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7. Abstract

This document provides a preliminary evaluation of the feasibility of the project W-059 conceptual design from a safety aspect. A preliminary list of safety related equipment is included.

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1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

Project W-059 will isolate existing High Efficiency Particulate Air (HEPA) filters from the B Plant canyon exhaust system. These filters contain an estimated 750,000 Curies of radioactive Cesium (Cs^{137}) and Strontium (Sr^{90}) which, if released to the environment, could cause measurable off-site doses as well as unacceptable doses to workers.

In order to isolate the existing HEPA filters, barriers will be installed in the ductwork upstream and downstream of the filters. An Air Cleanup Train (ACT) with maintainable filters will be provided to maintain exhaust ventilation service for the B Plant canyon and cells. Figure 1 shows a plan of the existing filters and a conceptual layout of the isolation barriers and ACT.

The project will be part of a larger effort to prepare B Plant for deactivation. A Cleanout and Stabilization Plan (CSP) will provide the overall direction to inactivate operational systems, disposition hazardous and radioactive materials, and configure the plant for a long-term unmanned Surveillance and Maintenance (S&M) mode pending final disposition. Completion of Project W-059 will be required at the end of CSP execution. The new ACT will support the deactivated plant with reduced hazards and airflow requirements.

1.2 Summary

This document represents a Preliminary Safety Evaluation (PSE) of activities associated with Project W-059. The purpose of the evaluation is to support development of the Engineer/Constructor Management Plan (ECMP), Reference 12, by identifying the major risks associated with the plant modifications and construction; performing a preliminary evaluation of risks not already analyzed; and developing a preliminary listing of safety related equipment.

Most of the accident analysis required for the modified plant will be provided by the B Plant Interim Safety Basis (ISB), Reference 9. This PSE identifies requirements for further analysis.

This evaluation concludes that the risks associated with project construction and subsequent operation are acceptable. Equipment necessary to mitigate unacceptable consequences of a postulated accident scenario is listed in the Preliminary Safety Equipment List (PSEL) at Appendix A.

1.3 Facility Categorization

B Plant is currently a Hazard Category 2 facility per DOE-STD-1027-92 (Reference 2), based upon various hazardous and radioactive materials present in the canyon, cells, and canyon exhaust filters. The hazardous materials consist primarily of organic solvents used in previous chemical processes within the plant. The primary radioactive isotopes of concern are Cs^{137} and Sr^{90} present as solute inside process tanks, as contamination on process equipment, and on the building structure itself.

1.0 INTRODUCTION AND SUMMARY (continued)

1.3 Facility Categorization (continued)

During execution of the CSP, the hazardous materials will be removed, along with much of the radioactive inventory. Nevertheless, the facility is expected to remain Hazard Category 2, due to residual radioactive contamination in the canyon and process cells and the large quantities of radionuclides present in the existing canyon exhaust filters.

2.0 DESIGN CRITERIA

2.1 Project Scope

The primary elements of Project W-059 are:

- Isolate existing HEPA filters by installing physical barriers,
- Provide replacement ACT with associated instrumentation and ductwork.

The design will meet the requirements set forth in the Project W-059 Functional Design Criteria (FDC), WHC-SD-W059-FDC-002 (Reference 10). The significant design criteria associated with safety are outlined below.

2.2 Isolate Retired Filters

Physical barriers will be installed to block the air duct upstream and downstream of the existing canyon exhaust filters. The barrier installed upstream of the existing filters will separate the existing filters from the canyon exhaust system; the downstream barrier will isolate the filters from the atmosphere. Both barriers will prevent a release of radioactive materials contained in the existing filters in the event of a Design Basis Accident (DBA), per DOE Standard 6430.1A, General Design Criteria (Reference 1).

Once the barriers are installed, the final disposition of the existing filters may be accomplished at a different time than that of the rest of the plant. The downstream barriers will be Safety Class 2 because they will isolate the existing filters directly from the atmosphere. The upstream barrier also will be designed to Safety Class 2 requirements (see Sections 2.4 and 4.2), allowing it to act as the confinement boundary for the retired filters if the canyon facility is remediated first; or conversely, for the canyon facility if the filters are remediated.

A secondary purpose of the upstream barrier will be to prevent the migration of radionuclides from the existing HEPA filters to the new ACT, thereby limiting contamination inside the new duct and prolonging the service life of the new filter elements. A small bypass will be installed around the upstream isolation barrier to maintain a slight vacuum in the retired filters; however, the bypass air flow rate will be low enough to prevent any substantial transport of dust from the old filters to the new ones.

2.0 DESIGN CRITERIA (continued)

2.2 Isolate Retired Filters (continued)

The requirements for vacuum pressure in the retired filters and bypass airflow will be determined by an engineering study to be performed prior to detailed design. The size and configuration of the bypass will be determined during definitive design. The Preliminary Safety Analysis Report (PSAR) will consider the potential transport of radionuclides from the retired filters to the new ACT during normal and upset conditions.

Both isolation barriers will be designed to maintain confinement when subjected to loads specified in Standard Design Criteria (SDC) 4.1, Design Loads for Facilities (Reference 13), including a Design Basis Earthquake (DBE) for Safety Class 2 components.

