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1	1	Design Authority E. Shen	[signature]	6/5/98		1	1	Safety Review Board for P. LeRoy	[signature]	6/5/98 ×	
1	1	Design Agent M. Henderson	[signature]	6/5/98		1	1	Ops. ~~W. Cloos~~ C A Thompson	[signature]	6/8/98	
1	1	Cog.Eng. S. Peck	[signature]	6/5/98							
1	1	Cog. Mgr. D. Bergmann	[signature]	6/5/98	X3-79						
1	1	QA G. Davis	[signature]	6/5/98	X3-80						
1	1	Safety R. Meichle	R Meichle	6/5/98	X3-79						
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SNF Fuel Retrieval Sub Project Safety Analysis Document

D. W. Bergmann
DE&S Hanford, Richland, WA 99352
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Abstract: This safety analysis is for the SNF Fuel Retrieval (FRS) Sub Project. The FRS equipment will be added to K West and K East Basins to facilitate retrieval, cleaning and repackaging the spent nuclear fuel into Multi-Canister Overpack baskets. The document includes a hazard evaluation, identifies bounding accidents, documents analyses of the accidents and establishes safety class or safety significant equipment to mitigate accidents as needed.

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EXECUTIVE SUMMARY

This safety analysis document (SAD) defines hazards associated with the fuel retrieval system (FRS) installation and operation, documents the safety analyses, and identifies the need for controls to ensure safe operation of the FRS equipment in the K East and K West Basins. This SAD provides the FRS Subproject safety analysis to support revising the *K Basin Safety Analysis Report* (SAR)[1].

E.1 FACILITY BACKGROUND AND MISSION

The K Basins are located on the south bank of the Columbia River near the north end of the Hanford Site. The K Basins, built in the early 1950s, are two large basins for underwater storage of irradiated fuel produced by the K Reactors. Except for a few loose pieces, the K Reactor fuel stored in the basins was shipped for processing to the 200 East Area after the reactors were shut down in the early 1970s.

The K Basins presently store a large quantity of N Reactor spent nuclear fuel (SNF), which has been deteriorating for many years. A small amount of single pass reactor (SPR) fuel also is stored in the basins. The SNF Program was formed in 1994 to manage the 2130 metric tons of

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[1]DESH, 1998, *K Basins Safety Analysis Report,* WHC-SD-WM-SAR-062, Rev. 3B, DE&S Hanford, Incorporated, Richland, Washington.

SNF located in various Hanford Site facilities. The recommended path forward[2] requires removing the SNF from the K Basins and placing it in interim dry storage at a new facility on the Site. The FRS Subproject was established to provide the equipment necessary to retrieve, clean, and load the SNF in multi-canister overpack (MCO) baskets. The scope of the FRS Subproject is defined in the *Specification for Design of the SNF Project Fuel Retrieval Sub-Project*[3].

E.2 FACILITY OVERVIEW

The K Basin SAR[1] describes the K East and K West Basin storage facilities. The facilities consist of the two fuel storage basins (K East and K West) and related support facilities. Table E-1 of the K Basin SAR[1] lists the buildings and facilities that support the K Basin fuel storage mission. Inactive buildings are the responsibility of the environmental remediation and restoration contractor.

Major pieces of FRS equipment to be added to K East and K West include the following:

- Decapper (K West only)
- Primary clean machine
- Stuck fuel station

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[2]WHC, 1994, *Hanford Spent Nuclear Fuel Project Recommended Path Forward*, WHC-EP-0830, Westinghouse Hanford Company, Richland, Washington.

[3]WHC, 1996, *Specification for Design of the SNF Project Fuel Retrieval Subproject*, WHC-S-0461, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Process table
- MCO basket queue
- Manipulator system, cameras, and control equipment
- Telescoping stiffback, MCO basket stiffback grapple, empty MCO basket grapple.

Modifications to the existing fuel handling system in K East and K West include the following:

- Upgrade the capacity of selected monorails and flexible transfer crane rails
- Install new flexible transfer crane with drive system
- Install monorail extension south of the perimeter monorail
- Install new hoist with drive system for movement of loaded MCO baskets
- Install variable-speed hoists in the K East Basin
- Modify the basin grating to accommodate the new FRS equipment and operations.

E.3 FACILITY HAZARD CLASSIFICATION

The K Basin is a hazard category 2 facility. The hazard classification is documented in the *K- Basin Fuel Encapsulation and Storage Hazard Categorization*.[4] This hazard categorization addresses the potential for release of radioactive and nonradioactive hazardous material located in the K Basin and their supporting facilities. The analysis covered normal K Basin fuel storage and

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[4]Porten, D. R. 1994, *K-Basins Fuel Encapsulation and Storage Hazard Categorization,* WHC-SD-SNF-HC-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

handling operations, fuel encapsulation, and canister clean-up and disposal. FRS operational activities are similar to those covered by the existing hazard category. The accident evaluation section of this SAD demonstrates that installation and operation of the FRS does not change the existing hazard category.

E.4 SAFETY ANALYSIS OVERVIEW

This safety analysis considers accidental criticality and releases of radioactive and hazardous material under normal and accident conditions. A hazard identification process was completed to systematically and thoroughly review the FRS design, installation, and operations to identify hazards and select accidents and abnormal operations for further analysis. Hazards that showed the highest potential risk or consequences were chosen for accident analysis.

In the accident analysis, the unmitigated onsite and offsite dose consequences for the release of radionuclides were calculated. The unmitigated dose consequences were compared to the risk evaluation guidelines to establish the need for safety-class or safety-significant SSCs to prevent or mitigate the consequences. Mitigated consequences considering the use of any safety-class or safety-significant equipment were compared to the risk evaluation guidelines to assure acceptable mitigation. Event trees were prepared for some of the complex criticality accident sequences to establish credible frequency estimates and justify eliminating postulated accidents with a estimated frequency less than extremely unlikely ($<10^{-6}$/year). Tables E-1 and E-2 list the accidents and mitigated consequences associated with the FRS installation and operation.

Table E-1. Design Basis Accident Summary.

Section/accident	Frequency per year	Consequences, rem EDE					
		100 m	Guideline	Near River Bank 480 m	Guideline	Hanford Site boundary 12,040 m	Guideline
3.4.2.1 MCO scrap basket over-lift and fire	Beyond extremely unlikely[2]	0[4]	25	0[4]	N/A	0[4]	0.5
3.4.2.2 PCM wash basket over-lift	1E-04 to 1E-06 Extremely unlikely	23.7[5]	25	1.05	N/A	4.97E-02	0.5
3.4.2.3 Fuel assembly burns under water[3]	1.0E-02 to 1.0 E-04 Unlikely	2.51 E-02	10	7.3 E-04	N/A	1.2 E-05	0.5
3.4.2.4 Heavy load drop on basin floor[1]	9 E-03 Unlikely	No dose anticipated					
3.4.2.5 Heavy load drop on FRS safety class equipment causing criticality	1 E-02 to 1 E-04 Unlikely	No dose anticipated					
3.4.2.6 Seismic event	2.0 E-04 Unlikely	No dose anticipated					

Notes:
1. This is the only accident related to FRS equipment installation. FRS heavy loads will not be over basin drain valves.
2. Beyond extremely unlikely because of safety-class design features.
3. Case for single assembly with scrubbing of basin water assumed—most likely scenario of those defined.
4. Safety-class equipment prevents over-lift and subsequent fire.
5. Although safety-significant features are not required, the telescoping stiffback provides defense in depth protection.

Table E-2. Beyond Design Basis Accident Summary.

Section/accident	Frequency per year	Consequences, rem EDE		
		100 m	Near River Bank 480 m	Hanford Site boundary 12,040 m
3.4.3.1 Manipulator fuel handling accident	Beyond extremely unlikely	No dose anticipated		

As a result of the hazards analysis, preventive and mitigative design features and administrative controls have been identified. Safety-class design features include portions of the primary clean machine and the process table, MCO queue, MCO stiffback grapple, and empty MCO basket grapple. All safety-class features are passive. The safety significant design feature is the manipulator support structure tether system, which also is a passive feature. Administrative controls to ensure criticality safety will be implemented through the criticality prevention program required by the K Basin TSRs.

E.5 ORGANIZATIONS

As a subcontractor to Fluor Daniel Hanford, Incorporated, DE&S Hanford, Incorporated (DESH) is responsible for K Basin operations and the FRS Subproject. British Nuclear Fuels Limited, Inc. (BNFL) is the FRS design agent. Principle FRS vendors include the following:

- American Crane
- Fluor Daniel Northwest, Inc.
- GEC Alsthom/Shilling Robotic Systems
- Westinghouse Electric Corporation.

E.6 SAFETY ANALYSIS CONCLUSIONS

This SAD provides information to support the conclusion that proposed installation and operation of the FRS equipment and related K Basin facility modifications are in compliance with DOE and other agency rules, regulations, and orders, and can be performed with acceptable risks to the public and onsite personnel.

The accidents analyzed include fuel burns, heavy load drops, seismic events, criticality events, and manipulator fuel handling accidents. The FRS design took these proposed accidents into consideration to minimize their frequency and consequences. Safety-class or safety-significant design features or administrative controls have been implemented to prevent or mitigate the hazard where the unmitigated consequences exceed the guidelines. Chronic release of canister gases and leakage of hydraulic fluid were acceptable.

Installation testing will not include handling SNF. The scope of installation testing to be authorized is sufficient to ensure that the equipment is installed as specified and that the equipment and controls function.

E.7 SAFETY ANALYSIS DOCUMENT ORGANIZATION

The structure and content of the SAD, its chapters, and appendixes parallel the format of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*[5], as is appropriate for a major modification to an existing facility.

E.8 OUTSTANDING ISSUES AND DESIGN STATUS

FRS design, equipment procurement, and preconstruction and demolition activities in the K Basin have been approved by the U.S. Department of Energy (DOE) based on Critical Decision 3A. The preconstruction modifications include monorail and flexible transfer crane upgrades, manipulator support and grating modifications, pipe and electrical installation, and preliminary equipment operations center modifications. Installation and installation testing of the remaining FRS equipment will be approved by the U.S. Department of Energy (DOE) based on information provided for review during the Critical Decision 3B process. The information provided for Critical Decision 3B will allow DOE to assess the programmatic risk associated with approving FRS installation and installation testing. This SAD identifies the risk associated with the safety basis developed for the FRS equipment. The SAD must provide sufficient information to allow DOE to conclude the risk of approving installation and installation testing of the FRS is acceptable. The SAD also must provide sufficient information to assure DOE the FRS can be

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[5]DOE-STD-3009-94, 1994, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports,* U.S. Department of Energy, Washington, D.C.

operated without undue risk to the health and safety of the public, the workers, and the environment.

Preoperational testing, startup, and operation of the FRS equipment will be authorized based on DOE review and approval of the revised K Basin SAR.

The risks associated with approving the FRS installation and installation testing are summarized as follows:

- **Drops of equipment during installation.** These drops have been evaluated to demonstrate that equipment dropped in the basin will not cause the basin to leak

- **Potential changes to FRS design or safety analysis.** The design and the safety analysis are sufficiently complete and conservative to minimize the risk of changes to the FRS equipment or the safety analysis. The design change control process provides reasonable assurance that any changes will be adequately reviewed to ensure the change meets the safety analysis requirements.

Table E-3 provides a status of the FRS design and procurement as of May 31, 1998. This table demonstrates that the risk of significant design changes is small because the design is substantially complete.

Table E-3. FRS Design and Procurement Status

FRS Equipment	Design Status	Procurement Status
Decapper	Prototype design, 60% complete	Prototype in fabrication and test
Primary clean machine	Completed, issued	Procured, in fabrication
Stuck fuel station	Prototype design, 50% complete	Prototype in fabrication and test
Process table	Completed, issued	Procured, in fabrication
MCO basket queue	Completed, issued	Procured, K West equipment onsite
Manipulator system, cameras, and control equipment	Completed, issued	Procured, K West on site, part of K East on site
Telescoping stiffback	Completed, issued	Procured, onsite
MCO basket stiffback grapple & empty MCO basket grapple	In progress, 90% complete key dimensions and features established	Not procured
Empty Basket Stands	In progress, 90% complete, not significant from a safety perspective	Procured, in fabrication
Small tools	Will be identified in future, as needed, not significant from a safety perspective	N/A

MCO = multi-canister overpack
N/A = not applicable

Design calculations of structural and drop analyses have been completed and are in the review and approval cycle. No problems are expected, so the risk of change is small. FRS interfaces with other subprojects and facilities are defined and controlled. No changes are expected to these interfaces that will result in changes to the FRS design.

Technical issue closure associated with the SNF MCO sealing strategy are not expected to result in changes to the FRS equipment as designed and analyzed. If additional requirements result from technical issue closure new FRS equipment may be required to support SNF cleaning or inspection.

The recently closed K Basin unreviewed safety questions (USQ) were reviewed and have no impact on FRS equipment installation, installation testing, or expected operations.

- **Basin Perforation Issue (USQ K-97-0175)**. The heavy load drops discussed in this SAD do not result in penetration of the basin floor. The calculations of heavy load drops on the basin floor will be submitted for approval by the DOE in accordance with the DOE safety evaluation report requirements.

- **Basin Drain Valve Issue (USQ K-97-0265)**. FRS equipment and operations are not located over or in close proximity to basin drain valves. The FRS is not affected by this USQ.

The design and safety analysis are sufficiently complete and conservative that significant changes are unlikely. The programmatic risk of approving FRS installation and installation testing, which will be accomplished in accordance with the K Basin procedural requirements, is judged to be small.

Documents that provide source information for the safety analysis and/or implementation of safety criteria are identified in Table E-4. Table E-5 identifies the drawings used to define the physical configuration of the FRS. In both tables, the "STATUS" column identifies the revision (Rev 0, 1, 2, etc.) with unreleased documents indicated as draft. The status identified is for May 31, 1998.

Table E-4. Source and Implementation Documents.

Document	Status
HNF-SD-SNF-RD-001, *Spent Nuclear Fuel Project, K Basins/Cold Vacuum Drying Facility Standards/Requirements Identification Document,*	Rev. 1
WHC-SD-SNF-FRD-008, *Function and Requirements for Fuel Retrieval Subproject,*	Rev. 0
WHC-S-0461, *Specification for Design of the SNF Project Fuel Retrieval Subproject,*	Rev. 0
FRS Interface Agreement Sheets	Approved
L/B-SD-SNF-RPT-08, *Spent Nuclear Fuel Retrieval Subproject for the K Basin Facilities Preliminary Safety Evaluation,* Appendix E of FRS Conceptual Design Report	Rev. 0
WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report*	Rev. 3B/JCO/ 3C undergoing RL review
HNF-SD-SNF-TI-015, *SNF Project Technical Data Book*	Rev. 2
WHC-SD-SNF-TI-009, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel project Facilities*	Rev. 0
WHC-SD-SNF-ANAL-007, *Data Analysis, K West Basin Canister Liquid and Gas Samples, Gamma Energy Analysis and Mass Spectrometry Data*	Rev. 0
WHC-SD-SNF-ANAL-008, *Data Analysis of Gas and Liquid From K West Basin Fuel Canisters; 1995 Samples*	Rev. 0
HNF-SD-SNF-TI-049, *Analysis of K West Basin Canister Gas*	Rev. 0
HNF-SD-SNF-CSER-005, *Criticality Safety Evaluation Report for Spent Nuclear Fuel Processing and Storage Facilities*	Rev. 3
HNF-SD-SNF-CSER-010, *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*	Rev. 0
HNF-2229, *Fuel Retrieval Subproject Safety Class Design Analysis Report*	draft

Table E-4. Source and Implementation Documents.

Document	Status
HNF- SD-SNF-SARR-006, *Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks*	Rev. 0
HNF-SD-SNF-CN-009, *Fuel Retrieval Sub-Project K-Basin Facility Modification Calculations*	Rev. 0
HNF-SD-SNF-FHA-001, *Fire Hazards Analysis for the K Basins Facilities at 100K*	Rev. 1(draft)
HNF-SD-SNF-FRS-RPT-001, *ALARA Analysis Plan*	draft
HNF-SD-SNF-FRS-RPT-002, *Shielding Analysis Plan*	draft
HNF-SD-SNF-FRS-RPT-003, *Reliability, Availability & Maintainability Study*	Rev. 0
HNF-SD-SNF-FRS-RPT-004, *Process Control Philosophy*	draft
HNF-SD-SNF-FRS-RPT-005, *K Basin Fuel Rearrangement Plan* September 1996	Rev. 0
HNF-SD-SNF-FRS-RPT-006, *K Basin Fuel Retrieval Processing Strategy*	draft
HNF-SD-SNF-FRS-RPT-009, *SNF-FRS Criteria Evaluation Report*	Rev. 0
HNF-SD-SNF-FRS-RPT-010, *SNF-FRS Maintenance Assessment*	draft
HNF-SD-SNF-FRS-RPT-012, *Fuel Retrieval System ALARA Assessment*	Rev. 1
ARES Report No. 964001-001, *Evaluation of Fuel Retrieval System Design for Human Factors Engineering Features*	Rev. 0
HNF-SD-SNF-FRS-SPC-007, *Performance Specification for the Procurement of the FRS In-Pool Equipment*	Rev. 1

Table E-5. FRS Equipment Design Drawings.

Document	Status
DW-102, Overall System MFD K East Mechanical Flow Diagram	Rev. 1
DW-105, FRS-In-Pool Equipment Process Table	Rev. 9
DW-107, Manipulator Rails & Grating Mods E East, elevation and plans	Rev. 1
DW-108, Facility Modification Layout K East	Rev. 2
DW-202, Overall System MFD K East Mechanical Flow Diagram	Rev. 1
DW-205, In-Pool Equipment Process Table General Assembly	Rev. 10 draft
DW-207, Manipulator Rails & Grating Mods E West, elevation and plans	Rev. 3
DW-208, Facility Modification Layout K West	Rev. 4 draft

Table E-5. FRS Equipment Design Drawings.

Document	Status
DW-209, FRS In-Pool Equipment Decapping Station	Rev. 0 draft
DW-260, FRS Canister Off Gas Handling System	Rev. 1
DW-305, FRS In-Pool Equipment Primary Clean Machine Arrangement	Rev. 5 draft
DW-317, Telescoping Canister Hook Canister Retrieval System Arrangement	Rev. 3
DW-320, Manipulator Interface Control Diagram	Rev. 1
DW-324, Flexible Transfer Crane K East/ K West Arrangement	Rev. 2
DW-326, FRS In-Pool Equipment MCO Basket Queue Tables Arrangement	Rev. 4 draft
DW-327, FRS In-Pool Equipment Process Table Supports Arrangement	Rev. 5 draft
DW-328, FRS In-Pool Equipment Primary Clean Machine Overall Arrangement	Rev. 4 draft
DW-330, FRS In-Pool Equipment Primary Clean Machine Base Assembly	Rev. 4 draft
DW-334, FRS In-Pool Equipment Primary Clean Machine Wash Basket Assembly	Rev. 1
DW-342, FRS In-Pool Equipment MCO Basket Gauge Assembly	Rev. 4 draft
DW-347, FRS In-Pool Equipment K West General Arrangement	Rev. 6 draft
DW-353, FRS In-Pool Equipment K-East / K-West Load Schedule	Rev. 5
DW-360, Stuck Fuel Station	Rev. 0 draft
DW-363, Stiffback Grapple Assembly	Rev. 0 draft
DW-367, Decap and Stuck Fuel Support Table	Rev. 0 draft
DW-368, Empty MCO Basket Grapple Assembly	Rev. 0 draft
DW-370, Empty MCO Basket Support Stand	Rev. 0 draft
(No number issued yet), FRS In-Pool Equipment K East / K West Water Displacements	draft

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TERMS

AIChE	American Institute of Chemical Engineers
ALARA	as low as reasonably achievable
ARF	airborne release fraction
CCTV	closed-circuit television
DBA	design basis accident
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EOC	equipment operations center
ERPG	Emergency Response Planning Guideline
FRS	fuel retrieval system
HPU	hydraulic power unit
HVAC	heating, ventilating, and air conditioning
MAR	material at risk
MCO	multi-canister overpack
MSDS	material safety data sheet
MTU	metric tons uranium
PCM	primary clean machine
PHA	preliminary hazards analysis
RF	respirable fraction
SAD	safety analysis document
SAR	safety analysis report
SNF	spent nuclear fuel
SPR	single pass reactor
SSC	structures, systems and components
ST	source term
TLV	threshold limit value
TSR	technical safety requirement
TWA	time weighted average
URD	unit release dose

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1.0 SITE CHARACTERISTICS

Site characteristics are described in the K Basin safety analysis report (SAR), WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (DESH 1998). Implementing the fuel retrieval system (FRS) will not change the K Basin site characteristics because the FRS is located completely within the K Basins, which are covered by the existing description.

The only design basis natural phenomenon identified in the K Basin SAR that applies to the FRS is the design basis earthquake.

REFERENCES

DESH, 1998, *K Basins Safety Analysis Report,* WHC-SD-WM-SAR-062, Rev. 3B, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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2.0 FACILITY DESCRIPTION

2.1 INTRODUCTION

This chapter describes the fuel retrieval system (FRS) equipment, associated K Basin facility upgrades, and operation of the FRS equipment. Modifications to the existing K Basin facility are described in the sections related to the existing equipment. For example, upgrades to the basin monorails are covered in Section 2.9.4. Refer to WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (SAR) (DESH 1998a), for a description of the existing K Basin facilities and processes.

2.2 REQUIREMENTS

The facility standards and requirements are found in HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Facility Standard Requirements Identification Document* (DESH 1998b). The specific standards and requirements that apply to the FRS equipment are found in WHC-S-0461, *Specification for Design of the SNF Project Fuel Retrieval Subproject* (WHC 1996).

2.3 FACILITY OVERVIEW

Refer to the K Basins SAR (DESH 1998a) for an overview of the K Basin facilities.

2.4 FACILITY STRUCTURES

Refer to the K Basins SAR (DESH 1998a) for a description of the K Basin structures. The FRS equipment is totally enclosed in the 105 KE and 105 KW buildings. The manipulator support structure discussed in Section 2.5.1.6 of this document and other related piping and electrical runs are attached to the basin superstructure discussed in Section 2.4.1.1.3 of the K Basins SAR (DESH 1998a). The increased loads on the superstructure from the modifications are shown to be acceptable in HNF-SD-SNF-SA-004, *Seismic Qualification of 105K Basin Superstructure Using 0.12g Earthquake Ground Acceleration* (FDNW 1998).

2.5 PROCESS DESCRIPTION

The FRS to be installed in the K East and K West basins is basically a number of operator aids (tools) designed to support retrieval, cleaning, inspecting, and repackaging of fuel into multi-canister overpack (MCO) baskets, then queuing the MCO baskets for loading into the MCO. First, capped canisters (K West only) are degassed and have the lids removed in a manner that controls the effluent. Next, canisters are loaded into the primary clean machine (PCM) for cleaning. If required after cleaning, fuel stuck in the canisters is loosened using the stuck fuel equipment. Following cleaning, fuel is moved to the process table for sorting, inspection, and secondary cleaning, as required. Finally, fuel is loaded into an MCO basket and staged for MCO loading in the MCO queue. Fuel sorting and inspection and MCO basket loading are accomplished with the remotely controlled manipulator system. Canisters and MCO baskets are moved using the basin monorail system, the flexible transfer cranes, and several lifting devices.

The major FRS equipment that will be added to the K Basin facility is as follows:

- Decapping equipment and gas exhaust system to allow controlled removal of canister caps (K West Basin only)
- PCM to clean fuel and control wash water, including safety-class PCM support stand and PCM base
- Stuck fuel removal equipment to allow freeing fuel stuck in canisters
- Process table to allow sorting, inspecting, and loading fuel into the MCO baskets, including safety-class support stands, go-no-go gauges, and support tables to hold empty MCO baskets
- Safety-class MCO basket queue to stage the loaded MCO baskets
- Manipulator system to allow sorting, inspecting, and loading fuel into the MCO baskets, which includes the safety-significant manipulator support structure tether system, cameras, lighting, and an equipment operations center to allow viewing and control of fuel handling operations.

Upgrades to the existing basin monorails and hoists including the following:

- Upgrade the load rating and interlocks of several monorails and a portion of the flexible transfer crane rails to safely handle the increased loads of the MCO baskets
- Install new 4,000-lb-rated flexible transfer crane with drive system to ease movement of loaded MCO baskets
- Install 4,000-lb-rated monorail extension south of the flexible transfer crane in line with monorail 27 to facilitate bringing loads into the basin
- Install 4,000-lb-rated hoist with drive system to ease movement of loaded MCO baskets
- Install telescoping stiffbacks for moving canisters, PCM wash baskets, and debris bins

- Install variable-speed hoists only in the K East Basin to allow controlled lifting of canisters to minimize sludge plume
- Install safety-class MCO basket stiffback grapple and safety-class empty MCO basket grapple to allow moving MCO baskets.

Figure 2-1 shows a general arrangement of the FRS equipment in the basin. Figure 2-2 shows an elevation section in the area where the process table and manipulators are located. Figure 2-3 depicts the FRS operation.

2.5.1 FRS Equipment Description

This section describes the major pieces of equipment associated with the FRS.

2.5.1.1 Canister Movement and Staging Equipment Description. The FRS uses existing canister hooks and a telescoping stiffback to transport canisters. These hooks and the stiffback are supported by hoists attached to a monorail or flexible transfer crane. The monorails and flexible transfer crane rails are supported by the basin superstructure over the basin grating. The existing monorails, flexible transfer crane, and hoists are discussed in section 2.9.4.1 of the K Basin SAR (DESH 1998a). Modification to the monorails and flexible transfer crane rails to support the FRS are discussed in section 2.9.4 of this document.

Two types of canister hook exist: straight canister hook (Figure 2-4) and the offset canister hook (Figure 2-5). The canister hooks are hung from a hoist attached to the monorails or flexible transfer crane. Both types of canister hooks are fixed length to limit the height a canister can be lifted. The canister hooks have a hook on the lower end to hook the canister trunnion. The hoist raises and lowers the canister hook to raise and lower the canister. The canister hooks can only be moved in the basins through slots in the grating above the basin and in open pit areas. The straight canister hook is used to retrieve and place canisters located directly under the slot in the grating. The offset canister hook is used to retrieve and place canisters offset from the slot in the grating.

The FRS includes a telescoping stiffbacks (Figure 2-6) designed to lift canisters, the PCM wash basket, and other miscellaneous containers, such as the debris bin and strainer baskets. The telescoping stiffback is necessary to lift the canisters into the FRS equipment.

