHC-SD-WM-SAR-062).
6. All support and development activities in the basin shall be conducted within the bounds of the process to be established and approved by the Environmental Protection Agency (EPA) and Department of Health (DOH).
7. Radiation Work Permits (RWP) shall be issued for new operations.
8. Operations and maintenance personnel shall be trained on all the new sludge retrieval and packaging equipment in a radiologically clean facility prior to handling the equipment in the basin in order to minimize installation, operation and disassembly time in the basin and to verify that the operating/maintenance procedures are correct.
9. All testing activities in the basin shall be performed in accordance with a released test plan.
10. New operating procedures shall be written and approved for any new operation in the basin that is not covered by current, approved operating procedures.
11. All sludge operations shall be performed in a manner which precludes unacceptable radiation releases to the basin environment.
12. A goal for the design of the sludge retrieval and packaging equipment shall be that the equipment, when manually operated in the basin, should not raise the radiation dose rate in the basin above the existing levels.
13. All sludge operations involving canisters containing fuel elements shall maintain the fuel canisters below 2.44 m (8 ft) of water.
14. All operations in the basin shall comply with current industrial safety and health requirements.

2.2 REQUIREMENTS FOR SLUDGE TRANSFERS TO BASIN WEASEL PIT

The existing DOH air permit presently allows the transfer or pumping of sludge only in association with other required basin activities and it can only be transferred to the weasel pit. As the sludge retrieval and packaging system are developed, changes to the DOH air permit shall be required.

Activities that require transferring sludge to the weasel pit shall meet the following requirement: the sludge flow rate to the back section of the weasel pit shall have an upper limit of 3 GPM/ft² of screen surface that is open to flow; that is, the area of the screen that is not covered by sludge

and debris (Jarecki 1992). This requirement refers to the 400 mesh isolation screen that is installed between the back section and front section of the weasel pit. This upper limit is required to:

- Prevent overflow over the top of the weir from the back of the weasel pit to the basin.
- Assure acceptable settling of sludge in the back section of the weasel pit.
- Maintain acceptable loss of fines to, and clarity of, the basin in front of the weasel pit.

2.3 INTERFACE REQUIREMENTS

Sludge retrieval and packaging activities in K Basins shall be coordinated with parallel activities to remove debris, fuel, and water from the basin. In addition, the containers used to remove sludge must interface with the transportation system selected. It is anticipated that a single transportation system will be used for both fuel and sludge removal. These containers must also interface with pre-interim storage facility, the interim storage facility and the final disposition facility. These interfaces lead to the following interface requirements.

2.3.1 Debris Removal Requirements

Debris in the basin is generally covered with sludge. Any movement of the debris will stir the sludge and the resulting turbidity will cause delays while the sludge settles. This requires a coordinated sequence of sludge removal before, during, and after debris removal to permit continuous operations and avoid unnecessary operator exposure while waiting for turbidity to clear. Basin air and water quality requirements shall be met while removing debris and the surrounding sludge.

Any small articles or particles retrieved with sludge, less than 0.635 cm (0.25 inch), may be handled as debris if they can be separated and identified as non-fuel particles.

2.3.2 Fuel Removal Requirements

Fuel stored in K Basins is the source of the fuel and fission product sludge in the basin. Failed fuel elements stored in the canisters continue to be a source of sludge. All fuel canisters in K E Basin also have non-fuel source sludge settled around the fuel elements. Fuel element removal from the basins must be coordinated with sludge removal operations. Movement of fuel without first removing (treating) the surrounding sludge often result in loss of visibility which threaten delays and increases operator exposure. Basin air and water quality requirements shall be met while removing fuel and the surrounding sludge.

2.3.3 Water Removal Requirements

The K Basin water will eventually be removed to complete the K Basins mitigation program. In the meantime, the water must be kept acceptably clear

and clean for routine operations to proceed. Any sludge operation should minimize impact on the basin water quality. In addition, basin water will be used for sludge retrieval. The retrieved sludge will then be processed to concentrate the sludge for packaging and storage. The effluent water from the retrieval and packaging processes may be returned directly to the basin or may be processed by the basin water conditioning system (sand filters and ion exchange modules) before returning to the basin. In the latter case, the effluent water quality shall be acceptable for processing by the basin water conditioning system.