2.3 Replacement Filter System

The new ACT will include two or more separate housings with maintainable filters. The filters will be connected to the canyon exhaust duct and to the existing fans using an above-ground metal duct. Valves or dampers will be installed to allow isolation of each new filter train during maintenance. An electric heater will be provided upstream of the filter elements to prevent condensation inside the ACT. Instrumentation and controls will be installed as necessary to monitor the new ACT via the B Plant Facility Process Monitoring and Control System (FPMCS).

The confinement function provided by the new filter systems and associated ductwork will be Safety Class 2 (see Sections 2.4 and 4.2). Ductwork downstream of the ACTs will be Safety Class 3 (see Sections 2.4 and 4.2). The new ACT will be designed, analyzed, and constructed in accordance with: SDC 4.1, ASME N509 (Reference 3), WHC-SD-GN-DGS-30011 (Reference 12), and DOE Order 6430.1A. Testing will be performed per ASME N510 (Reference 4) and DOE Order 6430.1A, Section 1550.2.5.5.

Instrumentation and electrical equipment, which serves to limit the spread of contamination or otherwise promote safety, will be designed to meet requirements of DOE Order 6430.1A for Safety Class 3 equipment (see Sections 2.4 and 4.2).

2.4 Preliminary Safety Class Equipment Designation

The confinement function provided by the isolation barriers, duct, and ACT are assigned a preliminary Safety Class 2. This classification is based upon the potential for ground release of radionuclides in the event of a seismic event, which could shake dust from the retired filters or from the canyon building structure. This is consistent with the results of the B Plant ISB.

The Safety Class 2 designation applies to features necessary to maintain confinement. The confinement function is passive, as it is provided by the physical integrity of the duct boundary, isolation barriers, and final filters. No active components such as power, fans, or instrumentation are required to mitigate a release in case of a DBA.

2.0 DESIGN CRITERIA (continued)

2.4 Preliminary Safety Class Equipment Designation (continued)

The exhaust fans and some of the instrumentation will serve to minimize the risk of other accidents with lesser consequences, such as a minor spread of contamination. Those items are assigned a preliminary Safety Class 3.

Appendix A provides a Preliminary Safety Equipment List (PSEL).

3.0 HAZARDOUS INVENTORIES

3.1 Hazardous Inventories

During CSP, all hazardous materials, except metallic lead, will be removed from the B Plant canyon facility and retired HEPA filters. Lead in various forms has been used in the plant for radiation shielding. Lead, which is in the canyon or other areas from which removal and decontamination would be difficult, may be left inside the facility. Its location will be recorded for eventual D&D. Any lead left in the facility will be in solid form and will be situated where it will remain dry, thus posing no risk of air or water contamination.

3.2 Radioactive Inventories

According to the B Plant ISB, the existing HEPA filters contain an estimated 750,000 curies of radioactive Cesium (Cs^{137}) and Strontium (Sr^{90}). The B Plant canyon and cells contain an estimated 1 million curies of residual contamination in the structure itself. Various process equipment will be left in the cells which will add an estimated 1 million curies.

The new filters will contain only very limited quantities of radionuclides. The filter elements will be cleaned or replaced before radiation levels build to a point which would prevent contact maintenance. Because of the high energy decay characteristics of the primary contaminants, Cs^{137} and Sr^{90}, the requirement for contact maintenance will limit the source term on the filters to an amount which would have little consequence in terms of on or off-site doses to personnel in the event of a release.

4.0 ACCIDENT EVALUATION

4.1 Summary

The proposed modifications will not create unacceptable risks. Some of the systems and components within the project scope will, however, be required to mitigate the unacceptable consequences of postulated accidents; those items are listed as Safety Class 2 in the PSEL, Appendix A. Items, which have an impact on safety or environmental protection, but are not requred to mitigate unacceptable consequences are listed as Safety Class 3.

4.0 ACCIDENT EVALUATION (continued)

4.1 Summary (continued)

The B Plant Safety Analysis Report (SAR) was prepared based upon an operating plant. An Interim Safety Basis (ISB) has been drafted to reflect facility modifications, the absence of processing operations, and to improve accident analyses. The ISB addresses various postulated accidents involving natural phenomena and system failures. Several of those hazards will not apply to the plant at the end of CSP. The Design Basis Accident (DBA) will still be a seismic event.

Because this project will involve construction activities and further modifications to the plant, a Preliminary Hazard Analysis (PHA) was developed (Appendix B). The hazards not addressed within the ISB are those associated with the project construction and the potential buildup of heat, pressure, or radiolytic hydrogen in the isolated HEPA filters.

4.2 Earthquake

This is the Design Basis Accident (DBA) which governs the safety classification of the confinement provided by the B Plant structure, the exhaust system, and the retired HEPA filter cells. The B Plant Interim Safety Basis (ISB) includes an analysis of this accident, with results summarized in Sections 2.1.1.1.1 and 2.1.1.1.2.

The existing HEPA filters may have deteriorated due to long-term exposure to radiation and chemicals. It is conceivable that the dust which has accumulated in the filters could be released through the inlet or outlet end of the filters when shaken by an earthquake.

The residual radioactive contamination in the B Plant canyon, cells, and on the equipment is less likely to become airborne. Much of the loose dust has been cleaned from surfaces in the canyon and any process equipment left in the cells will have been cleaned to some degree. The release fraction used in the ISB accident analysis to calculate potential releases from the canyon and cells is, therefore, lower than that used for the existing filters.