The telescoping stiffback include a 1-ton electric chain hoist with rigid hook suspension, a chain container, chain stops, a nonmaintaining push-button pendant control, and a 1-ton plain trolley with lug suspension. One telescoping stiffback is equipped with an electric tractor for motorized movement of the stiffback and suspended load. The tractor is controlled by a nonmaintaining push-button pendant control. A second spare telescoping stiffback is also provided. The telescoping stiffback and drive tractor operate on the monorails or flexible transfer crane.

The existing canister hooks are designed to prevent lifting a canister to within 3 m (10 ft) (nominal) of the basin water surface. The telescoping stiffback is designed to prevent lifting a canister to within 1.8 m (6 ft) (nominal) of the basin water surface.

2.5.1.2 Canister Decapping Equipment Description. As shown in Figures 2-7 and 2-8, the decapping equipment includes a clamshell-topped steel box (enclosure) to enclose the canister and a gas-handling system to remove the canister gases. The enclosure is approximately 36 cm by 53 cm (14 in. by 21 in.) and approximately 112 cm (44 in.) tall. It is designed to contain a single canister loaded through the open clamshell top. The clamshell top is opened and closed by a hydraulic cylinder on each side. Access holes in the clamshell top allow the decapping tools to reach the canister.

With the clamshell top closed, canister water and canister gas can be captured and removed. The gas will be removed by the gas exhaust system. Water jets installed in the decapping equipment direct high-pressure water into the open canister to flush out canister water. Suction piping connected to the enclosure removes the spray water, water flushed from the canister, and water that leaks into the enclosure in a continuous flow to the integrated water treatment system. The decapping equipment water suction piping includes a remotely mounted strainer with a screen size of 0.6 cm (0.25 in.) to capture pieces of fuel that may be in the water discharged from the decapping equipment. Smaller pieces of fuel may be flushed into the integrated water treatment system.

To address as low as reasonably achievable (ALARA) concerns, the decapping equipment includes a gas exhaust system (See Figure 2-8) that directs canister gas releases away from the area of the FRS equipment. The system minimizes the buildup of canister gases in the area. Gas buildup could result in increased chronic dose to the basin workers. The system dilutes hydrogen in the canister gases with air in the exhaust system to reduce the hydrogen concentration to below 1 volume percent, which is 25 percent of the lower flammability limit. The exhaust system contains no sources of ignition before dilution air is added.

The gas exhaust system consists of 2-in. schedule 40 piping connected to the top of the decapping equipment to direct the canister gas up from the decapping equipment. The piping has holes just before it reaches the basin water surface to allow for an inflow of basin water to scrub the gas release. The piping includes a knit mesh demister just above the basin water surface. Just above the demister the piping connects to ductwork where the dilution air and canister gases mix. A fan in the ductwork draws the air and gases through the ductwork and releases the mixture near a monitored (air sampler) building ventilation exhaust point.

Controls for the clamshell top and water jet flows are mounted on the control panel above the grating near the decapping equipment.

The decapping equipment fuel mass limits for criticality control are defined in Appendix 6A.

2.5.1.3 PCM Equipment Description. Cleaning the fuel in the PCM is intended to remove sludge from the fuel elements and the canister and loosen any fuel assemblies stuck to the canister. To minimize the impact on basin water quality, the PCM is designed as an enclosure to control the sludge released as a result of cleaning. Minimizing the release of sludge into the basin water minimizes visibility problems and worker dose.

The PCM (Figure 2-9) includes the following equipment:

- A stationary outer enclosure box housing the rotating fuel wash basket mounted on a removable bearing assembly
- A wash basket drive assembly with torque limiter and associated bellows seal between the underwater gearbox and the outer enclosure box
- High-pressure flush nozzles
- A strainer basket located in the bottom of the PCM outer enclosure box
- An enclosure box water discharge pump housing
- A skid-mounted high-pressure pump assembly and control valves
- The PCM control station.

The enclosure box lid houses the following items:

- Wash basket guides
- Hydraulic wash basket locking mechanism.

The wash basket houses the following items:

- Fuel canister locating guides
- Fuel canister locking mechanism.

The enclosure is a steel box with a horizontal joint between the top and bottom. Hinges on one side allow the top to be tipped up by hydraulic cylinders to gain access to the inside of the PCM. The enclosure is mounted on a set of legs that passes through the fuel racks and rests on the floor. A two-piece cylindrical wash basket is mounted on bearings inside the enclosure. The wash basket is split in half with a joint allowing it to be opened by removing one half. The wash basket is designed to hold a canister, assemblies, or scrap. The wash basket is rotated inside the enclosure at 2 to 4 rpm by a drive mechanism. Water nozzles mounted inside the enclosure spray pressurized water through slots in the wash basket to flush out sludge.

The fuel is cleaned using a combination of pressure water rinsing and mechanical agitation of the fuel as the wash basket rotates. To minimize dispersal of sludge, a suction connection provides a continuous flow of water from the enclosure through a strainer basket with a 0.6 cm (0.25-in.) screen size to the integrated water treatment system. Outflows are greater than inflow to ensure that water is drawn into the PCM.

The main drive motor and associated speed-reduction gearbox and torque limiter are located on the grating above the basin. Gearbox reductions allow a maximum wash basket rotation speed of 4 rpm. The skid-mounted high-pressure pump assembly is positioned over the wall separating the center and west bays of the basin pool. The high-pressure pump provides the fuel flush nozzles with treated basin water.

The control and interlock panel is suspended from the superstructure above the operating walkway adjacent to the PCM. The fuel wash cycle and PCM flush cycle duration are displayed in minutes and seconds on the PCM local control panel programmable electronic display. The PCM controller is designed to allow modification of these parameters and provide rotation count and wash-flush cycle duration information and setup.

PCM fuel mass limits for criticality control are defined in Appendix 6A.

2.5.1.4 Stuck Fuel Removal Equipment Description. Generally, the PCM is expected to loosen fuel in the canisters. Occasionally, fuel may be stuck in a canister. Canisters with stuck fuel will be transferred to the stuck fuel removal equipment to loosen the fuel.

The stuck fuel removal equipment (Figure 2-10) is basically a platform that securely holds a canister containing stuck fuel. A hydraulically operated saw mounted on guideposts is designed to slice vertically through the canister barrels. Cuts can be made at four different locations on the canister as needed. This allows the canister to be spread open, freeing the stuck fuel. The controls for the hydraulically operated saw are mounted above the stuck fuel equipment.

Stuck fuel equipment fuel mass limits for criticality control are defined in Appendix 6A.

2.5.1.5 Process Table Equipment Description. The process table is used to hold fuel for sorting, inspection, and MCO basket loading.

Figure 2-11 shows the process table top. The process table consists of several adjoining support tables with defined areas to support unloading and sorting fuel and debris, disassembling and inspecting fuel, performing secondary cleaning of the fuel elements, and loading MCO baskets. The process table has a 15 cm (6-in.) (nominal) lip around the outside edge to minimize fuel spills from the table. The table is made from structural steel shapes and plate steel. The table surface is supported by the steel support leg structures that go through the fuel racks and rest on the basin floor.

A fuel tipper is located at the north end of the process table to empty fuel from the wash basket or canisters to the sorting area of the north section. The north section of the process table includes a debris bin for storing debris that has been separated from the fuel. The debris bin (Figure 2-12) is a rectangular "pail" that can hold a canister to collect debris from the FRS activities. The debris bin has a lifting handle used to lift and transport the bin with the telescoping stiffback. An empty canister can be placed in the debris bin located in the process table for accumulating debris from the sorting activities on the table. A vertical canister unloading bin can hold a canister vertically while assemblies are unloaded using the manipulators. An MCO basket go-no-go gauge placed in the support table holds the MCO scrap basket. This go-no-go gauge allows the MCO basket diameter to be checked before moving the basket to the MCO basket queue. The gauge also ensures that fuel is not lost from the MCO scrap basket during postulated accidents. MCO baskets are shown in Figure 2-13.

A pin-and-plunger device located in the fuel inspection area of the process table may be used to disassemble fuel assemblies by pushing the inner elements out of the outer elements to allow fuel inspections. The pin-and-plunger device holds only one fuel assembly at a time. The inspection station is equipped with cameras and lighting to allow examination of fuel elements to verify results of cleaning.

The middle section of the table includes a ramp to hold assemblies, elements, or pieces of fuel, and the secondary cleaning station that may be used to further clean fuel elements. The fuel ramp is raised 15 cm (6 in.) (nominal) above the inspection area, effectively creating separate fuel staging areas. The secondary cleaning station consists of concentric brushes that can be used to brush the fuel element's internal and external surfaces. The secondary cleaning station has a down-draft flow of basin water provided by the integrated water treatment system to remove any sludge loosened during the secondary cleaning process.

The south section of the process table includes the following:

- Two jigs to allow the manipulator to stand the fuel elements on end
- A fuel length gauge to measure "assembled" fuel elements to ensure that length requirements are met
- Two go-no-go gauges to hold an MCO assembly basket and an MCO scrap basket
- Test weight positions to hold test weights for calibrating the MCO stiffback grapple load cell
- A light to assist in loading the fuel in the MCO assembly basket.

The process table and supports are designed to take the dead load of the maximum allowed fuel loading and the test weights. The safety-class process table supports are designed so the table will not tip over or be damaged by a seismic event, drop of a loaded MCO basket, or the manipulator. Each MCO basket container can hold only one MCO basket and has a 61 cm (24-in.)-diameter liner to contain fuel in the event of an MCO basket failure during a seismic event. The process table fuel mass limits for criticality control are defined in Appendix 6A.

2.5.1.6 Manipulator System Equipment Description. To minimize dose to operating personnel, two remotely operated manipulators are installed above the process table to facilitate fuel sorting, inspection, and loading. The manipulators are operated from the equipment operations center.

Figure 2-2 shows the manipulators in place over the process table. The manipulator system includes the following equipment (quantities per basin):

- Manipulator bridge rail support structure and tether system attached to the basin superstructure
- Manipulator bridge rails mounted on the manipulator bridge rails support structure
- Two manipulator bridges with an attached manipulator support mast
- Two remotely operated manipulator assemblies
- Hydraulic power unit
- Hydraulic supply-return manifolds and cable-hose management system
- Local and remote master controllers for each manipulator, bridge subassembly, and hydraulic power unit
- Manipulator-mounted cameras with remotely controlled zoom, focus, and iris
- Camera control units and programmable electronic display systems located in the equipment operations center that provide manipulator system operational status and alarms and operational status and alarms for other FRS in-pool equipment
- Control cables and wiring
- Hydraulic fuses between the flow indicators on the hydraulic manifold and the bridge-mounted hydraulic controller
- A UNIX-based computer system with appropriate hardware for Ethernet communication with the manipulator control system.

The manipulators are supported by a mast attached to the manipulator bridge mounted on rails supported from the building structure. Each manipulator bridge can be moved north and south along the rails by remote control. The manipulators are mounted on the end of the mast and can be remotely rotated to change the direction in which the manipulator operates. The manipulator trolleys have stops that prevent over-travel on the rails and prevent the manipulators from colliding. The manipulator control system (software and position feedback) is designed to prevent fuel from being raised to within 1.8 m (6 ft) of the water surface under normal operating conditions.

The manipulator bridge has a two-speed drive system selectable from the operator's control panel. The drive system provides a maximum speed capability of 18 m/min (60 ft/min). The bridge will stop within ± 2.5 cm (1 in.). Removable mechanical rail stops designed to withstand the impact forces of the fully loaded manipulator bridge traveling at the maximum bridge design speed are provided on the bridge rails to prevent manipulator travel off the end of the rails. Manipulator collision-prevention controls maintain a minimum separation distance of 15 cm (6 in.) between the manipulator bridges.

A hydraulic pumping unit located in Room 3 provides the energy source for manipulator operations. The piping connecting the pumping unit and the manipulators includes hydraulic fuses and line sloping designed to limit leaks from the system.

The manipulators and bridge are remotely controlled by operators located in the equipment operations center, located in Room 20A. The equipment operations center also contains controls for the cameras and viewing equipment used to observe manipulator operations and perform fuel inspections. Local and remote emergency stop buttons are installed to allow disabling of the manipulators in the event of an emergency. The controls are mounted on a simple operating console. Displays and controls are designed so that operators can efficiently and safely share required activities and to comply with human factors requirements of the FRS specification (WHC 1996). See Chapter 13 for a discussion of how human factors were applied to the design process.

The manipulator system control and operational conditions, including the system status and alarms, are displayed on the programmable electronic display system located in the equipment operations center. The manipulator system status and alarm indicators are integrated with the in-pool equipment status indicators and alarms to provide the system operators an overview of the FRS operating parameters.

The control system provides four modes of access. The modes of access are defined in Table 2-1 and discussed in the following paragraphs.

Table 2-1. Manipulator Control System Modes of Access.

Mode	User type	Security system	Allowed operations
Normal	Operator	Default at startup	Standard operations
Disabled	Operator	Mouse and keyboard locks	Console remains powered, but user input is disabled
Maintenance	Engineer	Password	Error check disabling and setup operations
Programming	Systems engineer	Floppy drive lock	File access allowing parameter adjustment

Normal Mode. This is the default operating mode at system startup, allowing access to all normal-operation controls. In addition to providing for operation of the manipulator system (bridge, azimuth, and manipulator), the normal access mode allows the operator to perform the following functions:

- Enable or disable manipulator system hydraulics
- Set bridge home positions
- View diagnostics screens for master arm, slave arm, and serial communications
- View alarm and status indicators
- Acknowledge alarm conditions; turn off audible alarm
- Reset alarm conditions
- Select jaw speed, jaw force, and jaw mode (position, toggle, or lock)
- Select bridge speed (high or low).

Disabled Mode. This mode provides a locking mechanism that prevents access to the system input devices, mouse, and keyboard. This allows the operator to prevent access to the system by casual users without turning off the manipulator's electrical and hydraulic power.

Maintenance Mode. This mode is available via password. It allows a qualified person access to all the operator's functions plus allows the user to set manipulator joint limits and disable error-checking features.

Programming Mode. This mode allows a systems engineer access to files on the hard drive. Programming mode access is limited by a locking mechanism that prevents access to the system's bootable (floppy) drive. In addition to the access of the maintenance mode, the programming mode allows the systems engineer to perform the following functions:

- Modify alarm thresholds
- Modify bridge speed settings
- Modify jaw maximum force settings
- Modify display text and colors
- Modify status indicator units
- Add or remove alarm and status indicators
- Reconfigure arm feedback parameters when slave arm is replaced or repaired
- Reconfigure role of control computers for stand-alone operation.

The manipulators are expected to handle only one fuel assembly at a time. The manipulators are not capable of lifting fuel out of the basin water.

2.5.1.7 MCO Basket Movement Equipment Description. Loaded MCO baskets are moved from the process table to the MCO basket queue using an MCO basket stiffback grapple assembly supported by a motorized hoist and trolley on the upgraded overhead monorails and flexible transfer crane.

The safety-class MCO basket stiffback grapple (Figure 2-14) is designed to grapple and release a loaded MCO basket remotely. The grapple consists of a long lifting tube, an actuating rod inside the tube, and a ball-detent-style grapple affixed to the end of the tube. The grapple is operated by an actuating mechanism at the upper end of the lifting tube. The stiffback grapple is attached to a hoist with a lifting eye on the upper end of the stiffback grapple. Raising or lowering the hoist raises and lowers the stiffback grapple and any attached basket. The actuating mechanism includes a handle to position the grapple actuating rod and a locking pin to prevent inadvertently moving the actuating rod. A load cell is built into the grapple for weighing the loaded baskets. The stiffback grapple is designed to prevent fuel from being lifted to within 1.8 m (6 ft) of the basin water surface. The overall length of the MCO stiffback grapple ensures that the lift height limit is met.

The MCO basket stiffback overall length ensures that a Mark IV MCO basket cannot be lifted more than 162 cm (64 in.) above the basin floor. The Mark IV MCO basket drop bounds the Mark IA basket drop. The load rating for the MCO stiffback grapple is 4,000 lb.

2.5.1.8 MCO Basket Queue Description. Loaded MCO baskets are staged in separated storage areas in the MCO basket queue for criticality control until the MCO baskets are loaded into the MCO.

The safety-class MCO basket queue is made from four structural steel stands designed to hold from one to three loaded MCO baskets. The stand has structural steel legs that rest on the basin floor and hold the queue stand over the fuel racks. Each MCO basket storage area contains only one MCO basket and has a 61 cm (24 in)-diameter confinement pipe and bottom plate to contain fuel during a seismic event or heavy load drop. The MCO basket queue can hold a maximum of 10 MCO baskets because the section near the basin loadout pit can hold only a single MCO basket. Figure 2-15 shows a typical MCO basket queue section.

The MCO basket queue is designed to withstand the effects of a loaded MCO basket drop and a seismic event. MCO basket queue fuel mass limits for criticality control are defined in Appendix 6A.

2.5.1.9 Empty Multi-Canister Overpack Basket Handling Equipment Description. Empty MCO baskets are placed in the basin south of the process table using the monorail extension with a 1-ton-capacity chain hoist with the empty MCO basket grapple. The empty MCO baskets will be stored on empty MCO basket storage tables near the process table. The legs of the empty MCO basket storage table extend through the fuel racks and rest on the basin floor.

The safety-class empty MCO basket grapple (Figure 2-16) is a short grapple similar to the grapple on the end of the MCO stiffback grapple. The empty MCO basket grapple has a manual lock that must be locally engaged to grapple the basket, but can be remotely disengaged to release the basket. The grapple includes a cover for the basket to preclude loading fuel into a grappled basket. The grapple is disengaged with a long-handled tool. The grapple cannot be engaged remotely.

The design of the empty basket grapple prevents placing fuel in the MCO basket when the grapple is in place and prevents the empty MCO basket grapple from being engaged remotely, but allows remote disengagement. These features prevent loading fuel into an MCO basket grappled with the empty MCO basket grapple and grappling a loaded MCO basket with the empty basket grapple to ensure that a loaded MCO basket is not accidentally removed from the basin water.

2.5.2 FRS Operation Description

The following sections describe the operation of the FRS system.

2.5.2.1 Canister Staging. Fuel in the K Basins is stored in canisters placed in fuel racks located on the basin floor. Figure 2-17 is a schematic of the fuel storage configuration shown without racks. The canisters are located throughout the three bays of the basin. See section 2.5.2.1 of the K Basins SAR (DESH 1998a) for a discussion of the canisters and fuel racks. The canisters containing fuel will be transported to the staging area (Figure 2-1) north of the FRS equipment.

Before retrieving spent nuclear fuel (SNF), fuel campaign plans will be developed using location, key data, and process optimization criteria to control the canister retrieval sequence. These campaign plans will ensure proper segregation of Mark IA and Mark IV fuel. Canisters will be retrieved from their storage locations using the basin monorail system and placed in the FRS staging area in the existing racks north of the PCM. Fuel in damaged canisters (e.g., bottom corroded) may be transferred to new canisters before transit. Damaged canisters are expected to be found only in the K East Basin. SNF on the basin floor may be retrieved for processing using manual tools. Single pass reactor (SPR) fuel stored in SPR baskets (in K East Basin only) may be loaded into canisters before transport. In the K East Basin, variable-speed hoists are used to minimize sludge plume effects resulting from rapid canister lifting.

Canisters are moved by lowering the stiffback into position, engaging the hook on the canister trunnion, then raising the hoist to lift the stiffback and the canister. The canister is moved using the drive tractor if the stiffback is equipped with one or by manually pushing the trolley, hoist, and stiffback along the rail. The trolley can be moved onto the flexible transfer crane to enable movement between monorails. Once the load is in position, the hoist is lowered to set the canister down.

2.5.2.2 Canister Decapping (K West only). Canisters of fuel in the K West Basin have been stored capped. This has resulted in contaminated water, sludge, and gases accumulating in the canisters. The canisters must be opened to retrieve the fuel. To maintain basin water quality, canisters are decapped in an enclosure that minimizes release of the canister water and gas during decapping. Water is continuously pumped from the enclosure through a strainer to the integrated water treatment system. Consistent with ALARA principles, the gas-handling system directs the gases released away from the areas frequented by the basin worker.

The K West Basin contain two types of canisters: Mark I and Mark II. The Mark I canisters can be made of aluminum or stainless steel. The Mark I canisters have a loose gas trap connected to the canister lid by metal tubing. They can be sealed with a compression-type cover. The Mark II canisters are made of stainless steel, have an integral gas trap attached to the canister barrels, and can be sealed. The K West Basin contains approximately 800 aluminum and 1,000 stainless steel Mark I canisters and 2,000 Mark II canisters.

Canisters are decapped following these simplified steps.

1. Retrieve canisters from the staging area with the telescoping stiffback. For Mark I canisters, the gas trap lines are cut with a long-handled tool to remove gas traps before the canister is placed in the canister storage area. Stage the gas traps for transport to debris removal.

2. Open the decapper enclosure clamshell top, place a canister into the enclosure, remove the telescoping stiffback, and close the clamshell top.

3. Release gases by opening valves or pressuring cap, as appropriate.

4. Remove the canister caps from the canister.

5. Flush the canister with water.

6. Open the canister enclosure and remove the cap from the enclosure. Place the cap in a debris container.

7. Attach the telescoping stiffback to the canister; remove the canister from the enclosure.

8. Inspect decapping equipment for sludge accumulation; clean as necessary.

The integrated water treatment system and the exhaust gas system are in service during decapping activities. Not all the canister gases will be released in the decapping equipment. Some gas is expected to be released through the canister vent system as the canister is moved from the racks to the decapping equipment. Other losses may occur as the gas traps are cut or connections are made to the canisters to pressurize the canister. Some gas may remain in the Mark I gas traps after they are removed from these canisters.

Canister caps, gas traps, and other debris are transferred to the debris staging area as necessary, using the telescoping stiffback. Material accumulated in the strainer is emptied onto the process table, as necessary, using the telescoping stiffback.

2.5.2.3 Primary Cleaning. The primary cleaning process involves rotating a canister of fuel in an enclosure while high-pressure water is sprayed into the canister. This results in the fuel sliding from one end of the canister to the other, knocking the corrosion particles from the SNF and loosening fuel stuck to the canister.

The main suction pump operates during all PCM operations. With the PCM lid open, a canister is loaded vertically into the bottom half of the wash basket using the telescoping stiffback. The top half of the wash basket is put in place and the PCM lid is closed. The main drive and high-pressure pump are started and the fuel and canister are rotated in the wash basket for approximately 20 minutes. When the wash cycle is complete, the high-pressure pump is stopped and the PCM is flushed for approximately 10 minutes to clear residual sludge. The PCM is stopped and the lid is opened. The fuel canister is removed and transported to the process table with the telescoping stiffback.

During the initial operation of the PCM, validation testing will be performed to establish the operating parameters necessary to ensure that the SNF will be adequately cleaned. During this validation process, the fuel canister and the wash basket will be removed with the telescoping stiffback and moved to the tipping station of the process table to dump the fuel on the table surface. The fuel will then be inspected to demonstrate that it meets the cleanliness criteria.

The PCM will be inspected for sludge and scrap accumulation and cleaned as required. The PCM strainer will be cleaned as required. The strainer is moved by lowering the stiffback into position, engaging the hook on the strainer trunnion, then raising the hoist to lift the stiffback and the strainer. Wash baskets are raised in a similar fashion using only the telescoping stiffback, which has a spreader bar above the hook for lifting the wash baskets.

2.5.2.4 Stuck Fuel Removal. The cleaning process is expected to loosen SNF in the canister. Occasionally some fuel may remain stuck to the canister. Canisters with stuck fuel will be transported and loaded into the stuck fuel removal equipment with the telescoping stiffback. The canister will be secured in place. The saw will be placed on one of the two guideposts. The saw will be started, then a hand crank will be used to feed it down into the canister, slicing the barrel. After the cut has been made to the desired length, the saw can be repositioned to make a cut on the other barrel. If two cuts per barrel are required, the canister can be rotated 180 degrees and the cutting process repeated. When the cuts are complete, the canister barrels can be spread apart using a hydraulically operated spreader to loosen the fuel assemblies, if necessary.

The fuel will be cleaned again after the cutting operation to remove any loosened sludge and cutting particles. Fuel assemblies can be placed in a second canister held in the stuck fuel equipment for movement to the PCM for cleaning. Alternatively, slit canisters can be moved directly to the PCM for cleaning without removing the fuel elements.

Waste particles generated by the sawing operation fall into the canister or onto the platform under the canister. The stuck fuel equipment will be cleaned using a suction wand connected to the integrated water treatment system, as necessary, to prevent a significant accumulation of fuel scrap, sludge, or machine chips.

2.5.2.5 SNF Sorting, Inspection, and MCO Basket Loading. After cleaning in the PCM is complete, the SNF is transported to the process table. If the fuel is in good condition, the canister can be moved to the vertical unloading station in the process table. The SNF can then be removed from the canister with the manipulator. If the SNF is not in good condition, the wash basket containing the fuel is moved to the tipper station on the process table using the telescoping stiffback. The SNF is dumped onto the process table sort area by rotating the wash basket in the tipper.

If SNF inspection is required, fuel assemblies are moved to the fuel element disassembler station to separate the inner element from the outer element, if necessary. The fuel elements are inspected, as needed, to support validation or to determine cleanliness.

The manipulators will be used to sort and inspect fuel, sort debris from fuel, and load fuel into the MCO baskets. During normal operations, the process table will be covered by two manipulator assemblies running along the same set of bridge rails. Each manipulator position will be responsible for performing a predefined set of tasks. The first unit will pick up fuel from the sort table and move it through disassembly, inspection, and secondary cleaning as required. The fuel will be placed on the ramp of the table. The second manipulator position will be dedicated to MCO basket loading. Each manipulator can independently cover the entire process table length.

Fuel elements (whole or partial elements longer than 7.6 cm [3 in.]) separated from fuel scrap are placed on the ramp on the middle section of the process table. Fuel scrap between 2.5 cm (1 in.) and 7.6 cm (3 in.) long and other elements that cannot be loaded into the assembly basket because of bloomed ends will be loaded into the MCO scrap basket in the north process table. "Fine" fuel scrap between 0.6 cm (0.25 in.) and 2.5 cm (1 in.) long is placed only in the center "fines" section of the MCO scrap basket. This allows the amount of fine scrap loaded in the MCO to be controlled to support MCO loading safety requirements defined in the Spent Nuclear Fuel Project Product Specification, HNF-SD-SNF-OCD-001 (Pajunen and Sederburg 1998). Separation of fines is not a criticality issue.

Debris is nonreactor-origin material separated from the fissile material. Material that has been irradiated in the reactor as part of the fuel is not considered debris. Debris collected from the processing table is loaded into canisters placed in the debris bin in the process table. The canister in the debris bin sits above the table surface to prevent fuel from accidentally falling into the canister. When the canister is filled with debris, the canister and debris are transferred to a debris staging area using the telescoping stiffback and the monorail system. Procedural controls and inspections of the fuel sorting activities reasonably ensure that fuel pieces do not inadvertently get into the debris. The debris-removal activities will need to ensure that the delivered debris does not contain any tramp SNF before it is removed from the basin.

