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FUNCTIONS AND REQUIREMENTS OF THE 105 K-EAST
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FUNCTIONS AND REQUIREMENTS OF THE 105 K-EAST BASIN DOSE REDUCTION PROJECT

1.0 INTRODUCTION

Radiological surveys of the K-East Fuel Storage Basin indicate an average radiation level of about 16 millirem per hour (mrem/hr) in the bays of the basin (Vargo, 1994). From this dose level, approximately 20 person rem collective dose is accumulated annually by personnel at this facility performing normal operation and security functions (Kaviani, 1994). Any additional work completed in the basin adds to this figure, and because of the priority placed on fuel removal, the amount of work scheduled to take place in the basin has increased significantly. Radiation dose has already become an issue and will potentially be the limiting factor in the time to resolve the K-Basin fuel removal task. Several sources of radiation are present, however, the overwhelming majority of personnel dose comes from cesium-137 (^{137}Cs) contamination in the 1) concrete walls of the pool, 2) recirculation piping and equipment, and 3) pool water (Vargo, 1994).

This project is to provide engineered solutions that reduce the average dose in the fuel storage area and the surrounding pits As Low As Reasonably Achievable (ALARA). This will be accomplished by completing engineering studies of available technologies, development of conceptual and final designs, fabrication or procurement of systems and performance analysis of those systems. The goal of this project is to reduce the average dose rate in the bays of the basin from its current level of 16 mrem/hr to a value between 2 and 5 mrem/hr. Even at these levels, there will be areas in the basin that will have higher dose levels, however, these will be minimized. Activities will be prioritized in accordance to the relative contribution to overall dose, cost versus benefit analysis and programmatic budget.

Work to be completed will be concentrated on mitigating the personnel dose from 1) the cesium contaminated concrete of the basin, and 2) the piping in the fuel storage basin area. Other "hot spots" will be considered outside the scope of this project. Decontamination and shielding will be the primary methods employed to reduce the exposure to radiation. Several specific methods, such as removing the contaminated layer of concrete, raising the water level, hanging shielding around the edge of the basin, cleaning out contaminated piping, or removal and replacement of piping could be employed to achieve the end result. The methods will be chosen through a decision process after a study of the available technology. After mitigation of the two primary objectives, a determination will be made on continuing to reduce dose by engineered methods. As of the concept design phase, this project is scheduled to take roughly two years.

1.1 DEFINITIONS

Function: A specific action, activity, or process that achieves or supports the achievement of an objective.

Requirement: Provides information on how well the system needs to perform a function or the extent to which a function must be executed. Generally requirements are measured in terms of quantity, coverage, timeliness or safety. Constraints, performance requirements and interface requirements are included in requirements.

ALARA: As Low As Reasonably Achievable. Provides guidance for reducing exposures to hazardous substances and radiation, and therefore minimizing risk. Places controls and regulatory limits to insure that there is no radiation exposure without commensurate benefits. ALARA prevents unnecessary radiation exposures to workers and the public and protects the environment.

Delimit: To fix or define the limits of.

Shall: Must be met.

Should: Desirable.

2.0 PURPOSE AND SCOPE OF FUNCTIONS AND REQUIREMENTS

2.1 PURPOSE

This document establishes the functions and requirements for the 105 K-East Basin Dose Reduction Project as described in WHC-SD-SNF-PMP-007, *Project Management Plan for the 105 K-East Basin Dose Reduction Project*, and WHC-SD-WM-WP-272, *Work Plan for the 105 K-East Basin Dose Reduction Project*.

2.2 SCOPE

The scope of these functions and requirements is to delimit the engineered dose rate reduction methods for the 105 K-East Basin. Functions and requirements provide approved criteria on which to base the design and for reviewing the adequacy of the design for any engineered equipment, facility modifications, or process improvements built and installed to reduce personnel dose at the facility. No other activities are covered by this document.

3.0 FUNCTIONS

3.1 PROJECT FUNCTION

The function of the K-East Basin Dose Reduction Project is to provide engineered reductions in the radiation dose to workers over the foreseeable life of the facility, to a level that is ALARA. The sources of consideration are the pool walls near the water line and the piping surrounding the basin. Other sources will be considered as secondary and shall only be considered upon completion of the primary tasks.