The worst case accident would involve a seismic event which could collapse part of the canyon roof or some structure inside a retired HEPA filter. Without containment to mitigate the contamination spread, the total estimated doses (EDE) to personnel would be:

Contamination Source	Off-Site Dose (rem)	On-Site Dose (rem)
Canyon/Cells	0.018	45
Retired Filters	0.07	166
Total	0.088	211

4.0 ACCIDENT EVALUATION (continued)

4.2 Earthquake (continued)

In each case, the estimated off-site dose would be below the 0.5 rem threshold for Safety Class 1, but the on-site dose would be above the 5 rem threshold for Safety Class 2. Consequently, the confinement provided by the new filters, air duct, and isolation barriers are designated Safety Class 2.

Only the physical confinement boundary provided by the duct, ACT and filters is necessary to prevent an unacceptable release. The duct downstream of the ACT, the fans, instruments and fans do not serve to prevent such a release, although they may serve to limit the spread of contamination.

A small bypass line will connect the retired filters to the new ACT. This line will form a constriction which tends to inhibit any release from the retired filters to the new ACT in the event of an accident. However, even considering the combined release potentials from the new ACT and the canyon facility, with no credit for any reduction in release fraction, the confinement function is not increased to Safety Class 1.

4.3 Fire

If a fire were to burn in the canyon, cells, or retired HEPA filters, it could cause a significant release of radionuclides. However, combustible materials will be removed from Building 221B during CSP. Electric power to the building will be shut off. The retired HEPA filters are constructed of fire retardant materials, and there is no source of combustion inside the filters. Consequently, fire is not a credible accident for either the canyon facility or the retired HEPA filters.

The probability and consequences of a fire in the new ACTs are low as well. The ACTs will be constructed using fire retardant materials, and the electric heating element will be installed on the outside of the duct. The accumulation of radionuclides on the new filters will be limited by filter cleaning or change-out to allow contact handling. Therefore, in the unlikely event of a fire in one of the new filter housings, there would be no appreciable dose to on-site or off-site personnel.

4.4 Buildup of Hydrogen, Heat, or Pressure in Retired Filters

The radioactive decay of materials present in the retired HEPA filters will generate heat which could vaporize water present in the filter cells; the radiation may also generate a small amount of hydrogen from water inside the filter cells. While the magnitude of these risks may be small, the project design will mitigate those risks by venting the retired filters to the new filter system. The size and configuration of the bypass will be determined as stated in Section 2.2.

4.0 ACCIDENT EVALUATION (continued)

4.4 Buildup of Hydrogen, Heat, or Pressure in Retired Filters (continued)

The total heat generated inside the retired filters is calculated to be less than 4 kW. Preliminary calculations presented in Appendix D indicate that the maximum temperature expected at the face of a retired filter will be less than 92°C, (197°F). Temperatures in this range would not create any hazard of autoignition.

Water vaporization inside the retired filters will be very small. The maximum production rate of water vapor due to a 4 kW heat source would be approximately:

(4 kJ/sec) (1668 l/kg) / (2315.8 kJ/kg) = 2.88 l/s (6 cfm).

The hydrogen production rate would depend upon the collection of water in the retired filters, the physical distribution of radioactive material, and the impurities present in the water. Based upon information presented in Nuclear Engineering Handbook (Etherington), Table 1, page 10-133, (Reference 14), a 10^9 rad dose to relatively pure water produced no net radiolytic decomposition of water. This dose would correspond to 1.75×10^6 Curies of Cs^{137}, well over twice the largest estimate for total radionuclide loading in the existing filter cells. Therefore, hydrogen generation is expected to be negligible.

A small bypass will be provided around the upstream isolation barrier in order to draw a slight vacuum pressure, inducing an inward airflow through any leaks in the filter housing, and removing any hydrogen or water vapor as it is produced. The pressure and airflow requirements will be determined by an engineering study prior to detailed design; the bypass size and configuration will be part of the detailed design.

4.5 Electric Power Failure

In the event of an overall power failure, the electric fans and the instrumentation would be lost. As a result, the differential pressures normally maintained in the canyon, cells, duct, and retired HEPA filter cells would be lost. In the absence of any other accident, such as earthquake, there would be no motive force to cause an unacceptable release of radioactive materials. Stack monitoring capability would be lost, but there would be no airflow out the stack.

The B Plant ISB analysis considers the risk of hydrogen buildup in the canyon/cells due to the presence of radioactive materials mixed with organic chemicals; however, those chemicals will be removed from the plant before this project is constructed.

Electric power failure would not create an unacceptable hazard, because of the passive confinement function provided by the duct, ACT housing, and filters. Consequently, there will be no Safety Class 1 or 2, nor will there be any redundancy requirements for electrical power, equipment, or instruments.

4.0 ACCIDENT EVALUATION (continued)

4.6 Redundancy

There are no active components (fans, instruments, etc.) whose failure would have unacceptable consequences. The new isolation barriers, duct, and ACTs are passive components which will be designed, analyzed, and constructed to maintain confinement through an earthquake (per SDC 4.1). Because a seismic event is the only postulated accident which could result in unacceptable doses, the equipment satisfies the "Single Failure" criteria given in Appendix A of WHC-CM-1-3, MRP 5.46, Safety Classification of Systems, Components, and Structures. Redundant systems are not required.