Fuel elements are cleaned in the secondary cleaning station, as needed, using long-handled tools. Fuel elements are placed in the "upending" jigs by the operator using the manipulator jaws. The fuel elements are then picked up from the jig with the manipulator "expansion tool" inserted into the center hole of the element. The fuel elements can then be loaded into the assembly basket. Fuel elements that do not fit in the jig because of damaged ends are placed in the MCO scrap basket in the south process table MCO scrap basket container.

Pieces of elements longer than 7.6 cm (3 in.) may be placed in the MCO fuel assembly basket located at the south end of the process table. Typically, an outer element is placed in the basket first, then an inner element is placed inside the outer element. This sequence may be adjusted case by case because some of the fuel elements are broken and will have to be made up by stacking pieces. Pieces shorter than 7.6 cm (3 in.) and damaged fuel elements that do not fit into the MCO assembly basket are loaded into an MCO scrap basket in the south end of the process table. The broken fuel jig may be used, as needed, to measure fuel element pieces before loading. Following loading of some scrap elements, the MCO scrap basket may be transferred to the MCO scrap basket container in the north sort area where additional scrap and fine scrap may be loaded.

Figure 2-13 shows the MCO baskets.

2.5.2.6 MCO Basket Handling. When loaded MCO basket needs to be moved, a 4,000-lb hoist with the MCO stiffback attached is positioned over the MCO basket. The hoist lowers the stiffback grapple to insert the end of the grapple into the center pipe of the MCO basket. The grapple locking pin is disengaged and the operating lever is moved to the "engaged" position to engage the ball detent grapple with the fit in the MCO basket center tube. The locking pin is reengaged to lock the operating lever in the engaged position. The hoist is raised slightly to lift the grapple and the attached MCO basket to ensure that the basket is free. The MCO basket is weighed using the built-in load cell before it is completely lifted from the storage position in the process table to ensure that basket mass limits for criticality control are not exceeded. After the MCO basket mass has been confirmed to be within limits, the basket is lifted clear of the supporting structure.

Once lifted, the MCO basket is transported along the monorail and onto the flexible transfer crane. When the basket is loaded onto the flexible transfer crane, the flexible transfer crane can move the MCO stiffback grapple and attached basket to the MCO basket queue. Once in position, the MCO basket is lowered into the storage space until it sits on the bottom plate. The MCO basket grapple is detached and removed. Similar steps are used to move the MCO basket between positions in the process table and remove a loaded MCO basket from the MCO basket queue and place it onto the MCO loading equipment shuttle.

Empty MCO baskets are brought into the building and staged in corridor 10. The empty MCO baskets are transported into the basin area on a cart or pallet jack and placed under the monorail extension south of the basin (monorail 27). The empty MCO basket grapple is attached to the basket and the empty MCO basket is lifted from the cart with the hoist. Once lifted, the trolley, hoist, empty MCO basket grapple, and empty MCO basket are pushed over the basin on the monorail and onto the flexible transfer crane. The hoist will lower the assembly and set the empty MCO basket on the existing fuel racks or empty MCO basket tables. The empty basket grapple is disengaged from the basket and removed from the water. When needed, the empty MCO basket is moved into position in the process table using the MCO stiffback grapple.

2.6 CONFINEMENT SYSTEMS

See the K Basins SAR (DESH 1998a), section 2.6, for a discussion of the K Basin confinement systems. Changes to the confinement system include the interconnections of the integrated water treatment system with the FRS equipment. Detailed changes to the K Basin SAR (DESH 1998a) will be developed in the safety analysis for the integrated water treatment system. These changes include piping to remove water from the decapping equipment, the PCM, and the secondary cleaning station. Piping also is provided to supply pressurized water to the FRS for the equipment wash-down stations and to remove the contaminated wash water.

2.7 SAFETY SUPPORT SYSTEM

See the K Basins SAR (DESH 1998a), section 2.7, for a discussion of the K Basin safety support systems for worker protection. The FRS Subproject does not change these systems.

The existing radiation protection system provides protection for K Basin personnel performing work over the basin near the FRS equipment. The K Basin fire protection system also provides fire protection for the FRS, as needed.

2.8 UTILITY DISTRIBUTION SYSTEM

See the K Basin SAR (DESH 1998a), section 2.8, for a discussion of the K Basin utility distribution systems. The FRS equipment ties into the K Basin electrical system to obtain electrical power for equipment operation.

2.9 AUXILIARY SYSTEMS AND SUPPORT FACILITIES

See the K Basin SAR (DESH 1998a), section 2.9, for a discussion of the K Basin auxiliary systems. The FRS Subproject changes to these systems are discussed in sections 2.9.1 through 2.9.4.

2.9.1 K Basin Water Supply Systems

No change is required to the K Basin water supply system for the FRS.

2.9.2 Infrastructure Systems

No change is required to the K Basin infrastructure systems for the FRS.

2.9.3 Water Treatment and Chemical Handling Systems

No change is required to the K Basin water treatment and chemical handling systems for the FRS. These systems provide water to the 100 K area.

2.9.4 Cranes and Hoists

To safely handle the increased loads of the MCO baskets, the load ratings of several of the monorails and the flexible transfer crane must be increased, as shown in Figure 2-18. New hoists with drive systems are added to move MCO baskets and other loads. New flexible transfer cranes with drive system are added to assist in moving the load along the rails. Specific upgrades for both K East and K West Basins include the following:

- Upgrade the capacity of a portion of the flexible transfer crane track to 4,000 lb
- Install new interlocks to prevent the upgraded flexible transfer crane from accessing existing monorails and the existing flexible transfer crane from access the upgraded monorails
- Install rail stops to prevent the upgraded flexible transfer crane from leaving the upgraded portion of the flexible transfer crane track, but allowing the existing flexible transfer crane to access the upgraded track
- Install a new 4,000-lb-rated flexible transfer crane and drive system on the upgraded portion of the flexible transfer crane track
- Upgrade monorails 26 and 27 over the process table to a 4,000-lb rating
- Install rail stops on monorails 26 and 27 to prevent loads from moving from the upgraded sections to the un-upgraded sections of the monorails
- Install a 4,000-lb-rated monorail extension south of the flexible transfer crane in line with monorail 27 to facilitate bringing loads into the basin
- Install interlock on the monorail extension to prevent the existing flexible transfer crane from accessing the monorail extension and prevent loads from coming off the rail unless the upgraded flexible transfer crane is in place to accept the load
- Install a new 4,000-lb-rated hoist with drive system, including an MCO basket stiffback grapple, for moving MCO baskets on the upgraded monorails
- Install a new telescoping stiffback hoist for moving canisters, PCM wash baskets, the PCM and pump stand strainers, the process table tipping jig, the debris bins, and miscellaneous table support

- Install a new empty basket grapple for loading empty MCO baskets into the basin
- Install new variable-speed hoists (K East only) to control the lift speed of the canister to minimize the sludge plume.

2.10 REFERENCES

DESH, 1998a, *K Basins Safety Analysis Report,* WHC-SD-WM-SAR-062, Rev. 3B, DE&S Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998b, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document,* HNF-SD-SNF-RD-001, Rev. 1, DE&S Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

FDNW, 1998, *Seismic Qualification of 105K Basin Superstructure Using 0.12g Earthquake Ground Acceleration,* HNF-SD-SNF-SA-004, Rev. 0, Fluor Daniel Northwest, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

Pajunen and Sederburg, 1998, *Spent Nuclear Fuel Project Product Specification,* HNF-SD-SNF-OCD-001, Rev. 2, SGS Eurisys Services Corporations for Fluor Daniel Hanford, Inc., Richland, Washington.

WHC, 1996, *Specification for Design of the SNF Project Fuel Retrieval Subproject,* WHC-S-0461, Rev. 0, Westinghouse Hanford Company, Richland Washington.

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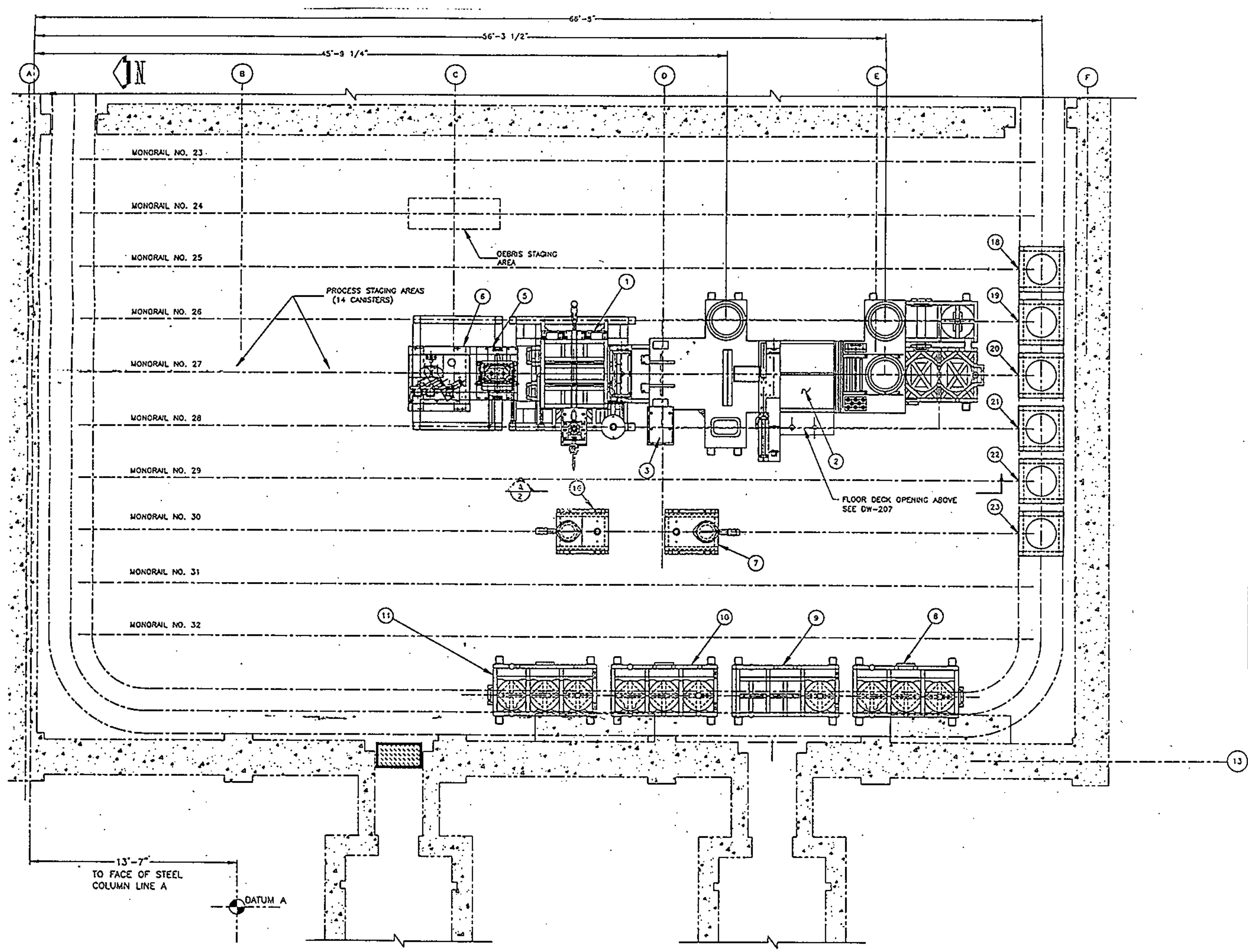
Figure 2-1. Fuel Retrieval System General Arrangement.



SUB ASSEMBLY DESCRIPTION

ITEM	QTY	DESCRIPTION
1	1	PRIMARY CLEAN MACHINE
2	1	PROCESS TABLE TOP ASSY
3	1	CANISTER TIPPING STATION ASSY ▷2
~~4~~	~~1~~	~~WASH BASKET STAND ASSY~~
5	1	DECAPP STATION ▷3 ▷4
6	1	STUCK FUEL STATION ▷3
7	1	SUBMERSIBLE PUMP STAND
8	1	MCO BASKET QUEUE TABLE #4
9	1	MCO BASKET QUEUE TABLE #3
10	1	MCO BASKET QUEUE TABLE #2
11	1	MCO BASKET QUEUE TABLE #1
12	1	PRIMARY CLEAN SUPPORT TABLE
13	1	PROCESS TABLE SUPPORT #1
14	1	PROCESS TABLE SUPPORT #2
15	1	PROCESS TABLE SUPPORT #3
16	1	SUBMERSIBLE PUMP STAND ▷3 ▷4
17	1	DECAP/STUCK FUEL SUPPORT TABLE ▷3
18	1	EMPTY MCO BASKET SUPPORT STAND #1
19	1	EMPTY MCO BASKET SUPPORT STAND #2
20	1	EMPTY MCO BASKET SUPPORT STAND #3
21	1	EMPTY MCO BASKET SUPPORT STAND #4
22	1	EMPTY MCO BASKET SUPPORT STAND #5
23	1	EMPTY MCO BASKET SUPPORT STAND #6

Figure 2-2. Fuel Retrieval System Equipment Section Elevation.

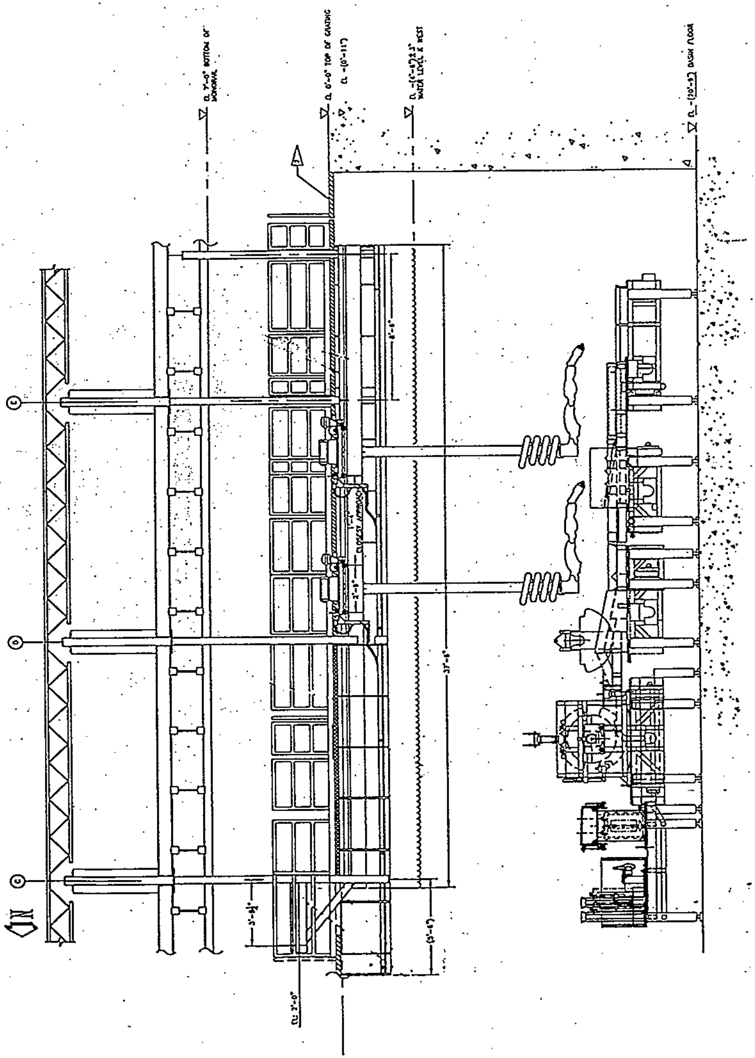


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Figure 2-3. Fuel Retrieval System Operation Schematic.

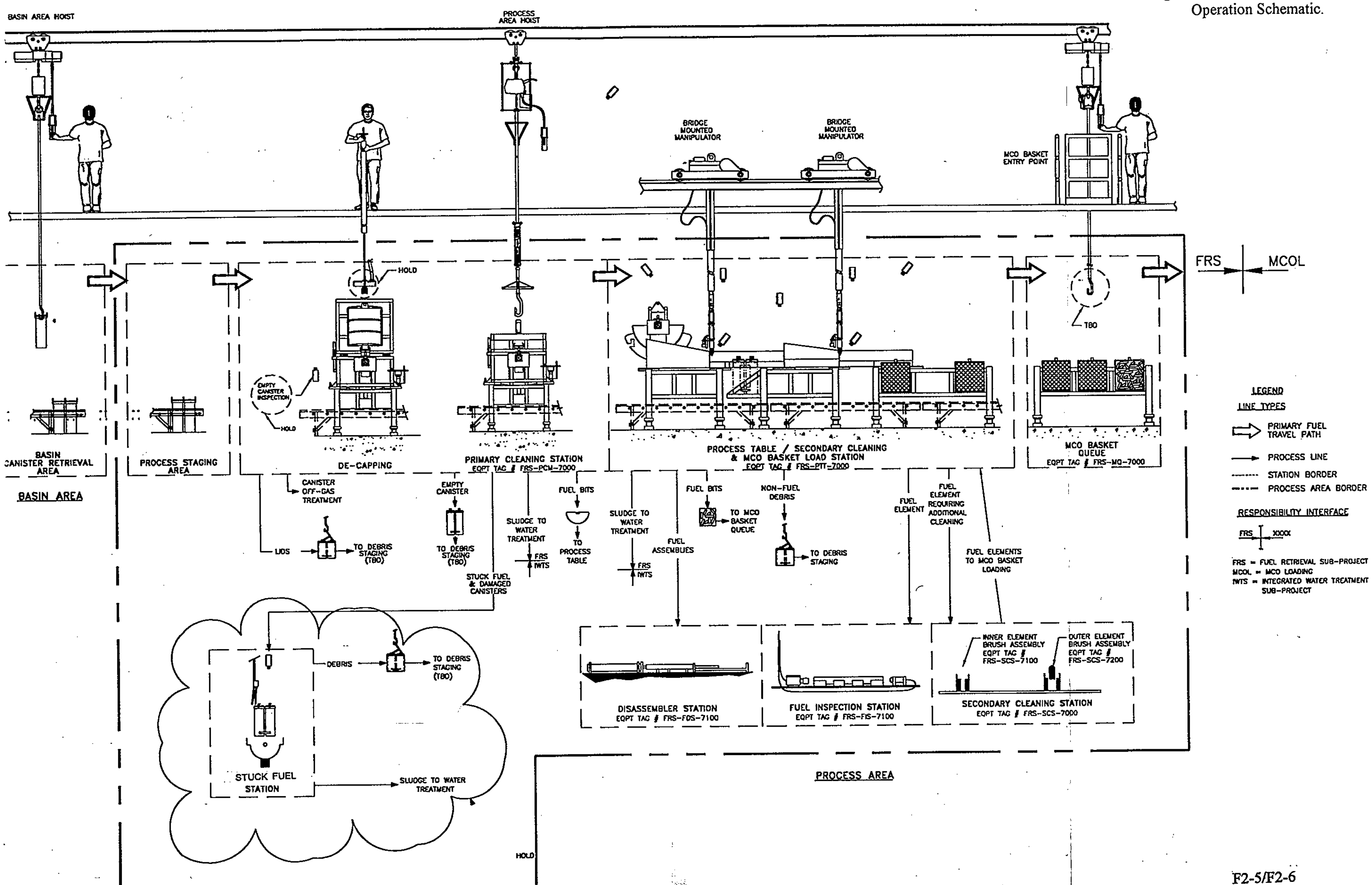


Figure 2-4. Existing Straight Canister Hook.

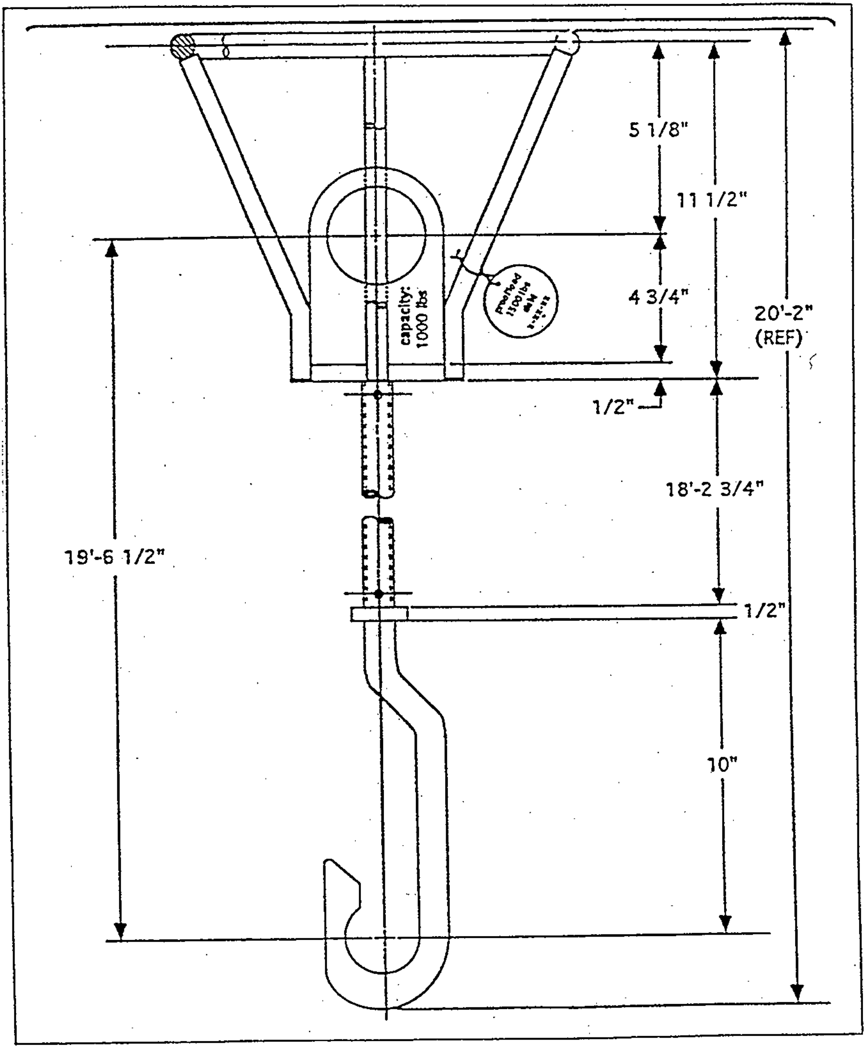


Figure 2-5. Existing Offset Canister Hook.

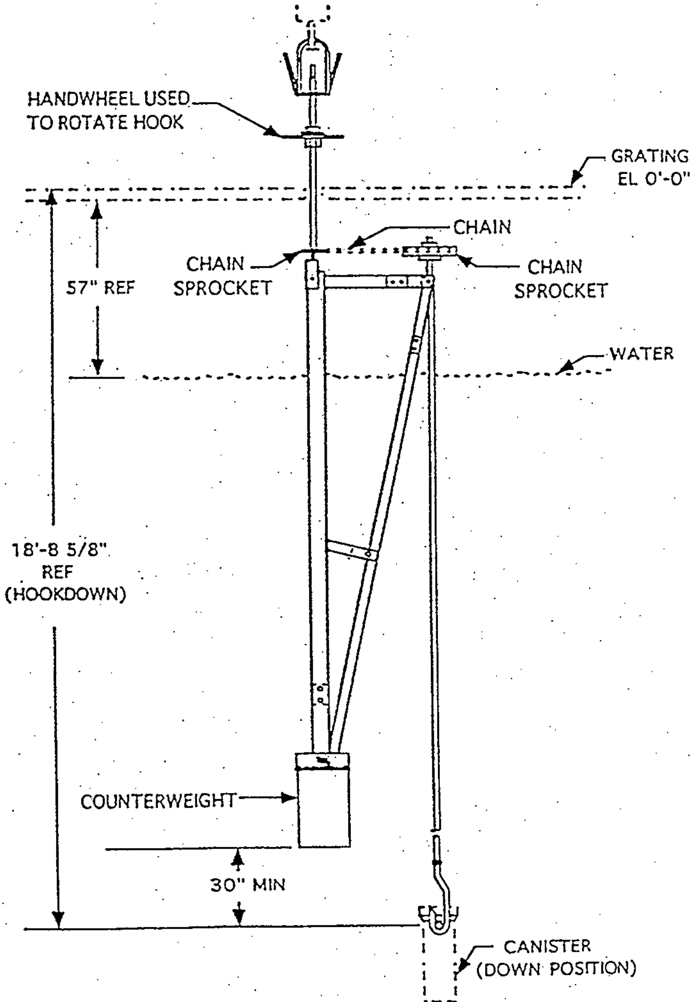


Figure 2-6. Telescoping Stiffback.

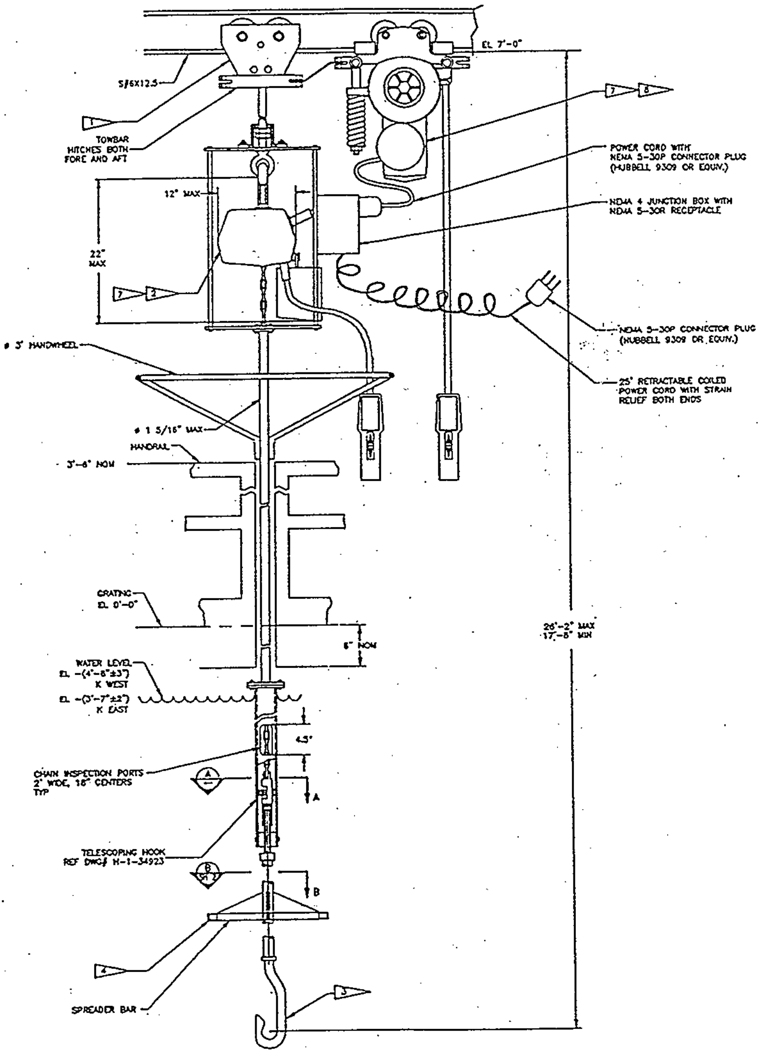


Figure 2-7. Canister Decapping Equipment.