3.2 ENGINEERED DOSE REDUCTION TECHNIQUE FUNCTIONS

3.2.1 Gamma Ray Shielding Function

The function of gamma ray shielding is to reduce the dose rate in a given area by absorbing or scattering incident gamma rays. Examples of this technique would be to shield overhead or underfoot piping for particular work locations, providing a shielded safe area for personnel awaiting performance of specific tasks, or raising the water level for reducing the dose rate on the grating over the basin.

3.2.2 Distance Function

The function of distance is to provide dose reduction by either moving sources of radiation away from workers or removing workers from the radiation field. Examples of this technique include removing contamination from within piping by hydrolyzing, removing and replacing piping, removing a layer of contaminated concrete from the pool walls above and below the water line, or providing remote fuel handling apparatus.

3.2.3 Time Function

The function of redesigned tools and equipment shall be speeding up specific operations thereby reducing the time workers spend in the radiation field. Examples of this technique include mocking up or eliminating activities.

3.2.4 Contamination Prevention Function

The function of contamination prevention is to prevent the reestablishment of radioactive sources in decontaminated areas. This would be utilized by covering the concrete with an impermeable coating/covering to prevent radionuclides in the water from diffusing into the concrete.

4.0 REQUIREMENTS

4.1 PROJECT REQUIREMENTS

4.1.1 The dose reduction project shall use the ALARA concept as defined in WHC-CM-4-11: "The goal and objective of the ALARA Program is to minimize human and environmental exposures to radiation and hazardous substances and conditions, commensurate with sound economics and operating practices."

4.1.2 The baseline for developing cost versus occupational dose saved shall be 731 person-rem, based upon best available estimates. Appendix A shows these estimates in spreadsheet format.

Estimated dose for fuel removal is based on conversations with K-Basin operations staff (Hoefer, 1994) and on time motion studies for encapsulation (Vargo, 1994). Primary considerations are that the fuel movement will take roughly 30 minutes per can, decontaminating the transportation cask roughly 60 minutes and health physics activities will take roughly 60 minutes. A conservative estimate is that it will take approximately one shift for each eight or ten canister overpack to be shipped. A contingency not included in this estimate is that other activities will be occurring at the same time, potentially causing slower production than anticipated.

Sludge mitigation estimates are based on unreleased process flow diagrams (McWethy, 1994) for the removal of sludge from the basin area. Contingencies are not included in these estimates, however, the times given for tasks are conservative.

Canister and debris removal estimates are based on a high level process flow diagram (Atchinson, 1994) and conversations with K-Basin engineering project staff (Crystal, 1994). The time for this activity is a best estimate from Scientific Ecology Group's past experience.

4.1.3 The cutoff cost for dose reduction shall be \$30,000 per person-rem dose saved based on the baseline cumulative dose in 4.1.2. This figure encompasses, but is not limited to, Engineering Studies, Design, Procurement, Supporting Documentation, NEPA Documentation, Design Review, Facility Modification, Installation, Operation, and Maintenance.

4.1.4 Dose reduction activities shall be designed to prevent damage to the fuel.

4.1.5 Dose reduction measures shall not exasperate fuel handling, introduce unmarked tripping hazards, degrade crane operability, or degrade access to equipment for maintenance. Review of proposed measures shall be provided by K-Basin Engineering and Industrial Safety.

4.2 ALARA REQUIREMENTS

4.2.1 Mock-ups for high exposure or complex tasks shall be utilized to the greatest extent possible.

4.2.2 Tools and equipment shall be inspected to verify operability, ease of decontamination, and possible waste streams before being brought into Contamination, High Contamination, or Airborne Radioactivity Areas.

4.2.3 Requirements for area cleanup shall be included in the technical work documents. Work Activities shall not be considered complete until support material and equipment have been removed and the area has been returned to at least prework status.

4.2.4 Surfaces of equipment that become contaminated with radioactive isotopes shall be such that they can be decontaminated to the levels in Table 1, unless there is a plan for final disposition of the equipment. This table provides the maximum levels as outlined in WHC-CM-4-11.