2.3.4 Air Quality Requirements

The K Basins have minimum air quality requirements for effluent from the building and for manned entry into the basins (WHC-SD-WM-OSR-006). Any sludge retrieval and packaging operation has the potential to increase the release rate of listed constituents to the air. All releases caused by sludge operations shall meet the minimum air quality requirements. In addition, any change in basin operations shall be reviewed and approved by DOH to assure meeting air quality requirements. The sludge removal operations shall be designed and operated to meet the air quality requirements for normal and accident conditions.

2.3.5 Equipment Disposal Requirements

All sludge operations in K Basins shall be designed to minimize the generation of contaminated waste requiring eventual disposal. Everything currently in the basin will eventually be disposed of as contaminated waste. This includes all hoses, vacuum heads, pumps, concentration equipment, containers, and support equipment. In addition, any filter medium used shall be disposed of. Every effort shall be used to minimize the waste generated in removing sludge from K Basins.

2.3.6 Transportation

All sludge retrieval and packaging operations in K Basins shall be designed in consideration of transportation requirements. All material currently in the basin and all equipment introduced during sludge retrieval and packaging shall be suitable for transportation. ALARA requirements shall be applied from introduction of equipment to ultimate disposal. Sizes and contamination of all equipment shall be compatible with available transportation systems. Where possible, transportation equipment should be shared with other functions. For instance, the primary container for transporting fuel shall be considered for sludge transportation if possible.

2.3.7 Sludge Disposition

Sludge retrieval and packaging options considered shall not preclude any viable sludge disposition option. Sludge packaging and storage should be capable of supplying sludge to whatever sludge disposition process is selected. If that process is selected before selecting the sludge retrieval and packaging equipment, the disposition requirements shall be integrated into the retrieval and packaging requirements.

3.0 FUNCTIONS AND REQUIREMENTS FOR SLUDGE RETRIEVAL SYSTEM

The sludge retrieval system provides the basic sludge removal equipment required for general cleanup and for use in conjunction with sludge packaging systems. The sludge retrieval system includes all equipment needed to collect the sludge (end effectors and suction tools), to pump the sludge, and discharge the effluent to the basin. The resulting system(s) may include, but may not be limited to, the following:

- Vacuum heads to suck up loose sludge
- Vacuum head debris removal devices to remove debris and fuel element pieces that are intentionally prevented from entering the vacuum head
- Hose(s) to transfer the pumped sludge and discharge effluent
- Sludge pumps

The basic equipment used in this system may be either the equipment used in the previous discharge chute cleanup campaign or new equipment which will provide improvements in efficiency and handling ease during operations and result in reduced operator radiation dose. In some cases remote or robotic control systems may be required.

3.1 FUNCTIONS

Provide sludge retrieval equipment to remove sludge from the basin. Specifically provide vacuum heads, debris removal devices, hoses, and sludge pumps to accomplish sludge retrieval from the basin.

3.2 GENERAL REQUIREMENTS

1. The requirements specified in Section 2 shall be met.
2. Engineering and design documentation/media for the sludge retrieval equipment should be produced to accomplish equipment design as specified in WHC-SD-SNF-WP-001, *105-KE Basin Pilot Run Design Plan* or equivalent.
3. The sludge retrieval equipment shall be checked for correct interface fit up with all interface equipment items, if required, prior to installation in the basin.
4. The sludge retrieval equipment shall be cold tested with simulated sludge in the 305 building test facility to evaluate the installation, operation and disassembly process, to train operations and maintenance personnel and to verify operating procedures.
5. The sludge retrieval equipment shall be hot tested in the KE Basin if the ALARA plan allows this additional activity to be performed. The hot tests would be performed to the requirements specified in Section 2.

6. Approved components of the sludge retrieval system (e.g., sludge pump, transfer hose, and vacuum head) shall be used to pump sludge to a staging area such as the back of the weasel pit, to the sludge packaging system, or to a transfer station as necessary.
7. Sufficient visibility shall be maintained to allow all basin activities to proceed in a normal fashion, without extra exposure to operators due to work delays due to water turbidity.