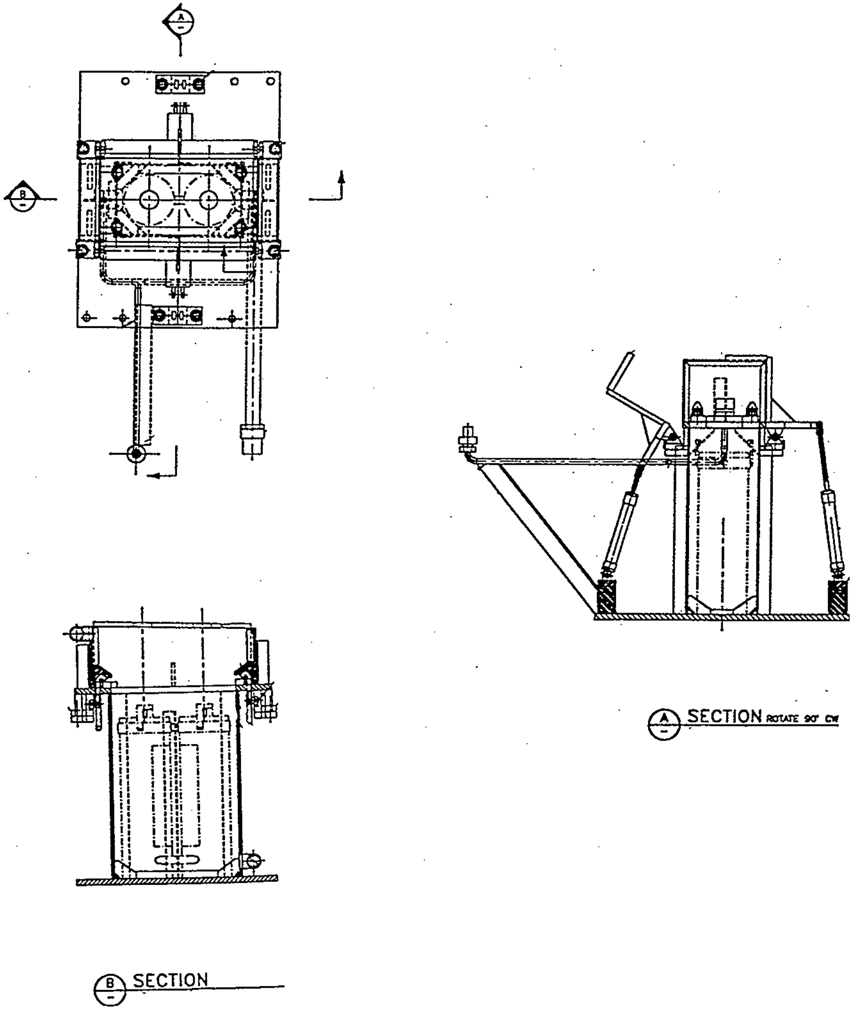


Figure 2-8. Canister Gas Handling Schematic.

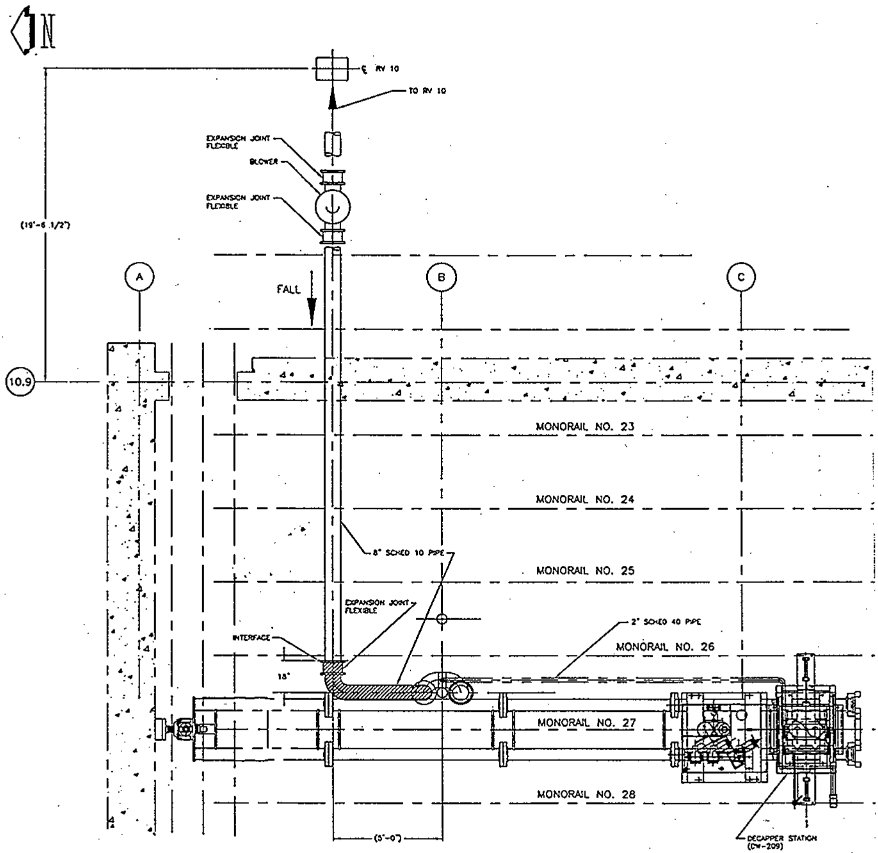


Figure 2-9. Primary Clean Machine.

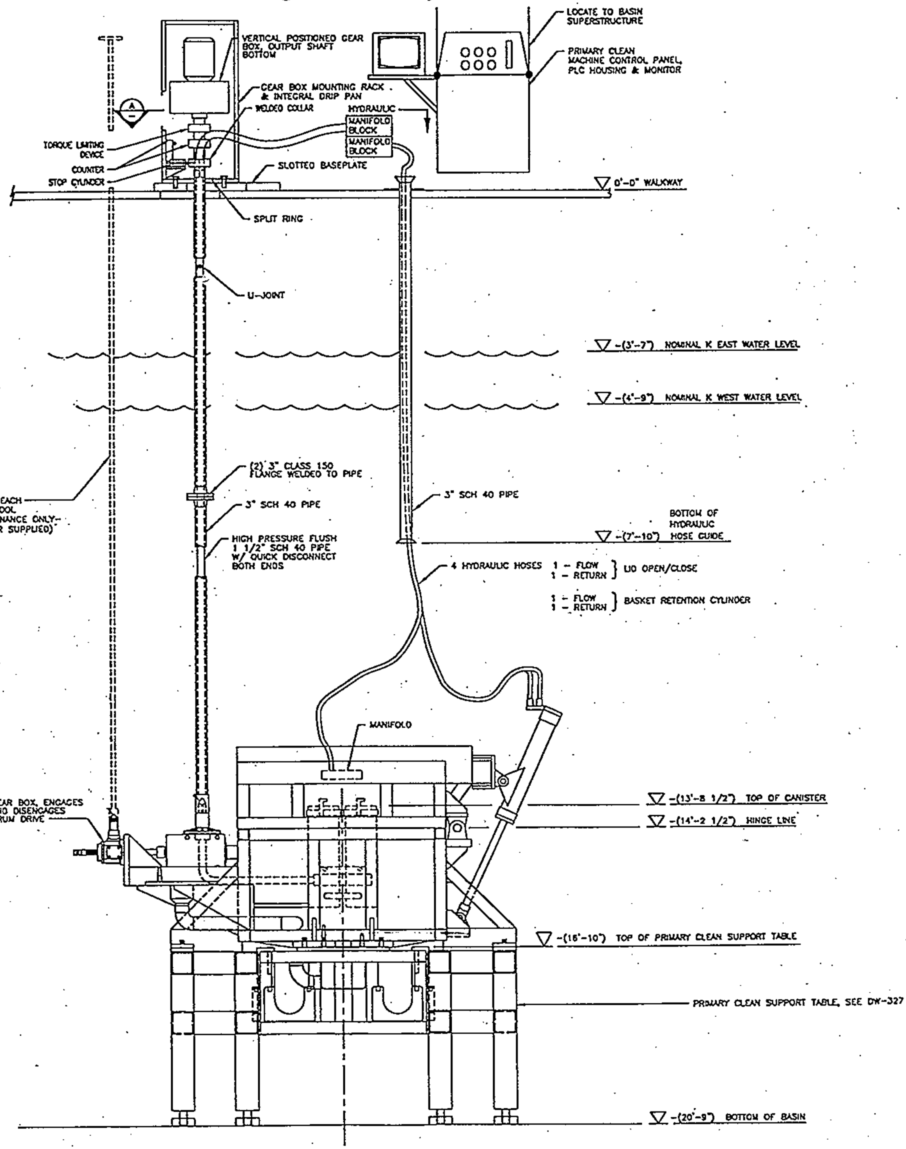


Figure 2-10. Stuck Fuel Equipment.

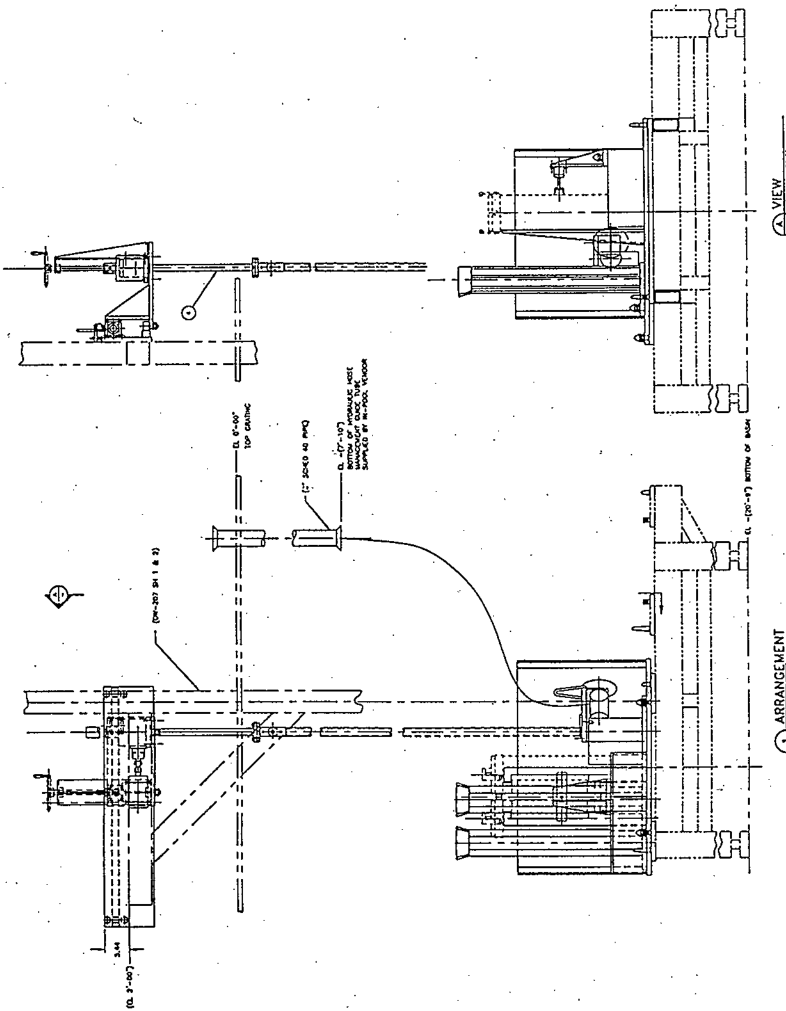


Figure 2-11. Process Table.

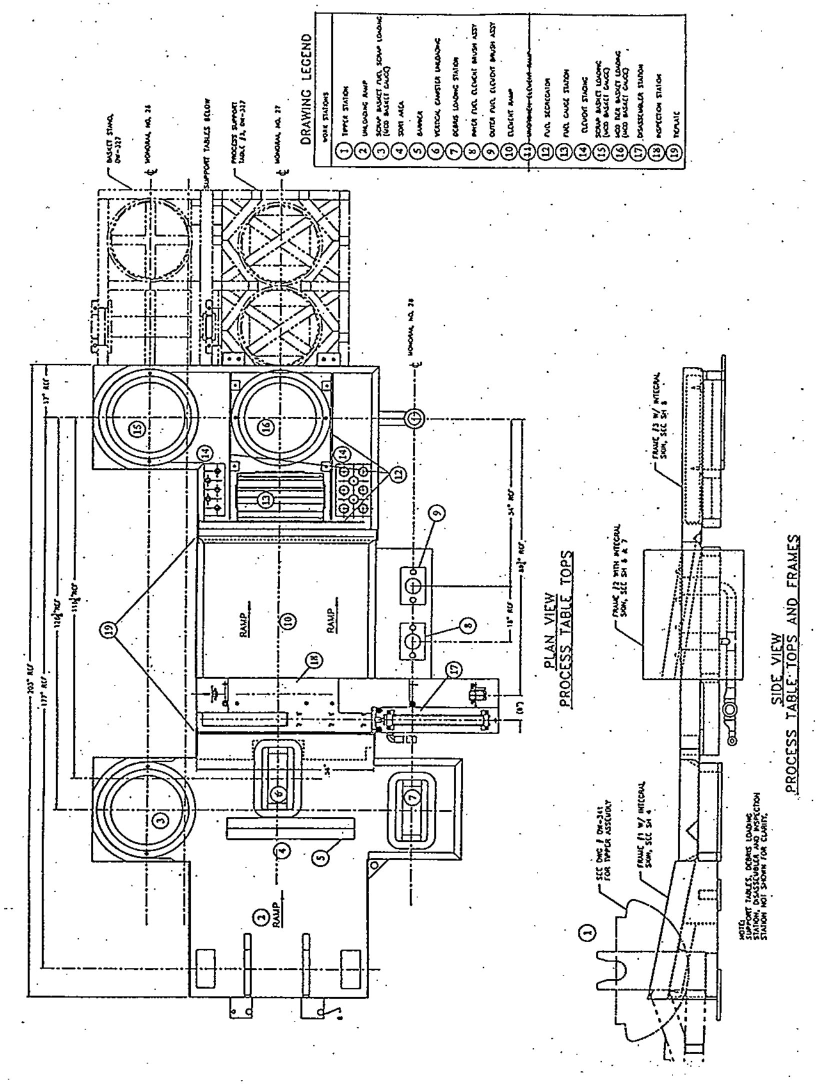


Figure 2-12. Debris Bin.

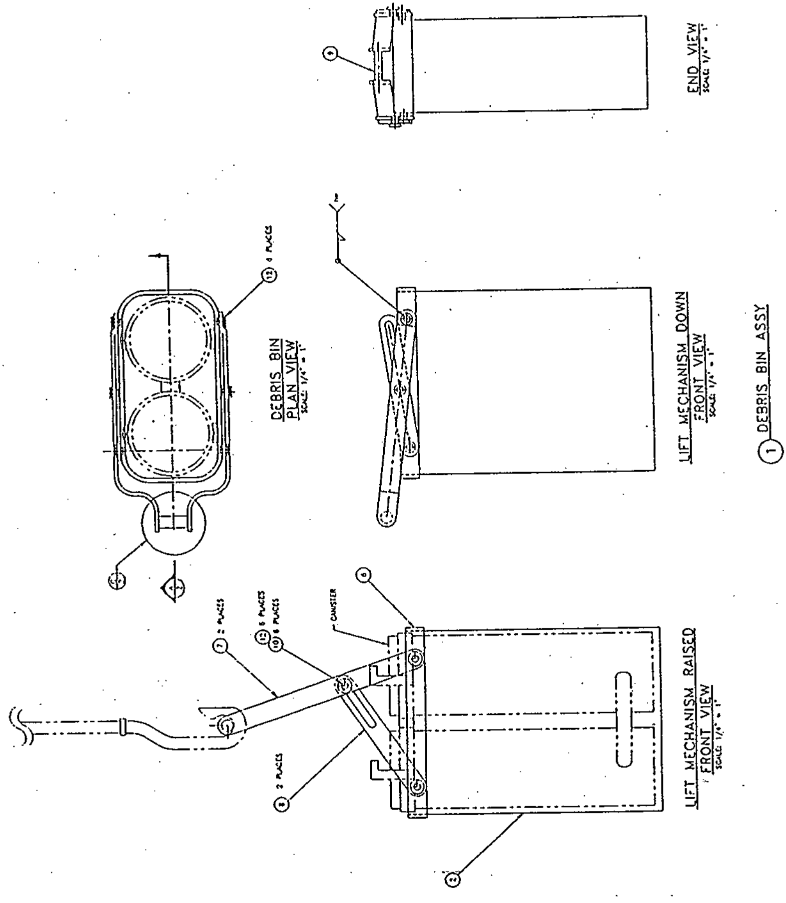
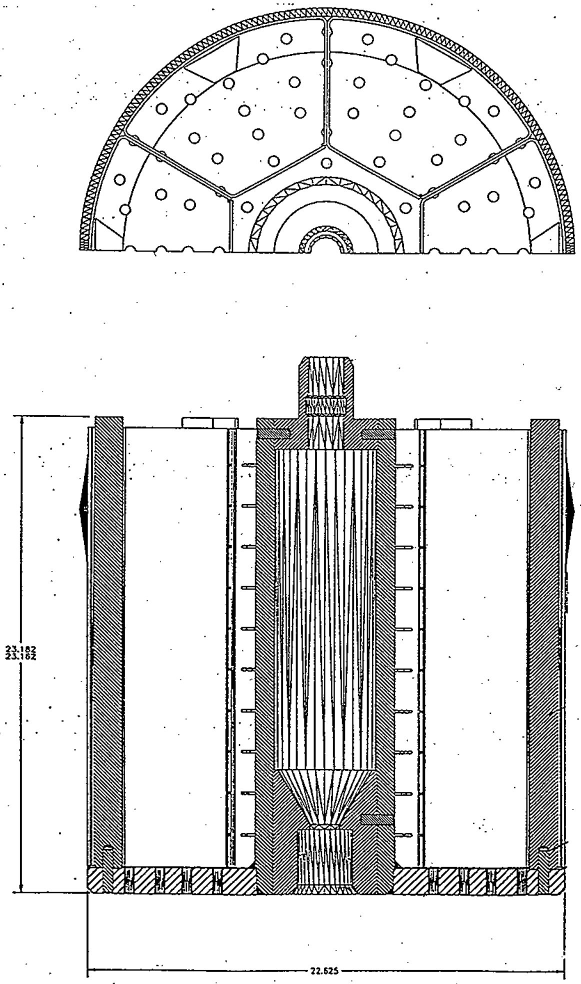
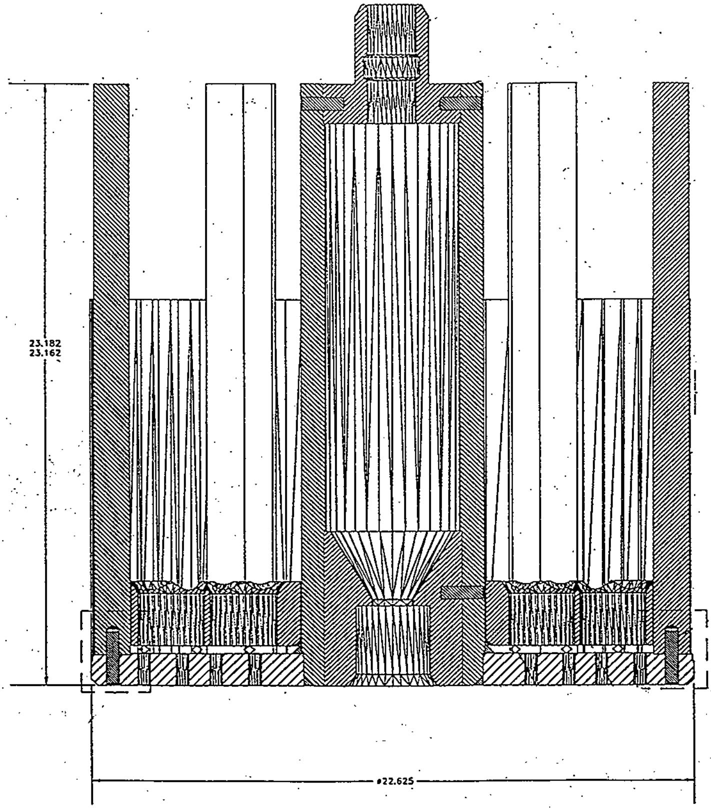


Figure 2-13. MCO Baskets. (sheet 1)



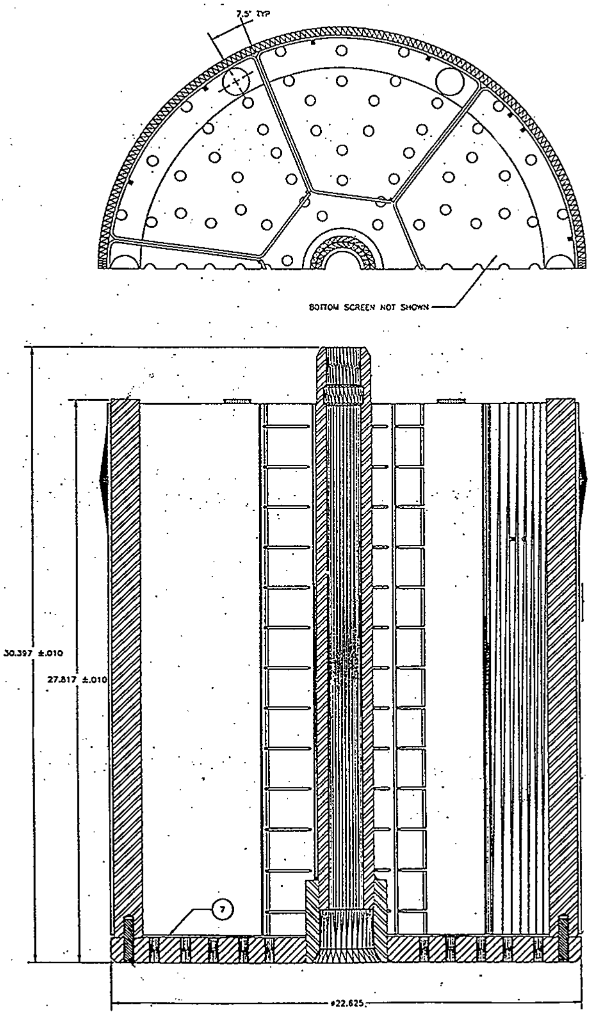
MARK IA SCRAP
BASKET

Figure 2-13. MCO Baskets. (sheet 2)



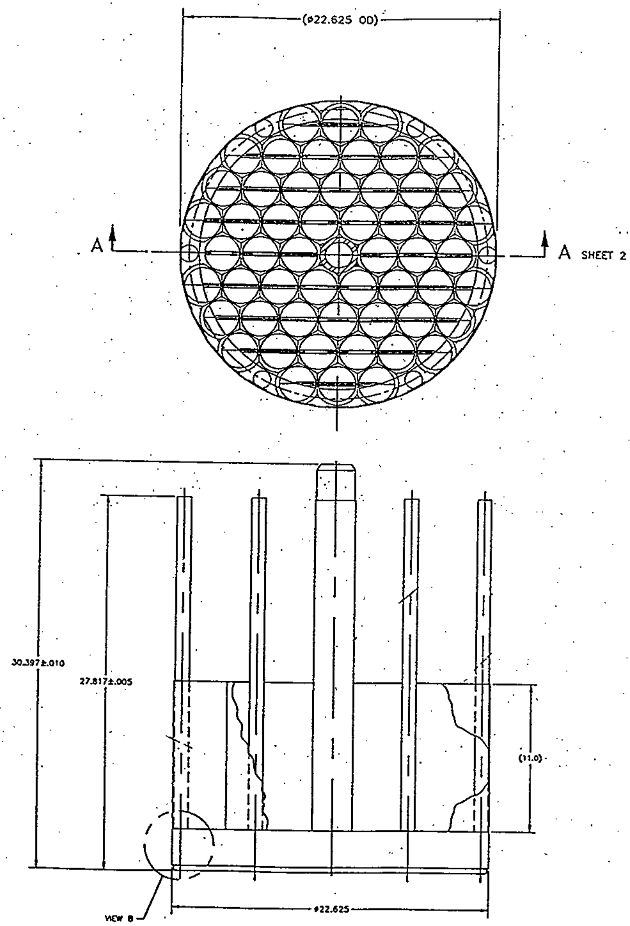
MARK IA ASSEMBLY
BASKET

Figure 2-13. MCO Baskets. (sheet 3)



MARK IV SCRAP
BASKET

Figure 2-13. MCO Baskets. (sheet 4)



MARK IV ASSEMBLY
BASKET

Figure 2-14. Multi-Canister Overpack Basket Stiffback Grapple.