Table 1. Contamination Limits for Selected Radionuclides

Nuclide	Removable (dpm/100cm ²)	Total (Fixed+Removable) (dpm/100cm ²)
U-natural, U-235, U-238	1,000 alpha	5000 alpha
TRU's, Ra-226, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20 alpha	500 alpha
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200 alpha	1,000 alpha
Beta-gamma emitters (includes nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90.	1000 beta/gamma	5000 beta/gamma
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols.	10,000	10,000

Values in this table apply to radioactive contamination deposited on, but not incorporated into the interior of the contaminated item.

4.2.5 Processes and activities that have the potential to produce airborne radioactivity shall include engineering controls to limit releases to the environment, the work space or both.

4.2.6 Water and steam shall be considered the primary decontamination agents. Other cleaning agents shall be selected based upon their effectiveness, hazardous properties, amount of waste generated, and ease of disposal.

4.2.7 Equipment that is expected to be contaminated during operation shall have provisions for both in-place maintenance and/or removal to an area with low dose rates for maintenance. Maintenance areas for repair of contaminated equipment shall include provisions for confinement of radioactive materials and contamination.

4.2.8 A waste disposal plan shall be developed for all waste.

4.2.9 All decontamination shall be accomplished in a manner such that the air quality remains below the Derived Air Contamination (DAC) limit for the facility.

4.2.10 Decontamination methods shall be reviewed by Westinghouse Environmental Safety and Health and Washington Department of Health.

4.3 SHIELDING REQUIREMENTS

4.3.1 Any shielding attached to the 105 K-East building structure shall not adversely affect seismic qualifications of the facility.

4.3.2 Shielding shall not obstruct or prevent fuel movement when fuel is actively being moved in the basin.

4.3.3 Shielding shall be considered on a case by case basis depending on work location and amount of time workers will be in the area.

4.3.4 Shielding design shall take into account provisions for handling and ease of installation and removal and undergo structural and safety reviews.

4.3.5 Shielding shall not increase water leaking from the basin to the soil column.

4.3.6 Shielding shall be appropriately evaluated for potential compromise of safety class 1 and 2 structures.

4.4 REMOTE OPERATIONS REQUIREMENTS

4.4.1 Prior to consideration for application in the basin, remote operated equipment shall have proven operability to Facility Systems Engineering and K-Basin Engineering.

4.4.2 Remote operations equipment shall have safety systems to prevent uncontrolled releases and interaction with the fuel.

4.4.3 Any pressurized fluids (hydraulics) shall be such that they do not create mixed waste problems. Water is the preferred pressurized fluid. The use of any other hydraulic fluid shall be specifically reviewed and approved (WHC-CM-4-11).

4.5 CONCRETE DECONTAMINATION REQUIREMENTS

4.5.1 The band of concrete to be decontaminated shall be from 0.45 ± 0.05 meters below the water surface to 0.20 ± 0.05 meters above the water surface. This level provides an 80% reduction in gamma radiation from the concrete at chest level (Vargo, 1994). Superficial cleaning shall be done in the area from the upper decontaminated level to 0.65 ± 0.05 meters above the water line along the basin walls.

4.5.2 The depth of concrete to be removed shall be determined by analyzing a process sample for depth of ^{137}Cs penetration. It is expected that 0.01 ± 0.002 meters will be removed based on samples taken in 1981 (Bechtold, 1981).

4.5.3 Concrete decontamination shall not change the basin water pH to levels outside current limits, 5 to 9 (Emory, 1994).

4.5.4 Decontamination equipment shall leave the basin wall in a condition such that a contamination prevention coating can be applied.

4.5.6 Decontamination equipment shall be designed to direct spoils to preselected areas such as the Weasel Pit, basin floor or a filtering system. Area shall be selected based on its simplicity and regulatory agreement.

4.5.9 Vacuum cleaners and portable air handling equipment used in Contamination, High Contamination, Airborne Radioactivity, Radioactive Material, or Radiological Buffer Areas shall have High-Efficiency Particulate Air (HEPA) filtered exhaust, a prefilter, and an internal catch container if used for dry pickup.

4.5.10 New HEPA-filtered vacuum cleaners shall not be used until they have been tested, inspected, and approved by the U.S. Department of Energy (DOE) Filter Test Station operated by the Hanford Environmental Health Foundation (HEHF).

4.5.11 After initial installation or replacement of the HEPA filters, vacuum cleaners or portable blowers shall be leak tested before their first use and annually thereafter.

4.5.12 HEPA-filtered vacuum cleaners and portable air handling units shall not be purchased without prior review and approval of K-Basins Health Physics.