3.3 SPECIFIC REQUIREMENTS

To support the basin cleanup effort, sludge retrieval from all basin areas is required. For cleaning the various pits and discharge chute, the sludge retrieval system equipment will primarily consist of a hose, vacuum head, and a sludge pump. A goal will be to use additional equipment items as available during pit cleanup in order to evaluate their performance for sludge cleanup efforts in the main basin.

In addition to the sludge retrieval system equipment, there are specific interface equipment items that are required for sludge removal in support of basin cleanup. The function and requirements for the interface equipment are specified in this section.

3.3.1 Retrieve Sludge From Pits And Discharge Chute Area

Cleanup is required in the following areas:

- The front of the tech view pit
- The weasel pit
- The dummy elevator pit
- The sand filter backwash pit
- The loadout pit
- The discharge chute

Most of these areas currently contain debris as well as sludge. This will probably require removing sludge before, during, and after debris removal operations. This may require design of special tools to accomplish sludge retrieval in unique geometries or conditions.

Sludge from the pits and discharge chute areas will initially be moved to the back section of the weasel pit. Sludge removal in these areas will be coordinated with the removal of other debris and the movement of single pass reactor fuel in the tech view pit to the front of the weasel pit as necessary. Ultimately, the sludge in the back of the weasel pit (and from any other place not yet cleaned) will be transferred to the sludge packaging system or other transfer stations as necessary.

3.3.2 Retrieve Sludge From Fuel Canisters

If determined to be appropriate, a canister vacuum head (CVH) will be designed to remove loose sludge from within open fuel canisters prior to moving them. The CVH will be attached to the sludge removal equipment.

3.3.2.1 Function

Provide the means to efficiently remove loose sludge from within an open fuel canister.

3.3.2.2 Requirements

1. The requirements specified in Section 2 shall be met.
2. The CVH shall be used with components of the sludge retrieval system equipment to pump sludge from an open fuel canister.
3. The CVH shall ensure that fuel element particles greater than 0.635 cm (0.25 inch) are not pumped and deposited with the sludge.
4. If the fuel canister is raised above the storage racks for installation and operation of the CVH, the canister shall be maintained below a minimum of 2.44 m (8 ft) of water.
5. The CVH shall be designed to be tested and evaluated in cold tests prior to use in K Basins.
6. The CVH shall be checked for correct interface fit up with a spare canister or a simulated section of the canister prior to installation in the basin.
7. The CVH shall be designed to permit hot testing in the basin.

3.3.3 Retrieve Sludge From The Main Basin

The main basin must be cleaned and the sludge transferred to the back of the weasel pit, to the sludge packaging system, or to other transfer stations as necessary. In addition to using components of the sludge removal system equipment to perform this task, small vacuum head(s) (SVH) configured to remove accumulated sludge from narrow spaces, shall be provided as necessary. Sludge may be removed either before or after fuel canister removal and before or after fuel rack removal.

3.3.3.1 Function

Provide the means to remove loose sludge accumulated in the main basin from on top of and under the fuel racks and from around the fuel canisters.

3.3.3.2 Requirements

1. The requirements specified in Section 2 shall be met.

2. The SVHs shall be used with components of the sludge retrieval system equipment to pump sludge to other locations or system as appropriate.
3. The SVH shall be designed to be tested and evaluated in cold test prior to use in the basin.
4. The SVH may be hot tested in the basin if the ALARA plan allows this additional activity to be performed. If the hot test is allowed, it would be tested on sludge remaining in front of the weasel pit or tech view pit. The hot test would be performed to the requirements specified in Section 2.

4.0 FUNCTIONS AND REQUIREMENTS FOR SLUDGE PACKAGING SYSTEM

This system will be dependant upon the final sludge disposition requirements. Sludge will be concentrated as necessary and packaged in a container. The main components of this system are a sludge concentrator and a sludge container. Other equipment used in this process will be components of the sludge retrieval system (Section 3) which have been developed and tested, and possibly improved upon, during the sludge retrieval activities in the basin.