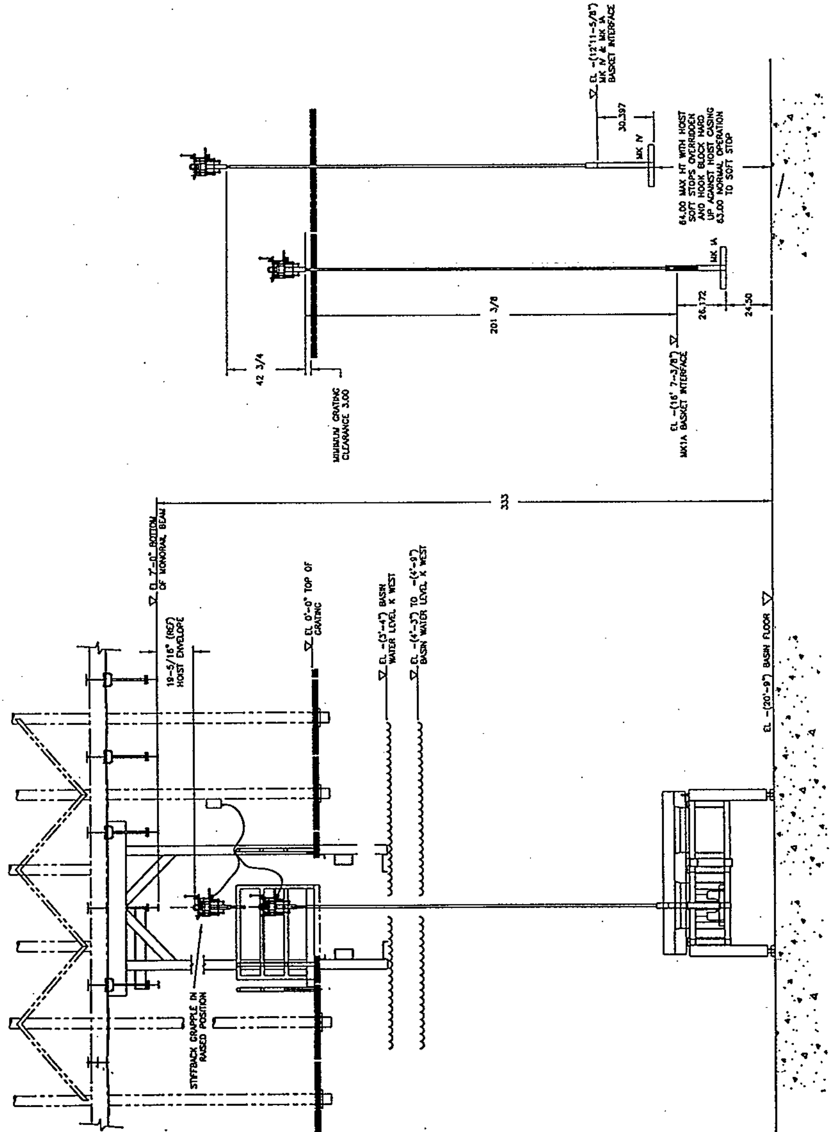
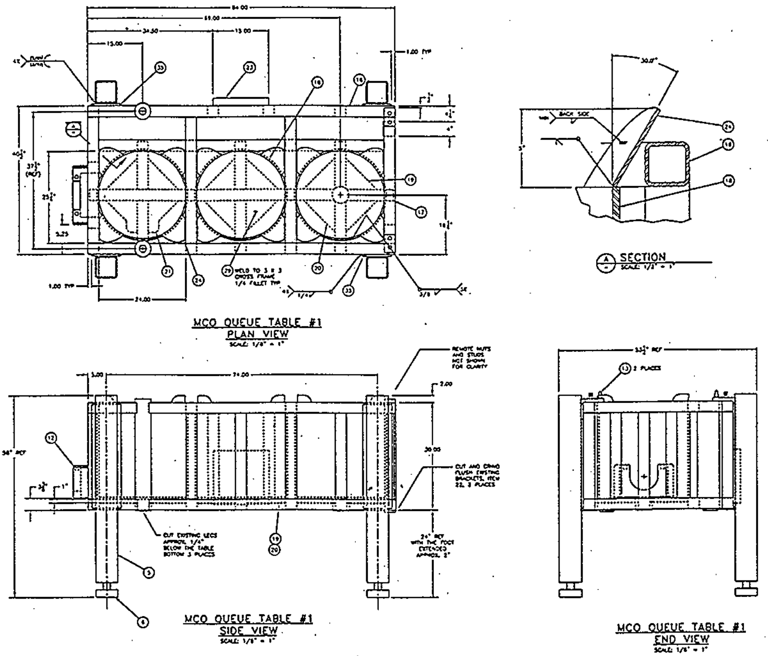
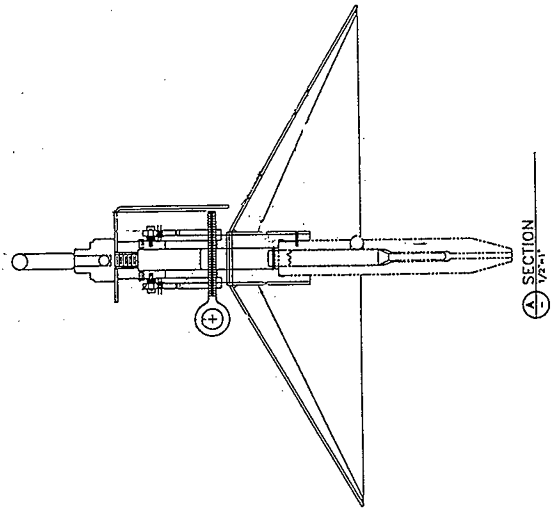


Figure 2-15. Multi-Canister Overpack Basket Queue.



TYPICAL

Figure 2-16. Empty Basket Grapple.



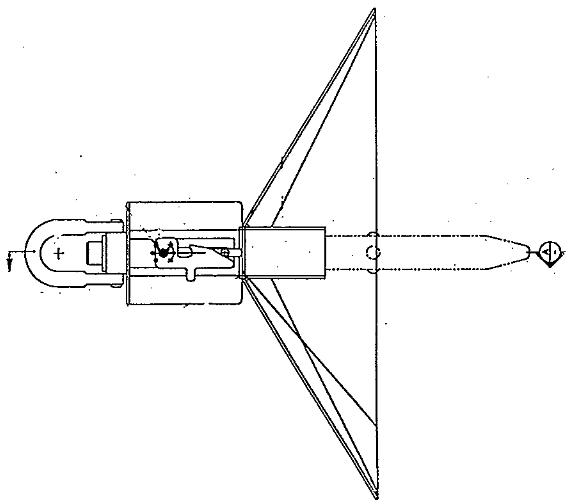


Figure 2-17. Fuel Storage Schematic.

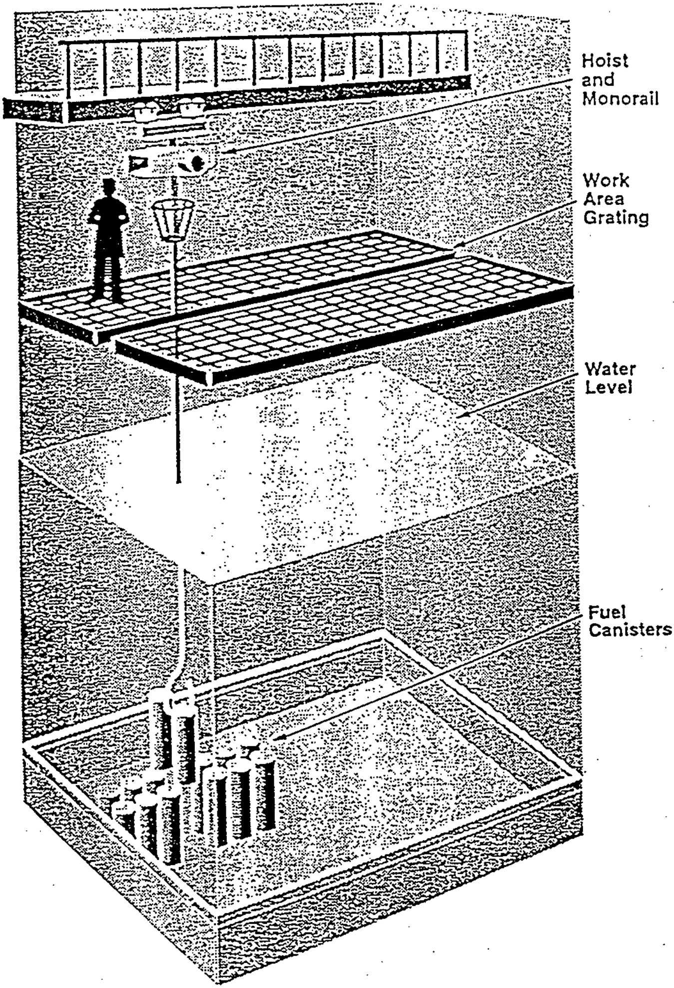


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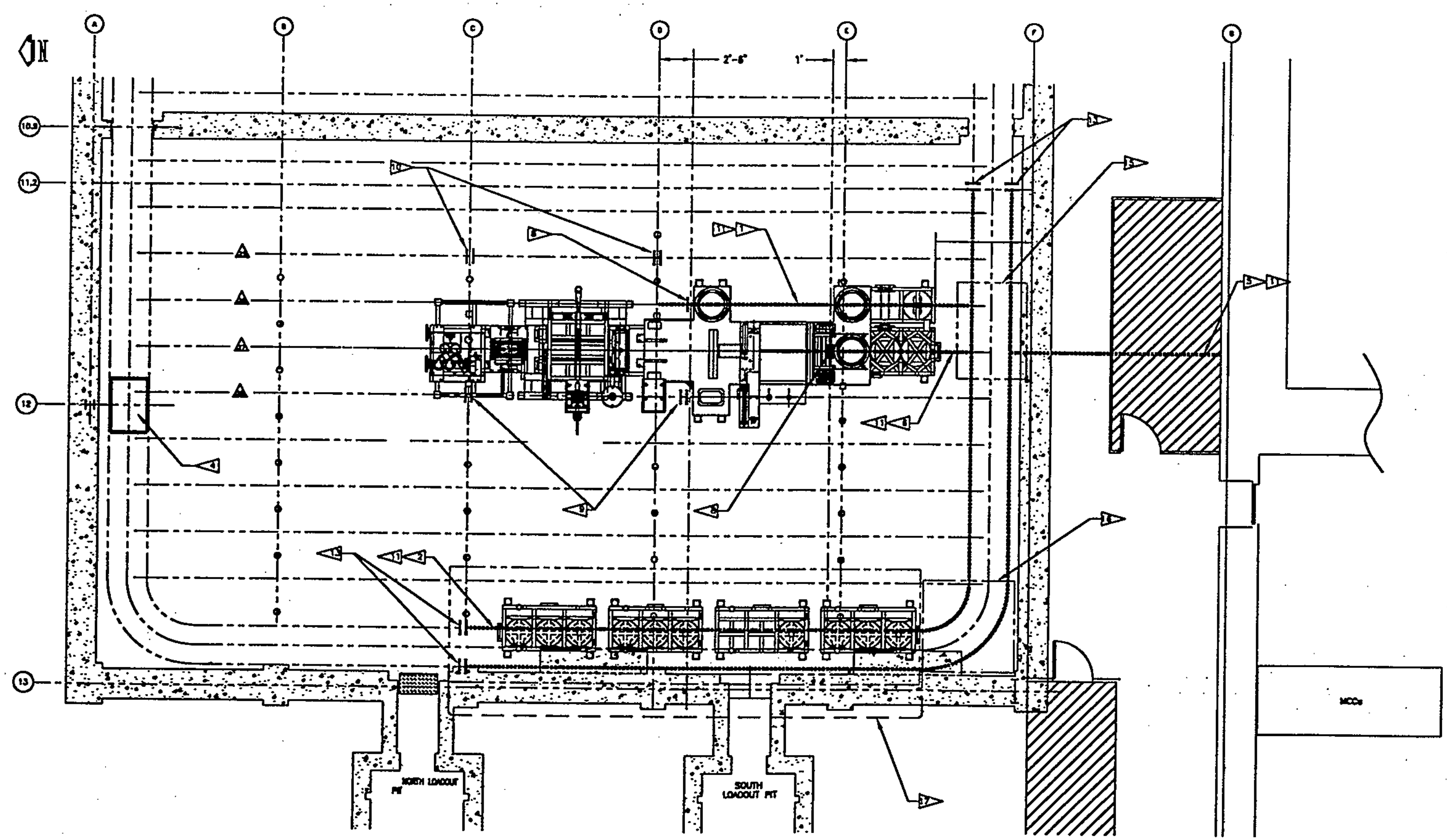
Figure 2-18. Monorail and FTC Upgrades.



LEGEND:

- UPGRADED MONORAIL/SUPPORTS OR UPGRADED FTC RAILS/SUPPORTS
- REMOVAL OF EXISTING BUILDING STRUCTURE
- EXISTING BARRIER
- COLUMN LINE
- MONORAIL LINES
- MONORAIL STOP

NOTES

1. UPGRADE MONORAIL AND SUPPORTS SOUTH OF COLUMN LINE D TO 4000 POUND RATED CAPACITY.
2. UPGRADE FLEXIBLE TRANSFER CRANE RAILS AND SUPPORTS SOUTH OF COLUMN LINE C AND WEST OF COLUMN LINE 11.2 AS REQUIRED FOR A FLEXIBLE TRANSFER CRANE HAVING A RATED CAPACITY OF 4000 POUNDS AS SUPPLIED PER SNF-FRS-SPC-004 AND DW-324.
3. ~~PROVIDE SUPPORTS AND INSTALLATION OF TRACTOR TRACK SUPPLIED PER SNF-FRS-SPC-004.~~
4. UPGRADE ALL EXISTING FLEXIBLE TRANSFER CRANES TO A 2400 POUND RATED CAPACITY WITH THE LOAD POSITIONED ANYWHERE ON THE CRANE BEAM (NOT WITHIN THE SCOPE OF THE FRS PROJECT- BY OTHERS).
5. INSTALL MONORAIL AND SUPPORTS FOR 4000 POUND RATED CAPACITY.
6. UPGRADE MONORAIL AND SUPPORTS SOUTH OF COLUMN LINE E AND 5' NORTH OF COLUMN LINE E TO 4000 POUND RATED CAPACITY.
7. ~~OPTIONAL 4000 LB MONORAIL ADDITION.~~
8. REMOVABLE MONORAIL STOPS TO BE PROVIDED AND INSTALLED BY THE A & E HANFORD CONTRACTOR. MONORAIL STOPS SHALL PROVIDE PHYSICAL SEPARATION BETWEEN 2400 AND 4000 POUND RATED RAILS ONE FOOT NORTH OF COLUMN LINE E ON MONORAIL 27 AND 2'-6" SOUTH OF COLUMN LINE D ON MONORAIL 26. EACH LOCATION SHALL HAVE 2 MONORAIL STOPS MOUNTED IN SERIES OF DIFFERENT DESIGN AND FAILURE MECHANISM.
9. REMOVABLE MONORAIL STOPS TO BE PROVIDED ON MONORAIL 28 TO ISOLATE TIPPER STATION AND PRIMARY CLEAN MACHINE DRIVE SYSTEMS FROM ACCIDENTAL COLLISON WITH PROCESS HOIST, LOCATE AT COLUMN LINE C AND 2'-6" SOUTH OF COLUMN LINE D.
10. REMOVABLE MONORAIL STOPS TO BE PROVIDED ON MONORAIL 25 TO ISOLATE THE LOCAL CONTROL PANEL FROM ACCIDENTAL COLLISION WITH HOISTS LOCATE AT COLUMN LINES C AND D.
11. THE MONORAILS AND FTC CRANE BEAM SHALL BE RATED FOR A 4000 LB CAPACITY BASED ON A 4-WHEEL TROLLEY (COFFING CT-40P, MT-40035, OR EQUIVALENT).
12. BEAM CLAMPS (COFFING BC-1 OR EQUIVALENT) WILL BE PROVIDED TO PROTECT PORTABLE EQUIPMENT IN THE GRATING SLOTS FROM INADVERTANT COLLISION WITH HOIST AND TOOLS ON MONORAIL SYSTEM. PROVIDE 20 BEAM CLAMPS TO PROTECT 4 CAMERAS AND 6 LIGHTS.
13. STOPS SHALL BE INSTALLED TO LIMIT THE RANGE OF MOTION OF THE 4000 LB FTC. RANGE OF MOTION FOR THE 2400 LB FTC SHALL BE UNAFFECTED.
14. NEW AND UPGRADED MONORAIL AND FTC SYSTEMS SHALL BE LOAD TESTED TO 125 % OF RATED CAPACITY PER DOE-RL-92-36.
15. THE FTC RAILS & SUPPORTS SHALL BE RATED IN ACCORDANCE WITH NOTES 2 & 11 WITH THE 4000 LB LOAD APPLIED BETWEEN MIDSPAN OF THE CRANE BEAM & THE MAXIMUM OFFSET TOWARD THE INSIDE FTC RAIL WITH HOIST AGAINST CRANE BEAM STOP (16" OFFSET FROM MIDSPAN). REFER TO DW-324 FOR FTC WHEEL LOCATIONS WHERE FTC CRANE BEAM IS ALIGNED WITH MONORAILS 26 & 27.
16. THE FTC CORNER RAILS & SUPPORTS SHALL BE RATED IN ACCORDANCE WITH NOTES 2 & 11 WITH THE 4000 LB LOAD APPLIED BETWEEN MIDSPAN OF THE CRANE BEAM & 6" OFFSET TOWARD THE INSIDE FTC RAIL.
17. THE STRAIGHT SECTIONS OF FTC RAILS & SUPPORTS ALONG THE WEST WALL SHALL BE RATED IN ACCORDANCE WITH NOTES 2 & 11 WITH THE 4000 LB LOAD APPLIED ANYWHERE ALONG THE FTC CRANE BEAM WITH HOIST AGAINST FTC CRANE BEAM STOP (16" OFFSET). REFER TO DW-324 FOR FTC WHEEL LOCATIONS WHEN THE FTC CRANE BEAM IS ALIGNED WITH MCO BASKETS CENTERLINE POSITION IN QUEUE.

3.0 HAZARD AND ACCIDENT ANALYSES

3.1 INTRODUCTION

This chapter accomplishes the following:

- Defines the processes used to identify and assess potential hazards associated with the fuel retrieval system (FRS) construction, maintenance, and operation

- Presents the results of the hazard identification and assessment process

- Develops those abnormal events and design basis accidents (DBA) that are representative of the potential conditions associated with the FRS construction, maintenance, and operation.

Specific topics covered include hazard identification, facility hazard classification, hazard evaluation, and accident analysis, including probabilities and consequences. The analyses were developed using a graded approach that considers the hazard magnitude, complexity of equipment and operations activities, and equipment life cycle.

The analyses presented in this chapter are for the unmitigated cases. Based on the consequences, requirements were developed for the equipment to reduce the frequency of occurrence or mitigate the consequences. The resulting equipment design features and controls are identified in Chapter 4.

3.2 REQUIREMENTS

The hazard and accident analyses developed for FRS comply with the U.S. Department of Energy orders, federal and sate regulations, and standards in the HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document* (DESH 1998a).

HNF-SD-SNF-RD-001 (DESH 1998a) identifies the set of requirements necessary and sufficient to adequately protect workers, the public, and the environment.

3.3 HAZARD ANALYSIS

This section describes the hazard identification and evaluation performed for construction and operation of the FRS equipment. A number of methods to identify and evaluate hazards were used throughout the FRS design effort. At the conceptual stage, two studies were performed:

- An energy source checklist to identify hazardous materials and energy sources

- A preliminary hazards analysis (PHA) checklist evaluation. The PHA was updated to evaluate the effect of equipment design changes.

The manipulator capacity was increased during the design process. Hazards associated with the larger capacity manipulator were evaluated using what-if analysis. Additional hazards analysis meetings were conducted to address detailed equipment designs for decapping and stuck fuel equipment. Other hazards identified during the detailed design and criticality analyses also have been addressed.

The safety analysis considers releases of radioactive and hazardous material during normal conditions, upset (abnormal, but anticipated) conditions, and accident (unlikely or extremely unlikely) conditions. Events that posed the highest potential risk or had the greatest consequence were chosen for analysis. Unmitigated onsite and offsite dose consequences for radiological material and toxic chemicals were calculated, as applicable. The consequences were compared with Table 3-1 to evaluate the risk level and establish the need for safety SSCs and TSRs. The radiological risk guidelines are given in terms of whole body effective dose equivalent (EDE) (rem) for the onsite and offsite receptors. The toxic chemical guidelines are given in terms of *Emergency Response Planning Guidelines* (ERPG) (AIHA 1990). The risk guidelines also are defined in terms of qualitative annual frequency of occurrence.

Table 3-1. Risk Evaluation Guidelines.[a]

Event frequency category	Event frequency (yr^{-1})	Radiological dose limits (rem)		Toxic chemical concentration limits	
		Onsite	Offsite	Onsite	Offsite
Anticipated	$0.1 - 10^{-2}$	1	0.5	ERPG-1	ERPG-1[b]
Unlikely	$10^{-2} - 10^{-4}$	10	5	ERPG-2	ERPG-1
Extremely unlikely	$10^{-4} - 10^{-6}$	25	5	ERPG-3	ERPG-2

[a]These guidelines are to be applied as step-functions. Guidelines are from Sellers, E. D., 1997, *Risk Evaluation Guidelines (REG) to Ensure Inherently Safe Designs*, letter 97-SFD-172 to H. J. Hatch, Fluor Daniel Hanford, Inc., dated August 26, 1997, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[b]Use the lower of ERPG-1, PEL-TWA or TLV-TWA.

ERPG = emergency response planning guideline.
PEL = permissible exposure limit.
TLV = threshold limit value.
TWA = time weighted average.

3.3.1 Methodology

This section presents the methodology used to identify, characterize, and evaluate the hazards associated with construction, maintenance, and operation of the FRS. The American Institute of Chemical Engineers (AIChE) *Guidelines for Hazard Evaluation Procedures* (AIChE 1992) defines a hazard in two ways: 1) an inherent physical or chemical characteristic that may cause harm to people, property, or the environment; 2) a combination of a hazardous material, operating environment, and unplanned event that might lead to an accident. Both definitions are considered when choosing hazard evaluation methods.

Potential hazards (combinations of a hazardous material, operating environment, and unplanned events) have been identified and qualitatively evaluated using the following processes:

- An energy source checklist
- A PHA study
- Several what-if analyses
- Specific design and criticality analyses.

3.3.1.1 Hazard Identification Methodology. Hazard identification is the process of highlighting material, system, process, and facility characteristics with the potential to initiate accidents having undesirable consequences. This section describes the methodologies used to identify potential hazards for the construction, maintenance, and operation of the FRS equipment.

3.3.1.1.1 Energy Source Checklist. To ensure that accident-initiating events that could result from intrinsic hazards were not omitted, an energy source checklist adapted from *Job and Task Analysis*, DOE-76-45-19 (DOE 1979), was used. Table 3A-1 in Appendix 3A provides the results of the review. Additional changes have been made to this table following the initial review to reflect changes in design or comments received during reviews. Changes are identified in the table.

3.3.1.1.2 Preliminary Hazards Analysis Methodology. The PHA is a systematic approach in which hazardous conditions associated with fuel retrieval activities are postulated by an experienced multidiscipline team familiar with the FRS design and K Basin operations and safety. Hazard identification involves formulating a list of hazardous conditions based on the following considerations: (1) raw materials and their intrinsic hazards, (2) plant equipment and facility layout, (3) operating environment, (4) operational activities including testing and maintenance, and (5) interfaces among system components that can produce undesirable consequences or accidents. Hazard evaluation is the analysis of the hazardous situation associated with the activity or accident using qualitative techniques to determine the importance of the hazard and the need for prevention and mitigation. The FRS PHA was completed by a team of knowledgeable individuals representing organizations responsible for various aspects of the FRS.

A PHA is a form-driven method of hazards evaluation where the results of the evaluation are entered on a form to help ensure that a systematic approach is followed. Using a form also helps describe the hazardous conditions consistently for comparison purposes. The completed form is presented in Table 3A-2 in Appendix 3A.

For each operation in the FRS, the team postulated potential hazardous conditions. Each hazardous condition was recorded in one or more lines on the form. The form includes the following columns.

- The "Process step" column records the SNF retrieval activity being discussed.
- The "Hazardous condition" column qualitatively describes an accident that could result from the combination of hazardous material and an abnormal condition.
- The "Cause" column describes a cause for the condition.

The hazard analysis checklist in Table 3-2 was used during the PHA process to stimulate discussion and ensure that the hazard identification activities were thorough.

Table 3-2. Hazards Analysis Checklist.

Hazards
• Internal radiation dose • Criticality • Loss of shielding • Loss of liquid containment • Ventilation • Fire • Explosion • Maintenance problem • Impact • Loss of utilities • Corrosion or erosion • Extreme weather • Seismic event • Toxicity • Construction hazard

3.3.1.1.3 What-If Methodology. In subsequent hazards analysis meetings addressing the design change to the manipulator and the initial design of the stuck fuel, decapping, and gas collection equipment, what-if methodology was used to define and evaluate the hazards. The what-if technique is a group effort in which questions about abnormal events in a system or process are posed. The questions are then answered and used to postulate various accidents. The form used is presented in Appendix 3A, 2 3A-3.

For each piece of FRS equipment evaluated, the team postulated potential what- if conditions. Each condition was recorded in the first column on the form. The "Accident" column describes an accident that could result from the what-if condition. The "Remarks" column was used to document action items, recommendations, or other pertinent items. The remaining columns are used to document the evaluation of the accident condition.

The team used the hazard analysis checklist in Table 3-2 to identify the hazards for the what-if analysis. Specifications, interfaces, design drawings, and system descriptions were used in combination with team knowledge of K Basin operations and FRS design to perform the what-if analysis.

3.3.1.2 Hazards Evaluation Methodology. Hazards evaluation determines the significance of hazardous situations associated with an activity using qualitative techniques. Tables 3A-2, 3A-3, 3A-4, and 3A-5 in Appendix 3A document the evaluation. The evaluation identifies the consequences of the event and associated findings using the following columns:

- The "Consequence" column qualitatively describes the consequences of a given hazardous condition.
- The "Frequency category" column lists the estimated frequency of occurrence.
- The "Engineered safety features" column lists equipment that helps prevent or mitigate the consequences of the hazardous condition. The items in this column are candidates for designation as safety-class or safety-significant structures, systems, and components (SSC), depending on the consequence severity.
- The "Administrative features" column lists administrative controls that assist in preventing the hazardous condition or mitigating its consequences. These features are candidates for technical safety requirements (TSR).
- The "Inventory" column (used only in the PHA) is a qualitative description of the hazardous material that might be discharged to the environment as a result of the hazardous condition.

The consequence categories of the hazardous conditions are defined in Table 3-3. The frequency of the cause of the hazardous condition is ranked qualitatively as defined in Table 3-4. The frequencies are separated into four categories (anticipated, unlikely, extremely unlikely, and beyond extremely unlikely). Frequency categories were not developed for the what-if analysis.

Table 3-3. What-if Safety and Environmental Consequence Severities.

Rank	Consequence severity
S0	No significant effects on persons or the environment.
S1	Facility worker injury or exposure to hazardous materials; reportable release of hazardous materials within or near the facility.
S2	Hazardous material exposure to a person (collocated onsite worker) at a distance from the facility; significant hazardous material discharge outside the facility.
S3	Hazardous material exposure to a person (member of the public) at a distance from the facility; significant hazardous material discharge offsite.

Table 3-4. Frequency (f) Ranges.

Rank	Description	Frequency range
F0	Beyond extremely unlikely	$f < 10^{-6}$/yr
F1	Extremely unlikely	10^{-6}/yr $< f \leq 10^{-4}$/yr
F2	Unlikely	10^{-4}/yr $< f \leq 10^{-2}$/yr
F3	Anticipated	10^{-2}/yr $< f < 10^{-1}$/yr

3.3.2 Hazard Analysis Results

This section presents the results of the FRS hazard analyses performed for the Fuel Retrieval Subproject. Section 3.3.2.1, "Hazard Identification," discusses the hazards identified for the Fuel Retrieval Subproject. Section 3.2.2.2, "Hazard Classification," discusses the impact of the Fuel Retrieval Subproject on the hazard classification for the K Basin facility. Section 3.2.2.3, "Hazard Evaluation," discusses the results of the evaluation for the identified hazards.