5.0 CONSTRUCTION RISKS

5.1 Summary

The most substantial construction task in this project is to install isolation barriers in the existing concrete duct. This is also the activity which poses the greatest risk of worker dose or contamination release. The duct interior surface upstream of the existing filters bears heavy radionuclide contamination, creating a high radiation field inside the duct. Breaching this duct will create a potential for high radiation doses to workers, as well as a pathway for releasing radioactive contamination from B Plant or the retired HEPA filters to the atmosphere. Construction planning must provide for assurance against the radiation doses to workers and contamination release.

Other construction activities include: cutting and welding; entering confined spaces; excavation of contaminated soil; running conduit; placing concrete; installing air duct and ACT; installing and testing instrumentation and controls. These tasks will involve construction methods which are in common use on the Hanford site. Assuming normal precautions will be used, the construction risks associated with those other tasks are considered to be acceptable.

5.2 Worker Dose While Installing Duct Isolation

The greatest potential for worker dose will exist when the underground duct is opened to install the upstream isolation barrier. This will be accomplished by removing the top and cutting the bottom from an existing manhole located on the duct roof between B Plant and the existing filters. There will also be a potential for moderate dose rates in the vicinity of the duct once the manhole is opened.

Opening the manhole and breaching the duct will be accomplished using remote handling. The duct penetration will be cut using a hole saw, which will be set up outside the manhole and lifted into place with a crane. The isolation barriers will be prefabricated and lifted into place.

5.0 CONSTRUCTION RISKS (continued)

5.3 Release of Radionuclides While Duct is Breached

When the duct is breached, a temporary containment will be provided to prevent contamination spread. As a further assurance, the canyon exhaust ventilation system may be run at a low flow rate, or an exhauster may be provided to maintain a pressure differential across the duct breach, preventing the escape of contaminants. If necessary, the inventories of the existing filter cells B, C, D and E may be temporarily isolated by filling the inlet and outlet water seals during construction.

Under normal conditions, there is no motive force to cause a release of radionuclides while the duct is breached. An earthquake or a fire could provide the energy for a release, but the risk of either accident during the installation of the isolation barriers is very low. The period of time when the duct will be breached is on the order of one week. From SDC 4.1, the probability of a Safety Class 2 Design Basis Earthquake (DBE) is 10^{-3}/yr, or about 2 x 10^{-5}/week.

A fire in the canyon or cells is considered not to be credible. Although it is conceivable that a spark could be created while cutting into the existing duct, the cutting will be conducted using water as a cutting fluid. Further, the location of the cutting will be approximately 100 ft from the nearest existing HEPA filter, and any air flowing toward the filters will have little or no velocity. The existing filters each have fire screens installed upstream. Further, the air can only flow through D or E (most distant) filters, because flow through the other filters is blocked by outlet water seals. Consequently, it is not credible to postulate a fire in the existing filters during construction.

6.0 SAFETY DOCUMENTATION

Safety documentation for the project parallels the corresponding documentation for the overall plant. Preliminary safety documentation for this project focuses primarily upon demonstrating feasibility of the conceptual plan and predicting safety classes for equipment and structures within the scope of the project.

The final documents must be coordinated with the corresponding safety analyses for the overall plant. Before this project reaches the construction phase, the safety documents for B Plant must be revised to reflect the expected plant configuration at the time of construction.

Project safety documentation prepared in conjunction with the ECMP includes:

- Preliminary Safety Evaluation (PSE) (this document)
- Preliminary Fire Hazard Analysis (Reference 11)

6.0 SAFETY DOCUMENTATION (continued)

Corresponding safety documentation for the overall plant includes:

- B Plant Safety Analysis Report (SAR) (Reference 8) - based upon an operating B Plant, this document is being updated via the ISB.
- Interim Safety Basis (ISB) (Reference 9) - documentation being prepared to update the B Plant SAR based upon current conditions.
- Fire Hazard Analysis (FHA) - B Plant does not have an FHA. The FHA will be prepared later in FY1995.

Before the project is completed, final safety documentation will be required. Preparation of the project SAR and FHA should be coordinated with an update of the corresponding plant documents to prepare for unmanned S&M mode.

7.0 PROJECT INTERFACES

This project is a part of the overall process to deactivate B Plant. Directed primarily by the B Plant Cleanout and Stabilization Plan (CSP), the process includes other activities, such as: removing solvents and combustibles from the building; inactivating utilities; and sealing the structure against storm water leakage. Essentially all of these related activities will be accomplished before this project is completed.

The conceptual design for this project is based upon the expected plant configuration at the end of CSP. Design capacities, fire protection requirements, equipment safety classification, and redundancy requirements must all be integrated with overall plant requirements.

Final project documentation must be validated with respect to actual plant conditions. Project safety documentation will be coordinated with corresponding plant documentation as identified in paragraph 6.0, Safety Documentation above.

8.0 ITEMS REQUIRING FURTHER RESOLUTION

- Anticipated dose rates during construction of the upstream isolation barrier/tie-in.
- Investigation to determine extent of soil contamination.
- Airflow and differential pressure requirement for retired HEPA filter cells.
- Desirablilty of isolating retired filters during isolation barrier installation by filling inlet water seals.