This entire process will be tested with stimulants in the 305 building cold test facility before it is tested in the basin. However, because no simulant has been developed that adequately models KE Basin sludge, emphasis will be placed on performing in-basin feature tests as soon as possible, with real sludge, to obtain credible data to support process development. The development of a realistic simulant will improve the selection of equipment during cold testing, and has the added benefit of reducing operator exposure in that less in-basin testing will be required.

The following are functions and requirements for specific equipment items to be used for sludge packaging.

4.1 FUNCTIONS

Provide equipment to concentrate sludge retrieved from the basin and package it into a container.

4.2 REQUIREMENTS FOR SLUDGE CONCENTRATION

1. The concentration equipment shall meet all the requirements specified in Section 2.
2. The concentration equipment shall be used with components of the sludge retrieval system (Section 3) and the sludge container to achieve sludge transportation requirements.

3. Engineering and design documentation/media for the sludge concentration equipment shall be produced to accomplish equipment design as specified in WHC-SD-SNF-WP-001, *105-KE Basin Pilot Run Design Plan* or equivalent.
4. The concentration equipment shall interface with components of the sludge retrieval system and sludge container and shall be checked for correct interface fit up with all equipment prior to installation in the basin.
5. The sludge packaging system, which includes components of the sludge retrieval system, concentration equipment and the sludge container, shall be cold tested with simulated sludge in the 305 building test facility to evaluate the process and to train operation and maintenance personnel.
6. The sludge packaging system shall be designed to permit hot testing in the basin if the ALARA plan allows this additional activity to be performed. The hot tests would be performed to the requirements specified in Section 2.

4.3 REQUIREMENTS FOR CONTAINER

The primary goal is to retrieve and package sludge into a container for removal from the basin. In addition to the requirements specified in Section 2, the following requirements shall be met:

1. The sludge in the containers shall be criticality safe.
2. The containers shall be compatible with the radiological and chemical environment in the basin.
3. The container design shall:
 - Meet basin geometry interface requirements for in and out of water clearances, shielding space, and greenhouse requirements.
 - Meet basin support equipment interface requirement for use of the monorail.
 - Provide for sealing and venting the container, sampling the contents of the container, and providing for pressure relief.
4. The containers shall be capable of being decontaminated to a level required to allow removal from the basin and transport to the designated end point.
5. The containers shall be compatible with the shipping cask requirements.
6. The containers shall meet applicable Westinghouse Hanford Company safety and QA requirements, and applicable NEPA, DOH and DOT permitting requirements.

7. The container design shall not preclude any future sludge disposition option.

5.0 SLUDGE CHARACTERIZATION

5.1 SLUDGE CHARACTERIZATION FUNCTION

The function of sludge characterization is to provide information about the physical condition of the sludge. The information from these activities will be used to determine the requirements for the sludge retrieval and packaging activities. The sludge characterization program performs the following functions:

1. Provide radiation dose of the sludge to determine container shielding requirements.
2. Determine the total volume of sludge to be removed to determine the number of containers required.
3. Determine the rheology of sludge to determine the sludge pumping characteristics.
4. Measure the mass or density of sludge to determine container size limits based on facility handling requirements.
5. Determine the amount the sludge can be concentrated based on criticality limits and chemical reaction concerns (pyrophoric reactions).
6. Determine the particles size distribution to be used in designing sludge concentration equipment.

5.2 SLUDGE CHARACTERIZATION REQUIREMENTS

1. 105-KE Basin records shall be reviewed to collect available sludge characterization data that has been provided in the past.
2. The available data shall be evaluated against the requirements.
3. Available information shall be documented in either its original form or summarized in one or more reports.
4. A work plan describing the activities required to obtain any new data shall be developed. The work plan shall include data quality objectives (DQO) for the characterization efforts.
5. Sludge characterization already performed and planned by other projects shall be evaluated for applicability to preclude duplication. For example, the weight and properties of sludge in 105-KE Basin fuel canisters shall be determined.

6. Additional tests shall be performed to completely characterize the sludge.

6.0 REFERENCES

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