3.3.2.1 Hazard Identification. Table 3A-1 of Appendix 3A, lists the intrinsic hazards related to the FRS construction, maintenance, and operation. These intrinsic hazards were used to help identify specific hazards associated with the FRS activities. Table 3A-2 lists the hazards identified during the hazard analysis update to the initial PHA. Tables 3A- 3, 3A-4, and 3A-5 list the hazards identified during the what-if analyses associated with the manipulator system upgrade (Table 3A-3), stuck fuel and decapping equipment (Table 3A-4), and decapping equipment exhaust system (Table 3A-5). Tables 3-5 and 3-6 summarize the hazard and operability items considered.

Table 3-5. Summary of Category S2 and S3 Hazards and Operability Items. (2 sheets)

Category Estimated Frequency	Device/process parameter	Description
Up to S2 F1	Decapping equipment, primary clean machine, stuck fuel	Scrap and fines accumulation or exposure of uranium hydrides causes an energetic chemical reaction releasing contaminated gas bubble.
S2 F1	Empty MCO basket staging/MCO basket stiffback	Basket with fuel is removed from the water at the empty- basket staging location. Increased dose to personnel caused by unshielded fuel. A fuel fire results from exposure of damp, damaged fuel to air. Airborne contamination is released from the building.
S1/S2 F3	Equipment drop	Heavy object falls in basin causing damage to safety-class equipment.
S1/S2 F2	Seismic event (all equipment)/ equipment drop	Seismic event causes equipment to tip or be damaged or heavy loads to drop, damaging safety-class equipment or spilling fuel and causing a criticality. This event includes drops during normal operation.
S1/S2 F2	Excessive fuel accumulation (all equipment)	Poor controls, control violation, loss caused by manipulator drops or equipment failure results in fuel accumulation, causing criticality.
Up to S2 F1	Stuck fuel equipment	A fuel assembly is scored or heated by cutter. Uranium and zirconium fines are generated or uranium hydroxide is exposed, causing an energetic chemical reaction releasing contaminated gases.

MCO = multi-canister overpack.

Table 3-6. Summary of Category S1 Hazards and Operability Items. (2 sheets)

Category/ estimated frequency	Deviation/process parameter	Description
S1 F3	All equipment	Canister-handling equipment or other manual tools collide with FRS equipment. Personnel injury; repair increases dose to personnel.
S1 F3	Decapping equipment	Roof vent 10 motor or fan fails. Krypton accumulates in the basin, increasing dose to personnel.
S1 F2	Decapping equipment	The gas collection system fails. Hydrogen and krypton accumulate in the vent system. Results in fire and/or increased dose to personnel.

Table 3-6. Summary of Category S1 Hazards and Operability Items. (2 sheets)

Category/ estimated frequency	Deviation/process parameter	Description
S1 F3	Decapping equipment	Radioactive krypton released from canisters during decapping causes personnel dose.
S1/S0 F3	Decapping equipment	Contaminants accumulate in the vent system from precipitation on piping when water droplets evaporate. Causes increased dose rate from equipment or duct work.
S1 F2	Decapping equipment	The water inlet holes to the gas collection pipe are plugged. Water flow into the decapping station from other inlets is increased. Gas bubbles are not scrubbed as planned, causing a slight rise in contaminants in the gas stream.
S1 F2	Decapping, primary cleaning, and stuck fuel equipment	Equipment failure, leakage, or misoperation causes some sludge and/or canister liquid to be discharged directly to the basin instead of to the integrated water treatment system. Small increase in dose to personnel.
S1 F3	Hydraulic system and hydraulically operated equipment	The hydraulic system develops a spray leak, leaks fluid, and changes the chemistry of basin water, affecting water treatment and exposing personnel to chemical, and causing potential injury from pressurized spray.
S1 F3	Manipulator operation	Fuel chips lodge in the arm, causing high dose rates during maintenance.
S1 F3	Manipulator operation	The manipulator contacts FRS equipment or manual tools. Force of impact injures operator; repairs cause additional dose to personnel.
S1 F3	Manipulator operation	The manipulator hits a camera or other underwater equipment, such as lighting, causes electric shock.
S1 F1	Manipulator operation	The arm lifts a fuel element too close to the water surface. The reduced shielding causes a higher than normal radiation dose rate.
S1 F1	Manipulator operation	The arm throws an element out of the water and onto the grating, causing high dose rate in the basin area.
S1 F2	Manipulator operation	The manipulator is activated during maintenance and moves unexpectedly, causing injury.
S1 F2	Stuck fuel equipment	The cutter motor starts during a change of cutter blades. The motor spins, causing equipment to strike the operator.
S1 F3	Stuck fuel equipment	The cutter encounters a sludge pocket and stirs the sludge, adding alpha contamination to the basin water. Increases basin dose rate.

3.3.2.2 Hazard Classification. The hazard classification of K Basins fuel storage in the 100-K Area of the Hanford Site has been established and documented in *K-Basin Fuel Encapsulation and Storage Hazard Categorization*, WHC-SD-SNF-HC-001 (Porten 1994). This hazard categorization addressed the potential for releasing radioactive and nonradioactive hazardous material located within the K Basins and their supporting facilities. The following activities were covered by this analysis: normal K Basin fuel storage and handling operations, fuel encapsulation, and canister clean-up and disposal.

This hazards categorization was performed using the methodology and criteria found in *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92. Porten (1994) determined that the K Basins should be considered a hazard category 2 facility, i.e., a facility in which the "Hazard Analysis shows the potential for significant on-site consequences" (DOE-STD-1027-92).

Activities performed by the FRS operations are similar to those covered by the K Basin hazard analysis (Porten and Crowe 1994). The FRS operation activities do not change the hazard category of the K Basins because neither the maximum amount of fuel stored in the basins nor the form of the fuel is changed.

The FRS fuel handling will not add any toxic substances. The toxicological risk from accidents associated with the fuel are bounded by the radiological risks (FDNW 1998b).

3.3.2.3 Hazard Evaluation. Hazards identified by the PHA were evaluated to determine the following:

- Define the event's causes and identify its consequences
- Identify possible engineered safety features that could prevent the hazards or mitigate their consequences
- Identify possible administrative features that could prevent the hazards or mitigate their consequences, and define the material at risk.

The evaluation also established consequences and frequency categories for each hazard based on the team's experience.

The evaluation of the hazards identified by the what-if process differed from the PHA in the following ways. The cause of the hazard is inherent in the what-if condition so causes did not require separate identification. The material at risk and the frequency of occurrence of the what-if condition were not developed and a different ranking system was used to establish the severity (consequence category) of the what-if hazards. The results of the hazard evaluations are documented in Appendix 3A in Table 3A-2 for the updated PHA and in Tables 3A-3, 3A-4, and 3A-5 for the what-if analyses.

The consequence and frequency categories were established conservatively based on the available knowledge at the time of the evaluation. These consequence and frequency categories would be rated less severely for many cases based on the current design and safety analysis (particularly criticality analysis). In addition, several hazards identified or comments made in the hazards analysis no longer apply because design or process changes have been made or different limits imposed. In some cases, updates have been made to the content of the historical hazard analysis results included in Appendix 3A to improve accuracy or complete missing information. The results of the hazard analysis have been reviewed to ensure that they reflect the design as it has evolved.

Following the evaluation, the hazards identified were reviewed to develop a summary list of hazards. Many hazards were typical for several pieces of equipment and many hazards had similar consequences. Table 3-5 summarizes category S2 and S3 events having potentially significant safety consequences. No S3 events were identified in the hazards analysis. The category and frequency estimates are unmitigated estimates. With mitigation, the consequences would be less serious. Table 3-6 summarizes category S1 events. Category S0 events were not summarized. Design and process changes were taken into account when the event summaries were developed.

3.3.2.3.1 Planned Design and Operational Safety Improvements. The FRS is a planned improvement for the K Basins to facilitate removal of the spent nuclear fuel. The FRS design incorporates many designed features intended to provide protection from hazardous conditions. No design or operational improvements are planned for the FRS equipment.

3.3.2.3.2 Defense in Depth. This section summarizes significant aspects of defense in depth as applied to the FRS equipment. Defense in depth consists of multiple features (equipment and administrative) relied on for accident prevention or mitigation to a degree proportional to the hazard potential (likelihood and consequences). Defense in depth includes administrative programs to ensure that features continue to be available for accident prevention or mitigation and administrative programs that promulgate a particular set of safety practices. In *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94, defense in depth includes identifying safety-significant SSCs and other items needing TSR coverage.

In conjunction with the facility design, FRS equipment design is the most important component of the defense-in-depth strategy for protecting workers, the public, and the environment. Specific FRS design features and controls that implement defense in depth include the SSCs with the following functions:

- Water cover over fuel and sludge to prevent uncontrolled release of radioactive material and protect workers from excessive radiation doses

- Safety-class geometric controls to prevent criticality events caused by heavy load drops and seismic events for fuel in storage

- Administrative controls implemented through the K Basin criticality prevention program prevent criticality events during fuel-handling activities
- Rails stops, interlocks, and bumpers to control movement of heavy loads to prevent drops
- Monorails, hoists, flexible transfer crane and rigging minimize possibility of load drops
- Administrative controls on lifting and moving heavy loads to prevent drops
- Administrative controls to prevent heavy loads from being moved over canisters containing fuel[1]
- Equipment that prevents lifting the PCM wash basket and canisters out of the basin water
- Safety-class equipment that prevents accidental removal of MCO baskets with fuel from the basin to prevent excessive worker dose and fuel burns
- Safety-significant equipment that prevents uncontrolled drops of the manipulator support system
- Area radiation monitor system that provides an indication of increasing dose level to allow corrective actions to minimize worker exposure.

The FRS safety equipment list identifies the items that have been designated as safety class or safety significant based on the accident consequences and the requirements of Table 4A-1. The FRS safety-class and safety-significant items are listed in Table 3-7, along with an indication of the safety concern. The nonsafety items are listed in Table 3-8.

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[1]Because the basin floor is covered with fuel racks and the racks are not going to be removed, heavy loads will by necessity be moved over fuel racks. Dropping of heavy loads on these racks has been analyzed as acceptable in this safety analysis document. The last bullet of Section 3.3.2.3.2 of the K Basin SAR (DESH 1998b) credits administrative controls with preventing heavy loads from being over the racks and canisters. This bullet will need to be revised accordingly when the FRS equipment impacts are included in the K Basin final SAR (DESH 1998b).

Table 3-7. Fuel Retrieval System Safety Equipment List
(Safety Class and Safety Significant).

System/subsystem	Safety classification
Primary clean machine lower half and support structure (criticality)	Safety class
Process table support structure and MCO basket containers (criticality)	Safety class
MCO basket queue (criticality)	Safety class
MCO basket stiffback[a] (fire/airborne release)	Safety class
Empty MCO basket grapple[a] (fire/airborne release)	Safety class
Manipulator rail support structure tether system (penetration of basin floor)	Safety significant[b] 3 over 1

[a]See discussion of safety-class features in Chapter 4.

[b]The tether system was classified, designed, and procured as safety significant based on the safety classification that existed at the time. Under the current criteria, this would be a safety-class device.

Defense in depth also is linked to the overall safety management programs that directly control operation at the K Basins. These include the following:

- Procedural restrictions or limits imposed
- Manual monitoring of critical parameters
- Responses or actions counted on to limit abnormal conditions, accident progression, or potential personnel exposure.

On an activity basis, defense in depth includes job hazard and safety analysis for activities, prejob safety meetings for nonroutine or infrequent tasks, worker training and qualification, procedures, good housekeeping, and a feedback and lessons-learned program.

Preventive and mitigative programs and measures protect the public, as well as the facility workers. These include the K Basins criticality safety program, the radiation protection program, the industrial safety and industrial hygiene programs, procedures and training, and the conduct of operations program. The area radiation monitors warn the facility workers in real time of loss of shielding and contribute to defense in depth.

Table 3-8. Fuel Retrieval System General Services Equipment List.

System/subsystem	Safety classification
Stuck fuel equipment	General Services
Decapping equipment, decapping equipment ventilation system	General Services
PCM upper half, PCM control system	General Services
Process table top and appurtenances	General Services
Manipulator, manipulator trolley, manipulator control system, manipulator hydraulic power system, manipulator rail support structure	General Services
Monorail, flexible transfer crane upgrades, including rails stop, bumpers, interlocks and control system, fuel retrieval system-provided hoists	General Services
CCTV system and equipment operations center equipment	General Services
Empty MCO basket tables	General Services

CCTV = closed-circuit television.
PCM = primary clean machine

3.3.2.3.3 Worker Safety. Worker safety for the installation and operation of the FRS equipment is ensured by a combination of design safety features, shielding, and institutional practices. Designed equipment-lifting features and installation procedures will provide for safe installation. The FRS equipment is designed to store and handle radioactive spent nuclear fuel in a configuration and manner that protects workers, the public, and the environment. The FRS mass fuel storage equipment (PCM, process table MCO basket supporting structure, and MCO basket queue) is designed to withstand the effects of an earthquake and heavy-load drops. Worker protection features for specific hazards were addressed in the hazards analysis. There are no unique hazards involved with fuel retrieval activities outside the scope and controls of the existing K Basin programs. The FRS was reviewed for ALARA considerations to determine the adequacy of the design features used to protect personnel from exposure to radiological sources.

The activity job hazard and safety analysis and prejob safety meetings provide the workers with information for identification and control of hazards. The control of hazards is accomplished using engineered controls, administrative controls, work restrictions, and/or personnel protective equipment. K Basin administrative procedures requires job hazard analyses as part of the job planning. The K Basin SAR, (DESH 1998b), identifies the typical worker safety hazards addressed by the job hazards analysis. Comments and clarification to the draft Appendix E of the fire hazards analysis have been provided to the cognizant engineer of the fire hazards analysis for incorporation into the next revision. No worker safety issues were identified.

Monthly, quarterly, and yearly safety inspections are conducted to identify unsafe conditions throughout the facility, including the FRS equipment. Unsafe conditions will result in postings, personnel protective equipment requirements, and/or timely corrective actions.

3.3.2.3.4 Environmental Protection. The FRS equipment design requires that all operational activities, except some maintenance activities, be conducted under water. This greatly reduces the potential for large material releases to the environment and reduces exposure to workers.

3.3.2.3.5 Accident Selection. Accident analysis criteria require that DBA be quantitatively analyzed. The hazards analysis identified a number of postulated hazardous conditions that could have consequences to the onsite worker or offsite individual. These postulated conditions constitute the set of hazards and accidents to be considered for further analysis. The hazards identified were evaluated to establish estimated consequence severity. Some of the hazards were eliminated from consideration because of design or process changes or because another existing safety analysis, such as canister movement hazards analysis, bounded the hazard. The accidents were sorted (binned) for severity category. Because many of the hazards identified were similar, a set of hazards was developed that bounded the identified hazards. Hazard severity category S0 items are covered by the normal facility industrial safety, radiological, or other institutional programs and are not discussed further. The hazard severity category S3 and S2 hazards, summarized in Table 3-5, were reviewed to establish a representative and bounding set of accidents selected for further detailed analysis. The hazard severity category S1 items, summarized in Table 3-6, can be further subdivided into the following general hazards:

- Hazards covered by existing control programs:
  - Basin water quality decreases because of FRS operations or equipment failures
  - Industrial accidents leading to worker injury
  - Increased worker dose caused by FRS activities.
- Unique Hazards that will be addressed in Section 3.4:
  - Manipulator fuel handling drops or spills of fuel; lifts fuel too high; and throws fuel

Accidental criticality is unacceptable. Safety-class engineered features and/or technical safety requirements are applied where necessary to prevent accidental criticality. Preventing an inadvertent criticality eliminates the need for calculating a scenario-specific consequence. Criticality accidents are analyzed in Chapter 6.

3.4 ACCIDENT EVALUATION

This section presents the results of the accident analysis performed for the FRS DBA identified in Section 3.3.2.3.5. The safety analysis process begins by identifying the accident sequence of initiating events and preventive features and mitigative feature responses. Each accident sequence was analyzed to determine if it represented a DBA or was covered by an already-analyzed DBA. The DBAs were analyzed using deterministic methodology and phenomenological calculations to determine the source terms and radiological consequences.

For some criticality accidents, the analysis included developing event trees to quantify the likelihood of accident occurrence on a probabilistic basis. The methodology, assumptions, and event trees were developed in the FRS Subproject Criticality Safety Evaluation Report (FDNW 1998a). Although not strictly required by DOE-STD-3009-94, the use of event trees enhances the credibility of frequency estimates and the justification for eliminating accident scenarios in the typical beyond extremely unlikely ($<10^{-6}$/yr) category. The postulated criticality accidents are discussed in Chapter 6.

This accident analysis considers releases of radioactive and hazardous material during upset (abnormal but anticipated) conditions; accident (unlikely or extremely unlikely) conditions; and beyond design basis (beyond extremely unlikely) conditions. The level of analysis and evaluation required depends on the type of accident and the receptor. Accidents that could potentially result in an unacceptable airborne radioactive dose at the Site boundary are analyzed in detail, either specifically or by analogy to an accident of the same type that is demonstrably more serious. Onsite and offsite dose consequences were calculated based on the methodology described in FDNW (1998b).

The general methodology and risk guidelines are described in Section 3.4.1. The postulated DBAs are analyzed in Section 3.4.2. Beyond design basis accidents are analyzed in Section 3.4.3. Appendix 3B contains detailed bases for the accident doses.

The following design basis events were analyzed.

- MCO basket containing fuel scrap is removed from the water. A fuel fire results from exposure of damp, damaged fuel to air. Airborne contamination is released from the building.

- PCM wash basket containing fuel scrap is removed from the water. A fuel fire does not result, but a release occurs due to additional oxidation of fuel. Airborne contamination is released from the building.

- Fuel scrap and fines accumulation, exposure of uranium hydrides, or fuel scored and heated by stuck fuel cutter causes an energetic chemical reaction. Airborne contamination is released from the building.

- Heavy load drops on basin floor and fuel racks. FRS heavy load drops onto the basin drain valves was ruled out because the FRS heavy loads will not be above these valves.

- Heavy load drops causing equipment to tip or be damaged, spilling fuel and causing a criticality.

- Seismic event causes equipment to tip or be damaged, or heavy loads to drop, damaging equipment or spilling fuel and causing a criticality.

The beyond design basis event analyzed consists of manipulator fuel-handling accidents, including lifting fuel too high or throwing fuel out of water.

The chronic emission of fission-product gases from the K West Basin canisters via the decapping exhaust system and leakage into the basin water during canister movements is expected. This is discussed in Chapter 7.

Removal of fuel from the water was analyzed to establish dose consequences due to the release. Preventive and mitigative programs and measures protect the public as well as the facility worker. These include the K Basins criticality safety program, the radiation protection program, the industrial safety and industrial hygiene programs, procedures and training, and the conduct of operations program. The area radiation monitors warn the facility worker in real time of loss of shielding and contribute to defense in depth.

3.4.1 Methodology

The accident analysis uses specific and consistent methodology to quantify the consequences of the postulated accidents and natural phenomena events selected for analysis. The models, data, and other bases used in the calculation of accident source terms, release fractions, atmospheric dispersion, and dose consequences for the selected accidents are contained in Appendix 3B.

The following steps were used to analyze each accident.

- **Scenario Development**. A detailed sequence of steps necessary to initiate and develop each accident was prepared using conservative assumptions and a clearly defined logic path. Preventive and mitigative design features and responses also are discussed.

- **Source Term Analysis**. Realistic maximum source terms were developed for each accident with the potential to release radionuclides. The source terms were based on known compositions and quantities of hazardous materials handled in the K Basins. The analysis includes the material at risk, the release fraction or rate that determines the initial source term, and the overall or process leak path factors that determine the release from the facility.

- **Consequence Analysis**. The consequence analysis was structured to determine the unmitigated receptor doses for each location. Consequence calculations were performed that analyzed the doses to onsite personnel and the general public for those accidents with a potential for producing such exposures. This section also includes an estimate of the probability of occurrence and frequency category for the postulated accident.

- **Comparison to Guidelines**. The estimated unmitigated radiological and toxic chemical consequences (risk) for the accident were compared to the risk evaluation guidelines (Table 3-1) to determine the need for safety equipment to prevent or mitigate the consequences and its effectiveness.

- **Summary of Safety SSCs and TSR Controls**. The requirements for safety-class or safety significant SSCs and TSRs depend on the results and conclusions from the detailed accident analysis. The analysis for each accident identifies the safety-class or safety-significant SSCs and the assumptions judged to require TSR coverage.

3.4.2 Design Basis Accidents

This section includes detailed analysis of DBAs. The types of accidents considered include internally initiated operational accidents and natural phenomena events for the Site that could affect the FRS equipment or operations. External human-caused events that can cause releases at the facility or have major impact on the facility operations are covered by the K Basin SAR (DESH 1998b) and are not affected by the FRS Subproject. Each accident evaluated contains the components listed under Section 3.4.1.

3.4.2.1 MCO Scrap Basket Over-Lift and Fire. This accident is characterized as a beyond extremely unlikely operational accident involving the release of radioactive materials due to a postulated uranium fire. This accident is considered beyond extremely unlikely because it is physically impossible when using the MCO stiffback grapple and the empty basket grapple cannot be remotely engaged in a loaded basket. The unmitigated consequences assume that the MCO stiffback grapple is not used.

If exposed to water, oxygen, and hydrogen, uranium metal fuel such as that stored in the K Basins will react to form uranium oxide and/or uranium hydride (WHC 1995). These reactions are exothermic and, under certain conditions, sufficient energy can be released so that a thermal excursion can occur. Materials that respond in this manner are often termed "pyrophoric" and the technical term for the excursion is "ignition." While the concept of ignition is most often associated with burning with associated flame, the term ignition is used in this context as the point at which the system has insufficient heat removal capability to balance the heat generated by this reaction (WHC 1995). When this occurs, a rapid temperature rise occurs that is terminated either by the consumption of the material or the available reactant. Fuel pyrophoricity is a key concern from an accident standpoint because such an event may provide the motive force for a release of radioactivity (WHC 1995). Convective cooling probably would prevent ignition from occurring after the MCO scrap basket was inadvertently removed from the basin water, but no specific analysis is available to conclude that ignition is not possible. Specific analysis demonstrating that a canister containing scrap would not ignite under similar or worse conditions has been conducted (Porten and Crowe 1994). Because the MCO basket contains significantly more scrap, the analysis cannot easily be extended to cover the MCO basket.

3.4.2.1.1 Scenario Development. This accident examines the consequences of an MCO scrap basket containing fuel scrap inadvertently being removed from the basin water. The MCO scrap basket is assumed to contain 980 kg (approximately 42 assemblies) of scrap fuel, the maximum allowed by the FRS criticality safety evaluation report (FDNW 1998a).

Accident assumptions include the following:

- The accident occurs during a 1- to 2-hour period
- Airborne release fraction (ARF) and respirable fraction (RF) are based on bounding values for burning uranium from DOE (1994)
- Annual frequency of > 1E-06 to ≤ 1E-04 without safety-class grapples.

The accident is postulated to occurs as a result of the hoist controls failing, which results in lifting the fuel out of the basin water. Once exposed to air, the moist scrap fuel spontaneously ignites and burns. The MCO basket stiffback grapple is sufficiently long to prevent the basket from leaving the water, even if the hoist controls failure allows the MCO basket to be lifted to the full lift height of the hoist. The MCO empty basket grapple cannot be remotely engaged once disengaged, and it must be disengaged to load fuel into an MCO basket. Administrative controls and design of the MCO baskets require that the MCO basket stiffback grapple be used to lift the loaded MCO baskets.

3.4.2.1.2 Source Term Analysis. The bounding MCO scrap basket can contain up to 980 kg of scrap. The airborne source term for the MCO scrap basket is estimated by the following equation:

$$M = (MAR)(ARF)(RF)(LPF)$$

where:

M	=	respirable source term
MAR	=	material at risk (Ci or grams) = 9.8 E+05 g
ARF	=	airborne release fraction = 1E-03 (DOE 1994)
RF	=	respirable fraction = 1.0 (DOE 1994)
LPF	=	leak path factor = 1.0

therefore M = 9.8 E+02 g

3.4.2.1.3 Consequence Analysis. The calculation of the unmitigated inhalation dose from airborne radioactive material transported downwind is computed as the product of the quantity released, the air transport factor, the inhalation rate, and the unit dose factor for the radionuclide mixture released. This is summarized in the following equation.

$$DE = (M)(\chi/Q')(BR)(UD)$$

where

DE	=	50 - year committed effective dose equivalent, rem (Sv)
M	=	mass released into the air as respirable particles = 9.8 E+02 g
χ/Q'	=	air transport factor = 1.24 E-02 s/m^3 for onsite worker 1- to 2-hr duration
BR	=	average inhalation rate during the release = 3.33 E-04 m^3/s (FDNW 1998b)
UD	=	committed effective dose equivalent per gram inhaled = 4.38 E+05 rem/g (4.38 E+03 Sv/g) from Table 4 of FDNW (1998b)

therefore, the dose for the onsite worker is calculated to be

DE = (9.8 E+02 g)(1.24 E-02 s/m^3)(3.33 E-04 m^3/s)(4.38 E+05 rem/g)
= 1.8 E+03 rem EDE (1.8 E+01 Sv)

Doses for other receptors are included in Table 3-9.

3.4.2.1.4 Comparison to Guidelines. Based on review of Table 3-9, the unmitigated dose of this accident exceeds the risk evaluation guideline for onsite receptors. With the application of safety-class SSCs, the release will be below the guidelines.

3.4.2.1.5 Summary of Safety Structures, Systems, and Components, and Technical Safety Requirement Controls. The unmitigated consequences shown in Table 3-9 exceed the evaluation guideline for the onsite receptor for the MCO scrap basket combustion. The consequences are below the evaluation guideline for the offsite receptor. The design of the MCO basket stiffback grapple and MCO empty basket grapple will prevent this accident from occurring.

While only the guidelines for the onsite receptor are exceeded, the MCO basket stiffback grapple and the MCO empty basket grapple must be designated as safety class based on the requirements of Appendix 4A because the offsite dose consequences exceeds 0.5 rem. The design of the MCO basket stiffback grapple precludes lifting the basket out of the water, even if the hoist controls fail. The design of the empty basket grapple prevents grappling an MCO basket remotely after fuel may have been loaded in the MCO basket.