9.0 REFERENCES:

1. DOE-STD-6430.1A, General Design Criteria

2. DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, December 1992

3. ASME N509-1989, Nuclear Power Plant Air Cleaning Units and Components

4. ASME N510-1989, Testing of Nuclear Air Treatment Systems

5. WHC-CM-1-3, Management Requirements and Procedures, MRP 5.46, Safety Classification of Systems, Components, and Structures.

6. WHC-CM-4-46, Safety Analysis Manual

7. WHC-SD-GN-DGS-30011, Radiological Design Guide, R. A. Evans, Sept 27, 1994.

8. WHC-SD-WM-SAR-013, B Plant Safety Analysis Report (SAR)

9. WHC-SD-WM-SARR-030, B Plant Interim Safety Basis Accident Analysis (DRAFT)

10. WHC-SD-W059-FDC-002, Rev 0, Project W-059 Functional Design Criteria

11. WHC-SD-W059-FHA-001, Rev 0, Preliminary Fire Hazards Analysis for W-059, B Plant Canyon Ventilation Upgrade

12. WHC-SD-W059-DR-001, Rev 0, Engineer Constructor Management Plan, Project W-059, B Plant Ventilation Upgrade

13. Hanford Plant Standards, SDC 4.1, Design Criteria - Design Loads for Facilities

14. Nuclear Engineering Handbook, First Ed., H. Etherington, McGraw-Hill, 1958.

APPENDIX A

PRELIMINARY SAFETY EQUIPMENT LIST

The confinement boundary for the B Plant canyon and cells, and for the retired HEPA filters, is generally classified as Safety Class 2. The safety class feature of the Safety Class 2 equipment is integrity against the leakage of unfiltered air. Safety Class 2 equipment includes:

- Final filters in the new Air Cleanup Train (ACT)
- Final filter mounting framework
- ACT housing upstream of the final filters
- Air duct upstream of the new ACT
- Valves and other fittings installed in the duct or ACT housing upstream of the final filters (physical integrity).
- Barriers installed to isolate the retired HEPA filters, both upstream and downstream.

Instrumentation and other equipment which provides monitoring and control of the ACT, exhaust fans, and stack are considered to be Safety Class 3. Safety Class 3 equipment includes:

- Instrumentation installed to monitor air temperatures, differential pressures, radiation, or stack emissions.
- Instrumentation to monitor liquid levels in the ACT.
- Devices which control canyon/cell exhaust airflow, such as valves and dampers.
- Heating elements and controls associated with the airstream upstream of the final filters.
- Exhaust fans downstream of the ACT.

APPENDIX B

PRELIMINARY HAZARDS ANALYSIS

PROJECT W-059
PRELIMINARY HAZARD ANALYSIS

HAZARD/ENERGY SOURCE	POTENTIAL ACCIDENT AND SEQUENCE	TARGET/ POTENTIAL CONSEQUENCES	MITIGATING BARRIERS	
			ENGINEERED	ADMINISTRATIVE
Mechanical	Vibration or wind during construction disturbs loose particles on filter. Cell open.	Some leakage of radioactive contamination at ground level.	1) Engineered connections to maintain confinement. 2) Use of greenhouses during construction. 3) Isolation of inlet duct connection during tie-in.	1) Construction phasing to tie in new filter system prior to final isolation of old filters. 2) Sequence tie to keep negative pressure on tie-in 3) Use tie-in concept generated in CDR.
Fire-welding	Sparks travel to filters; may not have fire detection.	Potential ground release.		1) Develop work procedures to prevent sparks from traveling into filters, e.g., shut off stack exhaust fans during tie-in. 2) Welder will provide fire detection / prevention with a permit.
Tie-in of New Filters (NB)	Potential for fire.	Ground release of contamination / radiation.	Sparks not likely during wet cutting operations.	1)Develop work procedures to prevent sparks from traveling into filters, e.g., shut off stack exhaust fans during tie-in. 2) Welder will provide fire detection / prevention with a permit.

HAZARD/ENERGY SOURCE	POTENTIAL ACCIDENT AND SEQUENCE	TARGET/ POTENTIAL CONSEQUENCES	MITIGATING BARRIERS	
			ENGINEERED	ADMINISTRATIVE
Flooding	1) Sources of water from construction activities. 2) Sources of water from water seals.	1) Wet filters 2) Water goes to plant.	1) Handle with low level waste system or local means. 2) E Filter expected to be on-line; will not flood until A, B, C, and D Filters flood. Filter will not be re-used so wetting is of no consequence.	Procedural. Procedure to be prepared during design and construction planning.
Flow Change	Change in flow picks up debris in "dead" spots.	Release of contamination.	New filters on-line prevent high release.	Change filters after startup.