4.5.13 Airborne radioactivity levels shall be monitored with Continuous Air Monitor alarms (CAM alarms) when a vacuum cleaner is used in a highly contaminated area.

4.5.14 The external dose rate on the filter housing shall be periodically monitored when the vacuum cleaner is used in a highly contaminated area.

4.6 CONCRETE COATING REQUIREMENTS

4.6.1 K-Basin Engineering and Health Physics shall approve the application of fixative coatings for contamination control. Coatings shall have proven industrial applications for the intended use.

4.6.2 Concrete coating shall have properties that allow its periodic cleaning by washing or wiping.

4.6.3 Coating shall be such that it does not become a waste disposal problem itself.

4.6.4 Coating shall have a lifetime of at least 10 years.

4.6.5 Coating shall have properties such that it can be applied under water.

4.6.6 Coating shall be applied from a level 0.45 ± 0.05 meters below the water/air interface to a level 0.20 ± 0.05 meters above the water/air interface if decontamination occurs in the same region. If raising the water level is to be considered a contingency plan, the coating shall be applied to the area from the water line up 0.65 ± 0.05 meters after superficial cleaning.

4.7 PIPING SOURCE MITIGATION REQUIREMENTS

4.7.1 Video inspection and/or nondestructive evaluation techniques shall be employed to detect weak spots in piping if internal decontamination or hydrolyzing is employed.

4.7.2 All piping or equipment removed from service and replaced in the basin shall be removed from the facility as part of the work package.

4.8 WATER SOURCE MITIGATION REQUIREMENTS

4.8.1 ^{137}Cs shall be removed from the basin water by existing ion exchange or by some more effective new technology as a final step in engineered dose reductions. This is to be completed only if it is determined to be cost effective and necessary.

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APPENDIX A

DOSE PREDICTIONS FOR MAJOR TASKS IN 105 K-EAST BASIN

DOSE ESTIMATES FOR SELECTED TASKS AT 105 KE BASIN

Sludge Mitigation						
Activity	Location	Staff size	Dose Rate (mrem/hr)	Time required (hr)	Dose for activity (person-rem)	
Pump sludge	Weasel Pit to Weasel Pit	2	20	67	2.67	
Pump sludge	Basin to Weasel Pit	2	15	2083	62.50	
Pump sludge	Weasel Pit to Canister	2	15	556	16.67	
Pump sludge	Other pits to Weasel Pit	2	20	556	22.22	
Move debris	Weasel Pit	2	20	8	0.33	
Move containers	Weasel Pit	2	20	8	0.33	
Filter operation	Weasel Pit to Elevator Pit	2	20	83	0.33	
Move containers	Weasel Pit	2	20	139	3.33	
Move containers	Loadout Pit	2	20	50	5.56	
Transport Cask	Loadout Pit	2	20	106	2.00	
Cleanup	Weasel Pit	2	20	194	4.22	
Total					128	

Fuel Removal						
Activity	Location	Staff size	Dose Rate (mrem/hr)	Time required (hr)	Dose for activity (person-rem)	
Move Fuel Canisters	Basin	2	15	1222	36.67	
Inspect Fuel/mass balance	Loadout Pit	2	15	306	9.17	
Place canisters in MCO	Loadout Pit	2	15	306	9.17	
Ship MCO (10 canisters/MCO)	Loadout Pit	2	15	461	13.83	
Total					69	

Day to Day operations						
Hours/year in basin	Years to exit basin	Dose (mrem/hr)	Dose (person-rem)		Dose (person-rem)	
1666	8	12	160		160	
Total					160	

Estimated that 80% of occupational dose comes from cesium contamination in the concrete along basin walls

Debris Removal						
Activity	Location	Staff size	Dose Rate (mrem/hr)	Time required (hr)	Dose for activity (person-rem)	
Debris from Basin to Pit	Basin	2	15	2500	75.00	
Debris to Burial Box	Pit	2	12	12500	300.00	
Total					375	

Dose calculations with dose reduction (person-rem)						
	No reductions	Shield pipe TVP	Clean and Coat	Raise Water	Hang shielding	
K-East Basin Total	731	690	515	493	495	
Implementation Dose	0	4	6	12	81	
Net Dose Saved	0	37	210	226	155	