Table 3-9. Summary of Unmitigated Dose Consequences - Ignition of Scrap Equivalent to 42 Fuel Assemblies.

Receptor location	Unmitigated		Guidelines rem[b]
	χ/Q' [a]	rem EDE (Sv)	
100 m east (onsite)	1.24 E-02	1.8 E+03 (1.8 E+01)	25
Hanford Site boundary (12,040 m west) (offsite)	2.6 E-05	3.8 (3.8E-02)	5
Near river bank (480 m northwest)	5.5 E-04	80 (8.0E-01)	N/A

Notes: [a]From Table 3B-4.
[b]At annual frequency of > 1E-06 to ≤ 1E-04 without safety -class grapples.

EDE = effective dose equivalent.

The empty basket grapple can only be grappled to a MCO basket by an operator near the basket. Once the grapple has been removed from the MCO basket, it cannot be reattached. Also, the empty basket grapple incorporates a lid to prevent fuel from being loaded or spilled into an empty basket while the basket is grappled.

Safety-class design features of the MCO basket stiffback are the overall length and the basic design, i.e., the basic design and specified length prevent a fuel container from being over-lifted. Safety-class design features for the empty basket grapple include the cover and the design features that prevent grappling a basket remotely. The design features will be ensured by quality control inspection on receipt and the change control program required to be in place by the existing K Basin TSRs. No new TSRs are required.

The safety-class devices are as follows:

- MCO basket stiff back grapple
- MCO empty basket grapple.

3.4.2.2 PCM Wash Basket Over-Lift. This accident is characterized as an extremely unlikely operational accident involving the release of radioactive material due to oxidation of fuel scrap in a wash basket inadvertently raised out of the basin water. This accident is considered extremely unlikely because it requires failure of the hoist controls and massive failure (splitting the pipe sections that contain the lifting chain) of the telescoping stiffback.

Ignition of the scrap in the wash basket will not occur based on analysis demonstrating that a canister containing scrap would not reach ignition temperatures with the scrap canister insulated by sludge layer of 10 percent of the debris bed height (Porten and Crowe 1994). In this accident, the scrap in the wash basket will not be insulated by sludge and will have more surface area for convective cooling.

3.4.2.2.1 Scenario Development. This accident examines the consequences of a PCM wash basket containing fuel scrap inadvertently being removed from the basin water. The wash basket is assumed to contain 328 kg (722 lbs.) (equivalent to the maximum mass allowed in a canister) of scrap fuel, the maximum allowed by the K Basin SAR (DESH 1998b). The fuel scrap in the wash basic will not ignite, but oxidation of the fuel can occur resulting in a release.

Accident assumptions include the following:

- The accident occurs during a 1 to 2-hour period.
- The projected surface area of the wash basket is the area available for release.
- The scrap fuel is assumed to have a depth of contamination of 0.001 m from which radiological material can be released.
- ARF and RF are based on bounding values for burning uranium from DOE (1994).
- Annual frequency of > 1E-06 to ≤ 1E-04.

The accident is postulated to occur because the hoist controls fail, which results in the hoist continuing to lift the wash basket after an operator attempts to stop the hoist. As the hoist continues to raise, the telescoping stiffback lifting pipe is split open allowing the basket to be raised to the surface. Once raised above the surface of the basin water, the uranium oxidizes in the moist environment and releases some of the oxidation products.

3.4.2.2.2 Source Term Analysis. The bounding wash basket can contain up to 328 kg (722 lb.) of scrap fuel. The inventory at risk was determined by assuming that the exposed surface area of the fuel was the predominant factor involved in the release of the radioactive material. The estimate of the amount of fuel at risk assumed the depth of the fuel available was 1.0 E-03 m. The surface area of the basket is (81 cm)(86 cm) = 6966 cm^2. The volume of fuel is (6966 cm^2)(1.0 E-03 m)(100 cm/m) = 697 cm^3. The mass of this volume of fuel is (18.8 g/cm^3)(697 cm^3) = 1.31E +04 g

The airborne source term for the wash basket is estimated by the following equation:

$$M = (MAR)(ARF)(RF)(LPF)$$

where:

M = respirable source term
MAR = material at risk (Ci or grams) = 1.31E+04 g

ARF = airborne release fraction = 1E-03 (DOE 1994)
RF = respirable fraction = 1.0 (DOE 1994)
LPF = leak path factor = 1.0

therefore M = 13.1 g

3.4.2.2.3 Consequence Analysis. The calculation of inhalation dose from airborne radioactive material transported downwind is computed as the product of the quantity released, the air transport factor, the inhalation rate, and the unit dose factor for the radionuclide mixture released. This is summarized in the following equation.

$$DE = (M)(\chi/Q')(BR)(UD)$$

where

DE = 50 - year committed effective dose equivalent, rem (Sv)

M = mass released into the air as respirable particles = 13.1 g

χ/Q' = air transport factor = 1.24 E-02 s/m^3 for onsite worker 1- to 2-hr duration

BR = average inhalation rate during the release = 3.33 E-04 m^3/s (FDNW 1998b)

UD = committed effective dose equivalent per gram inhaled = 4.38 E+05 rem/g (4.38 E+03 Sv/g) from Table 4 of FDNW (1998b)

therefore, the dose for the onsite worker is calculated to be

DE = (13.1 g)(1.24 E-02 s/m^3)(3.33 E-04 m^3/s)(4.38 E+05 rem/g)
= 23.7 rem EDE (2.37 E-01 Sv)

Doses for other receptors are included in Table 3-10.

3.4.2.2.4 Comparison to Guidelines. Based on review of Table 3-10, this accident is below the risk evaluation guideline for all receptors.

3.4.2.2.5 Summary of Safety Structures, Systems, and Components, and Technical Safety Requirement Controls. Because the consequences shown in Table 3-10 are below the evaluation guidelines, no safety-class or safety-significant SSCs are necessary. No new TSRs are required. Although the telescoping stiffback does not need to be safety class or safety significant, it is designed to prevent this event. The failure of the telescoping stiffback is considered to be beyond extremely unlikely.

Table 3-10. Summary of Unmitigated Dose Consequences - Oxidation of Scrap Equivalent to 14 Fuel Assemblies.

Receptor location	Unmitigated		Guidelines (rem)[b]
	χ/Q' [a]	rem EDE (Sv)	
100 m east (onsite)	1.24 E-02	23.7 (2.37E-01)	25
Hanford Site boundary (12,040 m west) (offsite)	2.6 E-05	4.97E-02 (4.97E-04)	5
Near river bank (480 m northwest)	5.5 E-04	1.05 (1.05E-02)	N/A

[a]From Table 3B-4.
[b]At annual frequency of > 1E-06 to ≤ 1E-04.
EDE = effective dose equivalent.

3.4.2.3 Fuel Assembly Burns Under Water. This accident may be initiated in several ways that are defined in the scenario development section. It is characterized as an operational accident.

3.4.2.3.1 Scenario Development. Decapping, primary cleaning, or removing stuck fuel could initiate an energetic reaction of uranium hydrides, uranium, or zirconium cladding materials. During decapping, uranium hydrides that have accumulated on or in the fuel suddenly exposed to water may initiate a chemical reaction. Uranium hydride can be pyrophoric. Ignition also could be initiated by imparting mechanical or heat energy to the fuel. The PCM and the stuck fuel equipment have the potential to impart mechanical energy to the fuel. For purposes of this accident, the uranium hydride reaction is assumed to ignite the uranium, resulting in the complete combustion of a fuel assembly. Because some of these events could happen in close proximity to the other fuel in the canister, the accident also was analyzed for combustion of all 14 assemblies.

Fuel-burn events associated with a loss-of-basin-water accident are analyzed in the K Basin SAR (DESH 1998b) and were determined to be beyond extremely unlikely. However, several incidents of "flash burns" of similar fuel elements have occurred at French facilities. The French experiences with flash burns are being evaluated to determine if similar events could occur with the fuel stored in K Basins. The fuel elements in these flash burns had been declad. This postulated event may be a problem only in the K West Basin where the fuel has been stored in capped canisters, which can lead to higher levels of uranium hydrides. Although the event is judged to be extremely unlikely based on the French experience (DESH 1997a) and the absence of any such reaction to date during K Basin operation, it will be included as an unlikely event to ensure that any preventive or mitigative features required are provided. In the incidents of fuel flashes evaluated, none were found where multiple fuel assemblies ignited. This event is not expected to occur after the fuel had been aggressively cleaned in the PCM.

Accident assumptions include the following:

- The accident occurs in less 1 hour
- ARF and RF are based on bounding values for burning uranium from DOE (1994)
- LPF to account for scrubbing of the combustion products by basin water is 1.0 E-04
- Annual frequency of 10^{-2} to 10^{-4}.

3.4.2.3.2 Source Term Analysis. Two cases of source term are developed for this accident based on a single fuel assembly burning and all 14 assemblies burning. Section 3.4.2.1.2 lists a source term for combustion of a MCO basket containing the equivalent of 42 assemblies (908kg). The source term for this event will be assumed to be 1/42 and 14/42 of the MCO basket. See Section 3.4.2.1.2 for details.

A suitable LPF to account for scrubbing of the combustion products as they exit the basin water is 1.0E-04. This value was used for a similar energetic uranium hydride reaction documented in WHC-SD-SNF-SARR-001, *Review of the Consequences of Uranium Hydride Formation in N-Reactor Fuel Elements Stored in the K-Basins* (WHC 1994).

The airborne source term for the canister is estimated by the following equation:

$$M = (MAR)(ARF)(RF)(LPF)$$

where:

M	=	respirable source Term
MAR	=	material at risk (Ci or grams) = 9.8 E+05 g (for 42 assemblies) x 14/42 = 3.3 E+05 g
ARF	=	airborne release fraction = 1E-03 (DOE 1994)
RF	=	respirable fraction = 1.0 (DOE 1994)
LPF	=	leak path factor = 1.0E-04

therefore M = 3.3 E-02 g for 14 assemblies.

For a single assembly, M = (3.3 E-02)(1/14) = 2.4 E-03 g

3.4.2.3.3 Consequence Analysis. The calculation of unmitigated inhalation dose from airborne radioactive material transported downwind is computed as the product of the quantity released, the air transport factor, the inhalation rate, and the unit dose factor for the radionuclide mixture released. This is summarized in the following equation:

$$DE = (M)(\chi/Q')(BR)(UD)$$

where

DE = 50 - year committed effective dose equivalent, rem (Sv)

M = mass released into the air as respirable particles = 3.3 E-02g for 14 assemblies; and 2.4 E-3g for a single assembly

χ/Q' = air transport factor = 7.32 E-02 s/m^3 for onsite worker <1 hr duration

BR = average inhalation rate during the release = 3.33 E-04 m^3/s (FDNW 1998b)

UD = committed effective dose equivalent per gram inhaled = 4.38 E+05 rem/g (4.38 E+03 Sv/g) from Table 4 of FDNW (1998b)

therefore, the dose for the onsite worker for the first release mass case (14 assemblies) is calculated to be

DE = (3.3 E-02 g)(7.32 E-02 s/m^3)(3.33 E-04 m^3/s)(4.38 E+05 rem/g)
= 3.52E-01 rem EDE (3.52E-03 Sv) .

Unmitigated doses for other receptors are included in Table 3-11 for 14 assemblies. Unmitigated doses for a single assembly (ratio of 1/14 from Table 3-11) are included in Table 3-12.

Table 3-11. Summary of Unmitigated Dose Consequences - Ignition of 14 Fuel Assemblies.

Receptor location	Unmitigated		Guidelines rem[b]
	χ/Q' [a]	rem EDE (Sv)	
100 m east (onsite)	7.32 E-02	3.52 E-01 (3.52E-03)	10
Hanford Site boundary (12,040 m west) (offsite)	3.58 E-05	1.7 E-04 (1.7 E-06)	5
Near river bank (480 m northwest)	2.15 E-03	1.02 E-02 (1.02E-04)	N/A

Notes: [a]From Table 3B-4.
[b]At annual frequency of > 1E-04 to ≤ 1E-02.
EDE = effective dose equivalent. N/A = not applicable.

Table 3-12. Summary of Unmitigated Dose Consequences - Ignition of 1 Fuel Assembly.

Receptor location	Unmitigated		Guidelines rem[b]
	χ/Q′ [a]	rem EDE (Sv)	
100 m east (onsite)	7.32 E-02	2.51 E-02 (2.51 E-04)	10
Hanford Site boundary (12,040 m west) (offsite)	3.58 E-05	1.2 E-05 (1.2 E-07)	5
Near river bank (480 m northwest)	2.15 E-03	7.3 E-04 (7.3 E-06)	N/A

Notes: [a]From Table 3B-4.
[b]At annual frequency of > 1E-04 to ≤ 1E-02.
EDE = effective dose equivalent. N/A = not applicable.

3.4.2.3.4 Comparison to Guidelines. Based on review of Tables 3-11 and 3-12, this accident is well below the risk evaluation guideline for all receptors.

3.4.2.3.5 Summary of Safety Structures, Systems, and Components and Technical Safety Requirement Controls. Because the unmitigated accident consequences are below the evaluation guidelines, no safety equipment is required to prevent or mitigate this postulated accident. No new TSRs are required.

3.4.2.4 Heavy Load Drop on Basin Floor. Equipment will be added to the facility by the FRS Subproject in and above the fuel storage basin. Construction activities will include upgrades to hoists and the monorail system and the addition of a manipulator system, a PCM, a decapper, stuck fuel equipment, a process table, and MCO basket queue stands. Dropping a heavy object, such as the PCM, into the basin could result in damage to the basin structure or the fuel storage racks. Operational heavy loads are bounded by loaded MCO baskets. Because FRS equipment and operational loads will not be brought over canisters of fuel, drops on fuel canisters were not considered.

3.4.2.4.1 Scenario Development. During installation or operation, a heavy load is dropped because of equipment failure. This accident is categorized as a unlikely operational accident. Table 3-13 defines load drops.

3.4.2.4.2 Source Term Analysis. Because no release is anticipated from this accident, no source terms were developed.

3.4.2.4.3 Consequence Analysis. Based on structural "drop analysis" performed for the bounding dropped loads, no significant damage or failure of the basin will result should a drop occur (BNFL 1998). A failure of the manipulator support structure that resulted in a drop of the structure, in conjunction with the manipulator trolley and manipulator, could challenge the basin floor. Drops of the manipulator support structure would likely hit the process table or other FRS

Table 3-13. Fuel Retrieval System Heavy Load Drop Matrix.

Heavy load → / Equipment affected	Canister	Wash basket	Strainer baskets	Debris bin	MCO basket	Manipulator/ trolley[a]	Operating deck grating	Overhead equipment[b]	Monorail/ hoist/flexible transfer crane	Test weights	Equipment[c] transported for maintenance
Basin floor	Yes	Yes	Yes	Yes	Yes	Yes	N/A[d]	Yes	Yes	Yes	Yes
Fuel racks	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]	N/A[e]
PCM	Yes[b]	No	No	No	No	Yes[f,g]	Yes[g]	No	No	No	No
North table[h]	No	No	No	No	No[i]	No	No	No	No	No	No
South table[h]	No	No	No	No	No	No	No	No	No	No	No
North scrap basket/frame	No[j]	No[j]	No[j]	No[j]	Yes	Yes[f]	Yes	No	Yes	No	No
South scrap basket/frame	No[j]	No[j]	No[j]	No[j]	Yes	Yes[f]	Yes	No	Yes	Yes	No
Assembly basket/frame	No[j]	No[j]	No[j]	No[j]	Yes	Yes[f]	Yes	No	Yes	Yes	No
Queue	No[j]	No	No	No	Yes	No	Yes	No	Yes	No	No
Decapper[h]	No	No	No	No	No	No	No	No	No	No	No
Stuck fuel[h]	No	No	No	No	No	No	No	No	No	No	No

Notes: [a]Manipulator trolley rail support frame is prevented from falling by safety-significant tether system.
[b]Requires grating failure.
[c]Stuck fuel saw and PCM gearbox only heavy drop loads.
[d]Covered by existing K Basin SAR.
[e]Existing empty fuel racks may be damaged without consequence per WHC-SD-SARR-006, Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks.
[f]Drop of manipulator/trolley can have three components - direct drop down over travel area, swing down from trolley if one side fails, and secondary impacts caused by a fall after direct drop.
[g]Cannot cause the PCM to tip caused by a seismic event-initiated drop of this equipment.
[h]Non-safety-class equipment.
[i]Drop assumed to hit table directly under travel path; dropping on other portions of table requires concurrent seismic event which is deemed beyond extremely unlikely.
[j]Bounded by MCO basket drop.

MCO = multi-canister overpack.
N/A = not applicable.
PCM = primary clean machine.
SAR = safety analysis report.

equipment protecting the basin from damage. To ensure that this load (manipulator trolley support structure, manipulator trolley and manipulator) cannot drop during a seismic event, a tether system will restrain the manipulator trolley support structure in the event of failure after installation. Drops of heavy loads on the empty fuel racks may crush or destroy the racks, which has been shown to be acceptable as analyzed in WHC-SD-SARR-006, *Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks* (DESH 1997b).

To ensure that an MCO basket is not dropped from a height greater than analyzed, the MCO stiffback grapple must control the maximum lift height for an MCO basket.

3.4.2.4.4 Comparison to Guidelines. Not applicable.

3.4.2.4.5 Summary of Safety Structures, Systems, and Components and Technical Safety Requirement Controls. Because the MCO basket stiffback grapple limits the drop height of an MCO basket to the analyzed values, it is required to be safety class. The tether system for the manipulator support structure is designated as safety significant. The design features will be ensured by quality control inspection on receipt and the change control program required by the existing K Basin TSR. No new TSRs are required.

3.4.2.5 Heavy Load Drop on Fuel Retrieval System Equipment Causing Criticality. FRS operating activities require movement of heavy loads over FRS safety-class equipment. This accident analyzes these drop events. This accident is categorized as an unlikely operational accident.

3.4.2.5.1 Scenario Development. Heavy load drops are postulated to occur because equipment failure while moving the heavy load. Heavy load drops onto FRS safety-class equipment fall into three cases:

- Drops of equipment during installation
- Drops of equipment during maintenance
- Drops of loaded MCO baskets.

The impact of the drops were postulated to damage or tip over the safety-class equipment resulting in a potential criticality event. The load cases considered are defined in Table 3-13. Cases with a "yes" were analyzed.

3.4.2.5.2 Source Term Analysis. No release is anticipated from this accident, so no source terms were developed.

3.4.2.5.3 Consequence Analysis. Drops of equipment during installation will not involve a criticality because no fuel mass will be in or on FRS equipment during the equipment installation. Drops of equipment during maintenance have been analyzed and all postulated drops are acceptable and do not challenge the ability of the FRS safety-class equipment to perform their safety functions. Drops of loaded MCO baskets on FRS safety-class equipment have been analyzed and all postulated drops are acceptable, the safety-class equipment will not tip over because of impact and will not fail structurally. Detailed drop analysis is contained in *Fuel Retrieval Subproject Safety Class Design Analysis Report*, HNF-2229 (BNFL 1998). Criticality analysis is documented in *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*, HNF-SD-SNF-CSER-010 (FDNW 1998a).

Existing empty fuel racks may be damaged without consequence according to the analysis described in WHC-SD-SARR-006 (DESH 1997b).

Criticality events caused by spills of the MCO basket are covered in Chapter 6.

3.4.2.5.4 Comparison to Guidelines. The guideline applicable to this accident is that these single failures do not cause a criticality. Because none of the postulated drops will tip or damage the safety-class equipment in a manner that would result in a criticality, the guideline is met.

3.4.2.5.5 Summary of Safety Structures, Systems, and Components and Technical Safety Requirement Controls. The criticality analysis (FDNW 1998a) associated with this accident requires that the following equipment be safety class to prevent a potential criticality caused by these drops:

- PCM support stand
- PCM lower half
- Process table support structures
- MCO basket queue structures
- MCO basket stiffback grapple (required minimum length ensures that the drop is within analysis assumptions).

The criticality safety evaluation includes a limit to prevent moving loaded MCO baskets over the MCO assembly basket-loading portion of the process table when a loaded basket is in place. This limit will be implemented by the K Basin criticality prevention specifications, which are part of the existing TSR required criticality prevention program.

The design features will be ensured by quality control inspection on receipt and the change control program required by the existing K Basin TSR. No new TSRs are required.

3.4.2.6 Seismic Event. During operation, the FRS equipment may be subjected to the forces of a seismic event. This accident is categorized as a unlikely natural phenomena event.

3.4.2.6.1 Scenario Development. A seismic event is postulated to occur during operation of the FRS equipment with full fuel loads in place. The following results were assumed to occur:

- Nonsafety equipment that contains fuel (stuck fuel, decapper, and process table top sections) falls over spilling fuel contents

- Other nonsafety equipment falls on the FRS safety-class equipment as defined in Table 3-13
- The manipulators and manipulator trollies fall
- The manipulator support structure tears free from the building structure, but is retained in place by the safety-significant tether system
- FRS safety-class equipment is moved on basin floor but does not tip over or fail because of impact from load drops.

3.4.2.6.2 Source Term Analysis. No release is anticipated from this accident, so no source terms were developed.

3.4.2.6.3 Consequence Analysis. The FRS safety-class equipment has been designed and analyzed to withstand the forces of a seismic event and the related drop events without failure (BNFL 1998). The safety-class equipment will maintain the bulk fuel in a safe configuration.

A combined drop of a manipulator (907 kg [2,000 lb]) and support structure (1414 kg [4,000 lb]) a distance of 2.1 m (6 ft 9 in.) to the basin floor during operations is above the recommended height/weight limit of the K Basin SAR (DESH 1998b) and is approaching the curve that would indicate basin perforation by a missile. As a result, the manipulator support structure tether system is designated safety significant (3/1) to protect the safety-class function of the basins. The manipulator support structure tether system was designed and analyzed to ensure that the manipulator support structure does not fall because the manipulator support structure itself fails. The manipulator may fall by itself; this is acceptable. These drops are analyzed in BNFL (1998).

The loads from the manipulator support structure that would be transmitted to the basin superstructure were analyzed and shown to be acceptable in *Seismic Qualification of the 105 K Basin Superstructure Using 0.12 g Earthquake Ground Acceleration*, Rev. 0, ECN 193597 (FDNW 1998c). The tether system has been analyzed in *Fuel Retrieval Sub-Project K-Basin Facility Modification Calculations*, HNF-SD-SNF-CN-009 (FDNW 1997).

3.4.2.6.4 Comparison to Guidelines. The guideline applicable to this accident is that these single failures do not cause a criticality. Because a postulated seismic event and related drops and spills will not tip or damage the safety-class equipment in a manner that would result in a criticality, the guideline is met.

3.4.2.6.5 Summary of Safety Structures, Systems, and Components and Technical Safety Requirement Controls. The criticality analysis associated with the postulated seismic event requires that the following equipment be safety class to prevent a potential criticality:

- PCM support stand
- PCM lower half

- Process table support structures
- MCO basket queue structures
- MCO basket stiffback grapple (required minimum length ensures that the drop is within analysis assumptions).

The manipulator support structure tether system is required to be safety significant.

The design features will be ensured by quality control inspection on receipt and the change control program required by the existing K Basin TSR. No new TSRs are required.

3.4.3 Beyond Design Basis Accidents

DOE Order 5480.23, *Nuclear Safety Analysis Reports*, requires that accidents beyond the DBAs be evaluated to provide a perspective on the residual risk associated with the operation of the FRS equipment and potential design enhancements. Beyond design basis accidents are typically considered to be those accidents that have a frequency of occurrence realistically estimated to be less than 10^{-6}/year (beyond extremely unlikely). The following beyond DBA has been postulated and analyzed.

3.4.3.1 Manipulator Fuel Handling Accident. This accident is characterized as an beyond extremely unlikely operational accident involving an overexposure of operating personnel and a postulated uranium fire as a result of misoperation or failure of the manipulator. Under normal conditions, the manipulator control system will prevent these over-lifts.

3.4.3.1.1 Scenario Development. The scenarios postulated include the following:

- Lifting a fuel element with the manipulator to the maximum possible height resulting in worker over-exposure because manipulator control system fails

- Throwing a fuel element out of the basin water causing an over-exposure and/or uranium fire

3.4.3.1.2 Source Term Analysis. No radiological release is anticipated from this accident. A dose rate was calculated based on the minimum water cover depth over a fuel element when raised to the maximum possible height by the manipulator. The dose rate was calculated as 300 mrem/hr (Shen 1996).

3.4.3.1.3 Consequence Analysis. Analysis (Shen 1996) was performed to determine the maximum height to which a fuel element could be lifted by the manipulator. The analysis determined that, in the worst case, a fuel element would be covered by at least 0.6 m (2 ft) of water. The calculated dose rate for this condition was 300 mrem/hr for a worker at the 0 m (0 ft) water level directly above the fuel element. While this dose is not low, it does not present an immediate threat to facility workers. It is concluded that this scenario is beyond extremely unlikely. An internal memo, *Safety Issues Associated with Fuel Raised to Surface by Manipulator* (Shen 1996), is included in Appendix 3C.

Additional analysis was performed to determine whether a fuel element could be thrown out of the basin by the manipulator. Ketner (1997) concludes that the fuel element could not exit the water. The calculations were conservative in that the assumed manipulator velocities were an order of magnitude greater than the manipulator capability based on test data. It is concluded that this scenario is beyond extremely unlikely. Ketner (1997) is included in Appendix 3C.

3.4.3.1.4 Comparison to Guidelines. The guideline for exposure for the onsite worker is 1.0E+00 rem EDE. For a worker to receive a larger dose, the worker would have to be in the defined position for more than 3.3 hours, with the manipulator in the fully raised position while holding a fuel element. This is not considered credible. In addition, manipulator controls provide protection from this event as well.

3.4.3.1.5 Summary of Safety Structures, Systems, and Components and Technical Safety Requirement Controls. No safety-class SSCs or additional TSRs are required for these accidents. The existing K Basin TSRs require implementation of a radiation protection program.

3.5 ADDITIONAL K BASIN SAFETY ANALYSIS REPORT IMPACT

Fuel contained in the FRS equipment will be at a higher elevation than fuel presently stored in canisters in the basin. Fuel elevations associated with loading the MCO are higher than those of the FRS equipment and consequently establish bounding conditions for the FRS. The basin leakage accident analyzed in the K Basin SAR needs to be revised to reflect changes in the elevations of fuel stored in the FRS equipment in the basin. Because the MCO loading activity bounds the FRS impacts and this impact is being addressed by the MCO loading accident analysis, it is not addressed further in this safety analysis.