HAZARD/ENERGY SOURCE	POTENTIAL ACCIDENT AND SEQUENCE	TARGET/ POTENTIAL CONSEQUENCES	MITIGATING BARRIERS	
			ENGINEERED	ADMINISTRATIVE
FOLLOWING PROJECT COMPLETION				
High Winds	Loss of facility electrical power and/or structural damage.	Will not impact isolated filters.	New ACT designed to withstand wind load.	
Flooding of Retired Filters	Water release and hydrogen generation.	Fire/explosion potential.	1) Hydrogen generation rate minimal. 2) Provide vent from retired filters to new ACT.	
Vehicle Accident	Vehicle impacts			
A. New ACT	filter housing, breaches confinement.	1) Mechanical impact covers release of radioactive material. 2) Vehicle fire starts fire in HEPA filters.	1) No vehicle traffic near ACT 2) Install traffic barriers. 3) Very low accumulation of radioactive material on filters at any given time.	
B. Isolated Filter		Incredible.		
C. Sand Filter		See 2.2.2.1 in ISB		
Fire/Explosion	Heat up due to radioactive decay. 500-4000 watts D filter.	Fire at ground level or release to stack.	1) Maximum expected filter temperature <92°C (197°F), well below autoignition temperature. 2) Limited oxygen for burning.	Analyze.

APPENDIX C

ENVIRONMENTAL IMPACT WORKSHEET

ADVERSE ENVIRONMENTAL IMPACT FROM RADIOACTIVE MATERIALS SAFETY CLASSIFICATION METHODOLOGY
(sheet 1 of 4)

1. MATERIAL FORM

Is the radioactive material dispersible (i.e., other than a consolidated or stabilized solid)? Dispersible materials include liquids, sludges, gases, powders and unconsolidated solids.

☐ No - Do not proceed further. The associated systems, components and structures are safety class 3, other criteria permitting.

☒ Yes - Proceed.

2. QUANTITY AND HALF-LIFE CONSIDERATIONS

The following matrix provides multiplying factors which are a function of the total estimated curie content postulated to be released to the environment from the system(s), component(s), and/or structure(s) of interest. These multiplying factors also consider the half-life of the radioisotopes that are present.

	Half-life		
Amount (Ci)	<1 yr.[1]	1-100 yrs.	>100 yrs.
< 1	1	10	100
1 - 1000	10	100	1000
1000 - 10^5	100	1000	10,000
> 10^5	1000	[✓ 10,000]	100,000

SUM of 2. multiplying factors = 10,000

Cs^{137}, Sr^{90} (~30 yr)

---

[1] Tritium is included in this category as an exception.

ADVERSE ENVIRONMENTAL IMPACT FROM RADIOACTIVE MATERIALS SAFETY CLASSIFICATION METHODOLOGY

(sheet 2 of 4)

3. TOTAL QUANTITY OF RADIOACTIVE MATERIAL RELEASED[2]

Quantity	Multiplying Factor
[✓ < 100 gal., 380 L, 840 lbs.[3]]	[✓ 1]
100 - 1,000 gal., etc.	5
1,000 - 10,000 gal., etc.	10
≥ 10,000 gal., etc.	100

3. multiplying factor = 1

4. PROXIMITY TO ENVIRONMENTAL RECEIVERS

a. Depth to Aquifer (feet) — Multiplying Factor

Depth to Aquifer (feet)	Multiplying Factor	
[✓ 1. > 150]	[✓ 1]	295'
2. 76 - 150	2	
3. 21 - 75	5	
4. 0 - 20	10	

4.a multiplying factor = 1

b. Distance to Sensitive Surface Water (feet)[4] Multiplying Factor

Distance to Sensitive Surface Water (feet)[4]	Multiplying Factor	
[✓ 1. > 2500]	[✓ N/A]	6 mi
2. > 1000 - 2500	9	
3. > 500 - 1000	16	
4. 100 - 500	20	
5. < 100	25	
6. Direct discharge to surface water	50	

4.b multiplying factor = 1

---

[2] The total quantity of radioactive material postulated to be released to the environment.

[3] Specific gravity of 1 at 4° C and atm. pressure.

[4] Airborne pathways do not apply for this sensitive surface water or offsite boundary criteria (refer to Table 1, criterion 1.d). Example sensitive surface waters are the Columbia River and West Lake.

ADVERSE ENVIRONMENTAL IMPACT FROM RADIOACTIVE MATERIALS SAFETY CLASSIFICATION METHODOLOGY

(sheet 3 of 4)

c. Distance to Offsite Boundary (feet)[4]	Multiplying Factor
1. > 2500	N/A
2. 1000 - 2500	5
3. < 1000	10

4.c multiplying factor = N/A

5. CALCULATION OF ENVIRONMENTAL IMPACT FOR SAFETY CLASSIFICATION

The environmental hazard safety classification (EHSC) is determined as follows where each term is the multiplying factor from the respective paragraphs above.

EHSC = (2.)(3.)(4.a*)(4.b*)(4.c*)

EHSC = $(10^5)(1)(1)(1)(1)$ = 10,000

"*" - Term is applied where legitimate pathways to the environmental receivers exist.

EHSC ≥ 1,000,000 = safety class 1

EHSC < 1,000,000 and ≥ 500,000 = safety class 2

[✓ EHSC < 500,000 = safety class 3]

NOTES:

1. A radioactive material in liquid form is considered to impact sensitive surface waters only when real pathways to those surface waters exist, e.g., through runoff based on the local topography. Legitimate pathways, including close proximity, must also be present to consider the offsite boundary criteria for radioactive material in liquid form.

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[4] Airborne pathways do not apply for this sensitive surface water or offsite boundary criteria (refer to Table 1, criterion 1.d). Example sensitive surface waters are the Columbia River and West Lake.

ADVERSE ENVIRONMENTAL IMPACT FROM RADIOACTIVE MATERIALS SAFETY CLASSIFICATION METHODOLOGY

(sheet 4 of 4)

2. In the process of determining potential radioactive material pathways to the environment and the quantity and nature of the release (the source term), consideration should be given to the material's physical and chemical characteristics. Examples include:
   - Operating pressure at the point of initial release.
   - Operating temperature at the point of initial release.
   - Boiling point.
   - Autoignition temperature.
   - Detonation capability when exposed to air (under confined and unconfined conditions).
   - Flashpoint when a fire may exist as part of a postulated accident scenario.
3. The physical characteristics of radioactive sludges, powders and unconsolidated solids should be evaluated in terms of dispersibility and legitimate pathways to potential receivers, i.e., aquifers, sensitive surface waters or the offsite environment.
4. Applicable administrative controls (e.g., mass balance checks during transfers) and leak detection should be considered in the process of determining the amount of radioactive material postulated to be released to the environment (release fraction), e.g., due to failures in waste transfer systems between tank farms and processing facilities and due to tank leakage. The accuracy of administrative controls, such as mass balance checks, should also be taken into account when determining the source term.
5. Should the above safety classification methodology provide a result that does not intuitively make sense, modelling and further evaluation may be required to make a more appropriate determination.

APPENDIX D

DECAY HEAT/TEMPERATURE CALCULATIONS

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page 1

B Plant Filter Room Temperatures

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Safety Analysis and Engineering

CHECKED: P.E. Roege 3/6
B PLANT DESIGN ENGRG

WHC-SD-WM-PHA-008 Rev 0

$$\text{heat loads} \begin{bmatrix} A \\ B \\ C \\ D \\ E \end{bmatrix} \quad Cs := \begin{bmatrix} 18 \\ 43 \\ 25 \\ 550 \\ 0 \end{bmatrix} \cdot 10^{3} \cdot Ci \quad Sr := \begin{bmatrix} 12 \\ 29 \\ 16 \\ 50 \\ 0 \end{bmatrix} \cdot 10^{3} \cdot Ci$$

$kPa \equiv 10^{3} \cdot Pa$

$F \equiv 1 \cdot R$

$Ci \equiv 1$

$mwatt \equiv 10^{-3} \cdot watt$

Heat load by filter

$$Q := Cs \cdot \left(4.72 \cdot 10^{-3} \cdot \frac{watt}{Ci}\right) + Sr \cdot \left(6.69 \cdot 10^{-3} \cdot \frac{watt}{Ci}\right)$$

WHC-EP-0063-4
Cs Power factor

WHC-EP-0063-4
Sr Power factor

$$\begin{bmatrix} A \\ B \\ C \\ D \\ E \end{bmatrix} \quad Q = \begin{bmatrix} 0.165 \\ 0.397 \\ 0.225 \\ 2.931 \\ 0 \end{bmatrix} \cdot kW$$

D filter Room Dimensions

surface area $length := (3 \cdot ft + 6 \cdot in) + (6 \cdot ft + 10 \cdot in) + (7 \cdot ft + 0 \cdot in) + (4 \cdot ft + 4 \cdot in) + (4 \cdot ft + 4 \cdot in)$

$width := 25 \cdot ft \qquad top := width \cdot length \qquad top = 650 \cdot ft^{2}$

$height := 19 \cdot ft + 8 \cdot in \qquad side := length \cdot height \qquad side = 511.333 \cdot ft^{2}$

thermal resistance

Material constants

moist sand
$$k_1 := 0.6 \cdot \frac{BTU}{ft \cdot F \cdot hr}$$

concrete
$$k_2 := 0.6 \cdot \frac{BTU}{ft \cdot F \cdot hr}$$

for airflow from filter surface
$$h_3 := 1.65 \cdot \frac{BTU}{ft^{2} \cdot F \cdot hr}$$

for airflow from enclosed surface
$$h_4 := 1.65 \cdot \frac{BTU}{ft^{2} \cdot F \cdot hr}$$

for airflow from soil surface
$$h_5 := 6 \cdot \frac{BTU}{ft^{2} \cdot F \cdot hr}$$

Conductance

Out the top of the room.
3 feet of sand
1 foot of concrete
filter surface
top of room
soil surface

$$U_{top} := \left(\frac{3 \cdot ft}{k_1} + \frac{1 \cdot ft}{k_2} + \frac{1}{h_3} + \frac{1}{h_4} + \frac{1}{h_5}\right)^{-1} \qquad U_{top} = 0.706 \cdot \frac{watt}{m^{2} \cdot K}$$

Between rooms.
13 feet of sand
2 foot of concrete
filter surface
2 walls

$$U_{side} := \left(\frac{13 \cdot ft}{k_1} + \frac{2 \cdot ft}{k_2} + \frac{1}{h_3} + \frac{2}{h_4}\right)^{-1} \qquad U_{side} = 0.212 \cdot \frac{watt}{m^{2} \cdot K}$$

Product of conductance and area

$$u_1 := top \cdot U_{top} \cdot \frac{K}{watt} \qquad u_1 = 42.619 \qquad u_2 := side \cdot U_{side} \cdot \frac{K}{watt} \qquad u_2 = 10.058$$

Simplified network of heat flow paths all rooms are connected to adjacent rooms through 2 feet of concrete and 13 feet of soil and connected to the surface through 3 feet of soil and 1 foot of concrete.

$$A := \begin{bmatrix} u_1 + u_2 & -u_2 & 0 & 0 & 0 \\ -u_2 & u_1 + 2\cdot u_2 & -u_2 & 0 & 0 \\ 0 & -u_2 & u_1 + 2\cdot u_2 & -u_2 & 0 \\ 0 & 0 & -u_2 & u_1 + 2\cdot u_2 & -u_2 \\ 0 & 0 & 0 & -u_2 & u_1 + u_2 \end{bmatrix} \cdot \frac{\text{watt}}{K} \qquad \Delta T := A^{-1}\cdot Q \qquad \Delta T = \begin{bmatrix} 8.8 \\ 16.6 \\ 23.7 \\ 90.5 \\ 17.3 \end{bmatrix} \cdot F$$

Check on the effect of conduction to the adjacent room, temperature calculated for with no heat transfer between cells.

$$\delta T := \frac{Q}{U_{top}\cdot top} \qquad \delta T = \begin{bmatrix} 7 \\ 16.8 \\ 9.5 \\ 123.8 \\ 0 \end{bmatrix} \cdot F$$

Calculations of magnitude of annual fluctuations through three feet of soil (see WHC-EP-0709)

$$c_p := 0.22\cdot\frac{BTU}{lb\cdot F} \qquad \rho := 113\cdot\frac{lb}{ft^3} \qquad \omega := \frac{2\cdot\pi}{1\cdot yr} \qquad \alpha := \frac{k_1}{\rho\cdot c_p} \qquad \beta := \sqrt{\frac{\omega}{2\cdot\alpha}}$$

$$T_{ave} := 56.3\cdot F \qquad \Delta t := 21.9\cdot F \qquad \alpha = 19.655\cdot\frac{m^2}{yr} \qquad \beta = 0.4\cdot m^{-1}$$

$$T_{max} := T_{ave} + \Delta t\cdot e^{-\beta\cdot 4\cdot ft} \qquad T_{min} := T_{ave} - \Delta t\cdot e^{-\beta\cdot 4\cdot ft}$$

Seasonal temperature variations within the filter rooms, maximum and minimum

$$\begin{bmatrix} A \\ B \\ C \\ D \\ E \end{bmatrix} \qquad T_{max} + \Delta T = \begin{bmatrix} 78.566 \\ 86.346 \\ 93.402 \\ 160.399 \\ 87.059 \end{bmatrix} \cdot F \qquad T_{min} + \Delta T = \begin{bmatrix} 51.664 \\ 59.444 \\ 66.5 \\ 133.497 \\ 60.157 \end{bmatrix} \cdot F$$

Pressure increase due to temperature increase fro the combined room volumes

$$\left(\frac{\frac{\Sigma\Delta T}{5} - T_{max} - 460\cdot F}{T_{ave} - 460\cdot F} - 1 \right)\cdot 1\cdot atm = 8.803\cdot kPa$$

$$\left(\frac{\frac{\sum \Delta T}{5} + T_{min} + 460 \cdot F}{T_{ave} + 460 \cdot F} - 1\right) \cdot 1 \cdot atm = 3.523 \cdot kPa$$

Filter Surface temperatures due to loading of radioactive material

Surface heat flux due to the beta radiation 50 % of the Cs loading and 100% of the Sr

$$Q_{filter} := 0.5 \cdot Cs_4 \cdot \left(4.72 \cdot 10^{-3} \cdot \frac{watt}{Ci}\right) + 1.0 \cdot Sr_4 \cdot \left(6.69 \cdot 10^{-3} \cdot \frac{watt}{Ci}\right)$$

$$Q_{filter} = 1.633 \cdot 10^{3} \cdot watt$$

75% on first filter, 25% on second, 40 filters 2 ft. by 2 ft, two sides

heat flux $\frac{0.75 \cdot Q_{filter}}{2 \cdot 160 \cdot ft^2} = 41.185 \cdot \frac{watt}{m^2}$

free convection from surface for air at 200 F

$\alpha = 0.519 \cdot \frac{cm^2}{sec}$ $\quad \nu = 0.345 \cdot \frac{cm^2}{sec}$ $\quad k = 0.039 \cdot \frac{watt}{m \cdot K}$ $\quad \beta = \frac{9.43 \cdot \alpha \cdot \nu}{g \cdot cm^3 \cdot K}$

filter height $\quad H = 18 \cdot ft$

$Ra_H(T_f) := \frac{g \cdot \beta}{\alpha \cdot \nu} \cdot H^3 \cdot T_f$ $\quad Nu_H(T_f) := 0.517 \cdot (Ra_H(T_f))^{0.25}$ $\quad Q(T_f) := \frac{Nu_H(T_f) \cdot T_f \cdot k}{H}$

laminar

Temperature increase required from top to bottom of filter to duct heat from filter $\quad T_f = 37 \cdot F$ $\quad Q(T_f) = 31.954 \cdot \frac{watt}{m^2}$ $\quad Ra_H(T_f) = 3.201 \cdot 10^{10}$

Finally, the maximum and minimum annual temperatures at filter surface

$T_{min} + \Delta T_4 + T_f = 170.497 \cdot F \quad T_{max} + \Delta T_4 + T_f = 197.399 \cdot F$

FIGURE 1

SITE PLAN