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APPENDIX 3A

HAZARD ANALYSIS RESULTS

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Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Electrical	Battery banks	N/A
	Diesel units	N/A
	High lines	N/A
	Transformers	N/A
	Wiring	Upgrades to existing system.
	Switchgear	Upgrades to existing system.
	Underground wiring	N/A
	Cable runs	New cable runs.[2]
	Service outlets and fittings	Already provided in K Basin area.
	Pumps	Downdraft pumps used for the primary clean machine, decapper, and secondary cleaning station; high-pressure pump for the primary clean machine; hydraulic pump for manipulator; pump for chiller.[2]
	Motors	Primary clean machine, tractor motors for telescoping stiffback and flexible transfer crane, exhaust fan, and hoists.[2]
	Heaters	N/A
	Power tools	Used during construction and decapping.
	Small equipment	Used during construction and maintenance.[2]
Nuclear	Vaults	N/A
	Temporary storage areas	MCO basket queue containing 10 baskets, each with a capacity of 48 to 54 elements or a similar amount scrap; process table, canister staging area.[2]
	Receiving areas	N/A[2]
		N/A[2]
	Casks	N/A[2]
	Burial grounds	N/A
	Storage tanks	N/A
	Canals and basins	K East and K West Basins.
	Reactor in-tank storage areas	N/A
	Dollies	N/A
	Trucks	N/A[2]
	Hand carry	N/A
	Cranes	Monorail and chain hoists used.[2]
	Lifts	N/A
	Shops	N/A

Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Nuclear	Hot cells	N/A
	Assembly areas	N/A
	Inspection areas	Inspection and sorting of fuel performed
	Laboratories	N/A
	Pilot plants	N/A
Nuclear (in reactor)	Reactors	N/A
	Critical facilities	N/A
	Subcritical facilities	N/A
Kinetic/linear (in plant)	Fork lifts	N/A
	Carts	Empty basket and equipment movement.[2]
	Dollies	N/A
	Railroad	N/A[2]
	Surfaces	N/A
	Obstructions (collision with)	Moving loads and manipulators may collide with stationary equipment.[2]
	Shears	N/A
	Presses	N/A
	Crane loads in motion	Trolley, hoists, and crane will be moving fuel and scrap canisters, debris, and MCO baskets. Motorized linear action.[2]
	PV blowdown	N/A
	Power assisted driving tools	N/A
Kinetic/linear (vehicle)	Cars	N/A[2]
	Trucks	N/A[2]
	Buses	N/A
Kinetic/rotational	Centrifuges	N/A
	Motors	Fuel primary cleaning machine; CCTV pan/tilt mechanism; hoists, flexible transfer crane.[2]
	Pumps	Above water: primary clean machine high-pressure flush pump, hydraulic pump.[2]
	Cooling tower fans	N/A
	Cafeteria equipment	N/A
	Laundry equipment	N/A
	Gears	Tipper station, primary clean machine.[2]

Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Kinetic/rotational (cont)	Shop equipment (grinders, saws, brushes, etc.)	N/A
	Floor polishers	N/A
PV-KD (pressure, tension)	Boilers	N/A
	Heated surge tanks	N/A
	Autoclaves	N/A
	Test loops and facilities	N/A
	Gas bottles	N/A
	Pressure vessels	N/A
	Coiled springs	N/A
	Stressed members	N/A
	Gas receivers	N/A
Potential energy from falls and drops	Human effort	Operation will use long-handled manual tools for some phases[2]
	Stairs	N/A
	Bucket and ladder	N/A
	Trucks	N/A
	Elevators	N/A
	Jacks	N/A
	Scaffolds and ladders	Basin is covered by a sectioned metal grating except for some areas open with guard rails during construction and process areas with guard rails.[2]
	Crane cabs	N/A
	Pits	N/A
	Excavations	N/A
	Elevated doors	N/A
	Canals	N/A
	Vessels	N/A
MGH (cranes and lifts)	Lifts	Crane, trolley, and hoists are present.
	Cranes	see above.
	Slings	May be used for lowering equipment into the basin during construction.
	Hoists	see above.

Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Flammable materials	Packing materials	N/A
	Rags	N/A
	Gasoline (storage and in vehicles)	N/A[2]
	Oil	Manipulator Hydraulic fluid.[2]
	Coolant oil	N/A
	Paint solvent	N/A
	Diesel fuel	N/A[2]
	Buildings and contents	A limited amount of solid radioactive waste from decontamination activities may be accumulated in the K Basin area.
	Trailers and contents	N/A
	Grease	Small amount in bearings/gearboxes compatible with K-Basins guidelines.[2]
	Hydrogen (including battery banks)	Hydrogen from decapping system and basin sludge.
	Gases - other	Hydrogen from canister decapping.[2]
	Spray paint	Equipment may be coated before placement in the basins; coatings may be repaired.
	Solvent vats	N/A
Corrosive	Acids	N/A
	Caustics	N/A
	"Natural" chemicals (soil, air, water)	N/A
	Decon solutions	Most of the equipment will be wiped down and decontaminated with process water. Environmentally favorable cleaning agents may occasionally be used.
Radiation	Canals	N/A
	Plug storage	N/A
	Storage areas	N/A
	Storage buildings	N/A
	Radioactive sources	Spent nuclear fuel rods in canisters, sludge, and contaminated plant equipment, walls, and water.
	Waste and scrap	Empty canisters and other debris.
	Contamination	The water in both K Basins is contaminated.

Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Radiation (cont)	Irradiated experimental and reactor equipment	N/A
	Electric furnace	N/A
	Blacklight (e.g., magniflux)	N/A
	Laser	N/A
	Medical x-ray	N/A
	Radiography equipment and sources	N/A
	Welding	May be performed as part of construction activities.
	Electric arc, other (high current circuits)	N/A
	Electron beam	N/A
	Equipment noise	Pumps, motors, power tools, etc.[2]
	Ultrasonic cleaners	N/A
Thermal radiation	Furnaces	N/A
	Boilers	N/A
	Steam lines	N/A
	Lab and pilot plant equipment	N/A
	Sun	N/A
	Convection	N/A
	Heavy metal weld preheat	N/A
	Exposed steam pipes	N/A
	Electric heaters	N/A
Thermal (except radiant)	Fire boxes	N/A
	Lead melting pot	N/A
	Electrical wiring and equipment	Process equipment will use electrical circuits; motors, lighting, controls, etc.[2]
	Furnaces	N/A
Explosive pyrophoric	Caps	N/A
	Primer cord	N/A
	Dynamite	N/A
	Power metallurgy	Uranium metal and uranium hydrides.[2]
	Dusts	N/A[2]

Table 3A-1. Energy Source Checklist from DOE 76-45/19.[1] (6 sheets)

Type of hazard	Form of hazard	Description
Explosive pyrophoric (cont)	Hydrogen (including battery banks and water decomposition)	Evolved continually under water from fuel corrosion and water radiolysis.[2]
	Gases, other	Hydrogen.[2]
Explosive pyrophoric (cont)	Nitrates	N/A
	Electric squibs	N/A
	Peroxides-superoxides	N/A
Toxic/pathogenic	Acetone	N/A
	Fluorides	N/A
	Carbon monoxide	N/A
	Lead	Existing shielding.
	Ammonia and compounds	N/A
	Asbestos	N/A
	Trichloroethylene	N/A
	Dusts and particulates	Blowing dust can get into the basin area.
	Pesticides, herbicides and insecticides	N/A
	Bacteria	N/A
	Beryllium and compounds	In-fuel braze rings (underwater).[2]
	Chlorine and compounds	N/A
	Sandblast	N/A
	Metal plating	N/A
	Asphyxiation, drowning	K East basin water depth is approximately 17 ft-2 in.; K West basin water depth is approximately 15 ft-9 in.[2]

Note: [1]DOE, 1979, *Job and Task Analysis*, DOE-76-45-19, U.S. Department of Energy, Washington, D.C.
[2]Changed since the initial development of this listing during the original PHA.

CCTV = closed-circuit television.
MCO = multi-canister overpack.
MGH = mass, gravity, height.
N/A = not applicable.
PHA = preliminary hazards analysis.

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Canister retrieval.	Movement of fuel storage rack.	Operator error.	Criticality issue if rack were lifted completely above fuel.		Procedures. Training.	Fissile material in canister rack position.	S0[1]	F0/F1	Criticality not an issue, see WHC-SD-SARR-006.[1,2]
Canister retrieval.	Plume of particulate.	Canisters containing deteriorated fuel moved too rapidly.	Higher dose rate from basin.	Variable rate hoist (K East only).[1]	Procedures (pick and pause). Training.	Fuel canister.	S1	F3	
Disassembly, sorting, inspection.	Radiation dose from maintenance on equipment from basin.	Contamination from basin water or contact with radioactive materials.	ALARA consequence from radioactive water.	Use of decontamination sprays. Equipment design (no traps for contaminated water).	Procedures.	Small quantity of basin water. Particles of fuel cladding.	S1	F3	
Disassembly, sorting, inspection.	Accumulation of excess fuel and scrap at work station	Failure to follow procedures.	Violation of work station criticality limit.	Cameras.	Procedures (administrative controls).	Fissile material in fuel in sorting area.	S0*	F3	*Requires flagrant violation to result in criticality.
Disassembly, sorting, inspection.	Spread of airborne contamination during removal of grating (applies to all other areas and other operations).	Residual contamination of grating.	Worker airborne dose.	Personal protective equipment.	Procedures. Inspections.	Small quantities of dried basin water residue.	S1*	F3	*Dose limited by control of work practices.
Disassembly, sorting, inspection.	Spread of contamination during maintenance activities or retrieval of equipment from basin.	Contaminated water in basin. Contact with irradiated materials.	ALARA consequence from residual liquids.	Use of decontamination sprays. Equipment design (minimize contamination traps).	Procedures.	Small quantities of basin water. Imbedded fuel or cladding particulates.	S1	F3	
Disassembly, sorting, inspection.	Radiation dose from maintenance of basin equipment.	Contamination from basin water. Contact with radioactive materials.	ALARA consequence from radioactive water.	Use of decontamination sprays. Equipment design (no traps for contaminated water).	Procedures.	Small quantity of basin water. Particles of fuel cladding.	S1	F3	
Disassembly, sorting, inspection.	Accumulation of excess fuel and scrap at work station.	Failure to follow procedures.	Violation of work station criticality limit.	Cameras.	Procedures (administrative limit).	Fissile materials in fuel.	S0	F3	[1]
Disassembly, sorting, inspection.	Spread of airborne contamination during removal of grating (applies to all other areas and other operations).	Residual contamination of grating.	Worker airborne dose.	Personal protective equipment.[1]	Procedures. Inspection.	Contamination on grating.	S1*	F3	*Dose limited by control of work practices.

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Disassembly, sorting, inspection.	Spread of basin water from dropping objects into pool:	Failure to follow procedures. Equipment failure.	Worker airborne dose.	Engineered lifting points.	Procedures. Inspection.	Small amounts of contamination from basin water and basin water aerosol.	S1	F3	
Equipment movement.	Dropping of manipulator arms, fuel basket, or other heavy objects.	Equipment failure. Failure to follow procedures.	Worker injury. Worker contamination and aerosol release from splash of basin water. ALARA problems during recovery of damaged equipment, such as a deformed fuel basket.	Material handling equipment will have a limited swing radius and limited position change rate.	Procedures.	Contaminated water.	S1[1]	F3	Splash release covered by existing K Basin SAR, Section 3.4.2.11.[1]
Load fuel into basket.	Excessive accumulation of scrap in the work place.	Failure to follow procedures.	Criticality concern.	Equipment sizing of scrap baskets. Design of work place. Closed circuit television camera.	Possible limit of one open canister at a time in addition to scrap.	Fissile material in work station.	S2*	F1	*Only if criticality occurred.
Load fuel into basket.	Placing fuel of wrong enrichment in a basket.	Failure to follow procedures.	Criticality concern.		Fuel will be campaigned by enrichment.	Fissile material in basket.	S2*	F1	*Only if criticality occurred.
Load fuel into basket.	Too much fuel on sorting table or work station.	Failure to follow procedures.	Criticality concern.	Cameras.	Procedures.	Fissile material in basket.	S2*	F1	*Only if criticality occurred.
Load fuel into basket.	Too much fuel in an MCO basket.	Failure to follow procedures.	Criticality concern.	Cameras.	Weight of basket controlled. Procedure.	Fissile material in basket.	S2*	F1	*Only if criticality occurred.
Load fuel into basket.	Too little fuel in an MCO basket. Leaving void spaces in the MCO array.	Failure to follow procedures.	Criticality concern.	Cameras.	Procedures.	Fissile material in MCO.	S2*	F1	*Only if criticality occurred.
Load fuel into basket.	Overloading scrap basket.	Failure to follow procedures.	Criticality concern.	Weight limit on basket. Basket size (either overall size or depth of scrap).	Procedures.	Fissile material in basket.	S2*	F2	*Only if criticality occurred.

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Load fuel into basket.	Lack of energy control during equipment maintenance (applies to all operations).	Failure to deactivate pressurized or electrically charged systems* before maintenance.	Worker injury.	Local disconnects for equipment will be provided by design.	Procedures. Lock and tag. Zero energy checks.	N/A	S1	F3	*Cameras, hoists, manipulators.
Load fuel into basket.	Lack of radiological control during construction or maintenance.	Failure to follow procedure.	Worker exposure caused by increased airborne contamination.	Maintainability aspects of equipment design. Greenhouse structures. Area radiation monitors.	Procedures. Health physics practices.	Residual contamination on equipment or in area.	S1	F3	Includes monorail extension.
Load fuel into basket (applies to other steps).	Spill of manipulator hydraulic fluid.[1]	Equipment failure.	Contamination of pool water or spray leak. Worker Injury.[1]		Inspection. Maintenance.	Small amounts of hydraulic fluid.	S0/S1 [1]	F3	[1]
Load fuel into basket.	Dropping manipulator arms, fuel basket, or other heavy objects.	Equipment failure. Failure to follow procedure.	Worker injury. Worker contamination and aerosol release from splash of basin water. ALARA problems during recovery of damaged equipment (such as a deformed fuel basket).	Material handling equipment will have a limited swing radius and limited position change rate.	Procedures.	Contaminated water.	S1/S2	F3	
Load fuel into basket.	Loading outer elements of Mark IA fuel into basket without inner elements.	Failure to follow procedures.	Criticality concern.	Closed circuit television.	Procedures. Accountability rules.	Fissile material in work station.	S2*	F1	*Only if criticality occurred because of effective high enrichment if only outer elements are loaded.
Load fuel into basket.	Worker contacts manipulator drive.	Human error.	Worker injury.	Railings around manipulator equipment.	Procedures.	N/A	S1	F2	
Load fuel into basket.	Worker falls into basin.	Human error. Failure of grating.	Spread of contamination. Worker injury and contamination.	Life rings, railings, and grating.	Procedures. Compliance with basin grating load limits.	Small amounts of basin water.	S1	F2	Could apply to all basin operations.
Load fuel into basket.	Spread of contamination during installation or removal of underwater lights, camera, or closed circuit television.	Lowering equipment into contaminated basin water.	Spread of contaminated water aerosols resulting in worker dose.		Radiation work permit. Basin procedures. Job Hazard Analyses.	Small amounts of basin water.	S1	F3	

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Load fuel into basket.	Displacement of basin water by dropping empty basket.	Hoist failure.	Spread of contaminated water from splash with resulting worker dose.	Hoist and grapples will be designed to manage the basket, including provision for off-balance loading.	Procedures. Inspection. Load testing.	Small amounts of basin water.	S1	F3	
Load fuel into basket.	Contamination of chain hoist when lowering the basket into the basin.	Contaminated water in basin (expected).	Spread of contaminated water aerosols when chain is raised resulting in worker dose.		Radiation work permit. Basin procedures.	Small amounts of basin water.	S1	F3	
Load fuel into basket.	Pulling an element out of the water.	Manipulator failure. Human error.	Worker hazard (excessive direct radiation dose or fuel fire).	When in the down position, manipulator arm will have mechanical cut-off to the hydraulic system and software backup to prevent taking a fuel element out of the water.	Procedures.	Single fuel element.	S1	F1	
Load fuel into basket.	Dropping an element or getting an element stuck.	Manipulator failure.	Operational delay. ALARA problems from recovery. Criticality implications.*	Manipulator will be designed to "fail safe" (holding fuel element) and be vertically retractable above the loading jig (if one is used).	Procedures. Training. Job hazards analysis.	Single fuel element.	S0/S1	F3	*Not expected from dropping a single element.
Load fuel into basket.	Interference of manipulator with hoist (or other materials handling equipment).	Failure of controls on fuel movement.	Dropped fuel. Process delay.	Stops. Permissives.	Communication between hoist and manipulator operators.	Fuel basket and extra element.	S1	F3	
Load fuel into basket.	Spread of radioactive contamination to area above pool cell.*	Wicking or capillary action of manipulator hoist parts, camera parts, cables, or fuel tongs. Increased radiation in water, which spreads to deck area.	Contamination of or airborne exposure to facility worker.	Minimize surface area above the basin. Minimize holdup in joints. Plastic sleeve over cable above water. Stainless steel for decontamination.	Radiation work permit. Maintenance and operating procedures.	Small amounts of basin water.	S1	F3	*Manipulator in automatic mode.

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Manipulator operation.	Drop of manipulator plus support structure.	Seismic event.	Damage to basin floor estimated combined weight of 2730 kg (6,000 lb) dropping 2 m (6 ft-9 in.) above the recommended height and weight limit per K Basin SAR and is close to the basin perforation curve for missiles.[1]	Manipulator support structure restraints to be safety-significant equipment 3/1.	Construction will be in parts so that the manipulator is not vertical (i.e., not a missile) over the basin floor during installation.	Basin water.	S1/S2	F1	
MCO basket staging.	Removal of MCO basket from water during staging.	Human error and equipment failure.	Fuel fire caused by exposure of damp, damaged fuel to air.	MCO basket stiffback grapple, empty basket grapple.[1]	Procedures. Training.	Single basket.	S3[1]	F1	MCO stiffback grapple and empty basket grapple will prevent occurrence.[1]
MCO basket staging.	Impact of fuel basket on rack or other staged basket.	Hoist failure.	Fuel fire caused by exposure of damp, damaged fuel to air. Deformation of baskets. Violation of criticality. specifications. Drop of full MCO basket (4,000 lb) is bounded by existing SAR for damage to floor. Empty racks are crushed in an area 66 cm (26 in.) in diameter. Safety-class function of remaining fuel racks is not impaired.[1]	Hoist design to handle basket. Stops on hoist monorails to keep the hoist from moving into area that does not support basket weight..	Procedures. Training. Hoist inspections.	One or two baskets.	S2* S1	F1* F3	*Criticality
MCO basket staging.	Seismic arrangement of fuel in staging area.	Seismic event.[1]	Fuel element damage contributing to dose rate in the basin. Criticality concern.	Seismic restraints on tables. Basket staging wells are designed to seismic criteria.		Staging area contents (8 baskets).	S2*	F2	No limits on the mass of unrestrained fuel in current condition have been developed. *Only if criticality occurred. Seismic restraints have been eliminated.[1]
MCO basket staging.	Damage to seismic restraints.	Dropping basket on restraint.	Process delay.	Hoist design. Stops on hoist monorails to keep the hoist from moving into area that does not support basket weight.	Training. Procedures. Inspection.	N/A	S0	F1	Seismic restraints have been eliminated.[1]

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
MCO basket staging.	Excessive accumulation of fissile material.	Stacking MCO baskets in staging area.	Criticality problems.		Procedures.	Fissile material in baskets.	S2*	F1	1 *Only if criticality occurred.
MCO basket staging.	Higher dose rates resulting from airborne contamination in K West from decapped fuel.	Delays that prolong staging time.	ALARA problems. Additional load for water treatment system.	Water treatment system.	ALARA program.	Fuel in baskets in staging area.	S1	F3	
MCO basket staging.	Standard hazardous conditions involved with moving hoists or manipulators out of water.			Hoist features to prevent lifts from water.	Radiological controls program.				
Primary cleaning.	Fuel spill.	Hoist failure during canister movement or loading or unloading primary clean machine.	Equipment damage. Process shutdown.* Additional particulate in water.	Hoist design.	Procedures. Training. Inspections.	One or more fuel canisters.	S1	F2	*Currently moving additional fuel within 10 ft of spilled fuel is prohibited..[1]
Primary cleaning (decapping cycle in K West).	Buildup of fuel particles and debris on bottom screen of primary clean machine during decapping.	Water transport of corrosion products.	Increased pump maintenance and problems in the water treatment system if the screen fails.	Design of screen.	Procedures.	Fuel pieces and debris.	S1	F3	It is suggested that two screens, one of which is easily removable, be used in series.[1]
Primary cleaning (decapping cycle in K West).	Krypton from canisters escaping degassing system.	Krypton buildup in canisters.	Personnel dose.	Vent line if tied to other vents.	Air sampling for krypton.	Krypton in canisters.	S1/S2	F3	
Primary cleaning (decapping cycle in K West).	Criticality caused by transfer of reactive fuel pieces to the water treatment system.	Failure of screens in primary clean machine.	Release of fission product gases.	Screens to be used in primary clean machine.	Accountability. Procedural controls.	Fissile material accumulated in water treatment system components.	S2**	F0	IWTS resolved with knock- out pots.[1] **Only if actual criticality occurred.
Primary cleaning (decapping cycle in K West).	Criticality caused by accumulation in stagnant spots in primary clean machine or water treatment components.	Fissile sludge transferred from canisters.	Release of fission product gases.	Design of water treatment system components.	Only one canister handled at a time.	Sludge.	S2	F0	

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Primary cleaning (decapping cycle in K West.	Accumulation of sludge in stagnant spots in piping.	Sludge transferred from canister.	Worker injury. High dose rate during equipment maintenance.	Design of piping.	Radiological controls. Job hazard analyses. Radiation work permit. Other procedures.	Sludge.	S1	F2	
Primary cleaning (decapping cycle in K West).	Pyrophoric material (metal hydrides) catching fire.	Hydrides in water treatment.	Release of gaseous fission products.	N/A	Procedures. Training.	Material in water treatment system.	S1	F1	IWTS will resolve.
Primary cleaning (decapping cycle in K West).	Hydrogen explosion inside process equipment (offgas system).	Hydrogen evolution in canister caused by radiolysis of water and fuel corrosion, ignition of hydrogen in offgas system.	Release of gaseous fission products. Worker injury.	N/A	Procedures. Training.	Small amounts of fission product gases.	S1	F1	Suggested that the offgas from decapping be combined with the vent gases for other operations such as sludge removal.
Primary cleaning.	Electrical fire.	Electrical failure in primary clean machine motor above basin.	Industrial hazard.	Overload protection.	Fire extinguisher.	N/A	S1	F2	
Primary cleaning.	Electrical fire.	Failure of hoist motor or manipulator power supply.	Industrial hazard.	Standard electrical code designs.	Inspection. Maintenance.	Wiring, etc.	S1	F3	
Primary cleaning.	Mixing of sludge from primary clean machine with basin water.	Failure to properly secure lid or opening lid too quickly.	Dispersion of particulate into basin water.	Lid securing device well designed. Water treatment system.	Procedures, etc.	Sludge from a single canister.	S0	F0	Could be ALARA issue.
Primary cleaning.	Criticality problem in primary clean machine.	Excess fissile material.	Probably no safety consequence because of small amount of material handled.	Scrap collector designed with small capacity. Clean machine holds only one canister.[1]	Procedures.	Fissile material in one canister and scrap basket.	S0	F0	Criticality is not credible here because of small equipment capacity.
Primary cleaning.	Increased particulate, etc., coming from primary clean machine.	Unexpected quantities of particulate in K West canisters	Overloading water treatment system resulting in ALARA problems with basin water quality or excessive changes of cartridge filters.	Water treatment system..		Particulate, etc., from K West canisters.	S1	*	*Further characterization required to determine frequency. IWTS will resolve.

Table 3A-2. K Basin Fuel Retrieval Updated Preliminary Hazards Analysis. (8 sheets)

Process step	Hazardous condition	Cause	Consequence	Engineered safety features	Administrative features	Inventory	Consequence category	Frequency category	Remarks
Primary cleaning (decapping cycle in K West).	Loss of pump during decapping allowing canister water to mix with basin water.	Loss of utilities. Equipment failure.	High dose rates in transfer channel or basin water, depending on where equipment is located.	Isolation device (to be designated). Interlocks. Isolation features of the degassing system.	Procedures.	Canister water.	S1	F3	An interlock could be included that would shut down the decapping system if the pump failed.

Notes: [1]Changed since the initial development of this listing during the original PHA.
[2]DESH, 1998, *Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks*, HNF-SD-SAAR-006, Rev. 0, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

ALARA = as low as reasonably achievable.
ITWS = integrated water treatment system.
MCO = multi-canister overpack.
N/A = not applicable.
SAR = safety analysis report.

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
1. What if the manipulator arm applies excessive (lateral and vertical) force to the process table top?	Manipulator tips the process table so that fuel is piled on floor.	Criticality.	Manipulator range of motion and maximum pull do not allow the table to be tipped. Manipulator pressure-regulating system.	Procedures for fuel handling and inspection after the event. Operator training.	S0	The manipulator can exert a maximum pull of 816 kg (1,800 lb) (2730 kg [6,000 lb] at the table center). Based on the weight of the fuel that would be present, one manipulator cannot lift the entire table.[1]
2. What if the arm grips the table? Similar to question 1, except that damage to the manipulator and supports is considered.	Force applied to table by manipulator arm.	Manipulator mast breaks with splash into water.[1]	Bridge support is designed to DOE Order 6430.1A specifications.	See previous.	S1	
3. What if the arm throws the element upward?	Fuel element clears water, lands on grating.	High dose rate in basin area.	Manipulator lacks sufficient escape velocity.[1] Area radiation monitors.	Procedures and training for handling fuel elements. Emergency procedures for evacuation of area in response to area radiation monitor alarm.	S1	Depending on the tip velocity and the success of the software derating. Cannot clear water.[1]

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
4. What if an element is lifted too high?	Less shielding than normal above the element.	Higher than normal radiation dose.	Physical reach of manipulator or element is within 1.4 m (4.5 ft) of water surface. Software stop designed to keep manipulator and element within 1.8 m (6 ft) of water surface. Area radiation monitors.	Procedures and training for handling fuel elements.	S1	The accident would cause a minor increase in basin dose rate.
5. What if the manipulator software or computer control fails?	Loss of manipulator control.	Could be the same consequences as for questions 1 through 4, depending on the control failure mode.	Fails "as is" under most circumstances.	Modifications to the software will be controlled.	S1	Fail-as-is requirement provided to manufacturer.
6. What if the manipulator contacts the primary clean machine?	Force applied to primary clean machine.	Could potentially damage either clean machine or manipulator, causing ALARA issues on repair.	Clean machine is heavy and mounted on rails so that the manipulator cannot lift it.	Procedures and training for handling fuel elements.	S1	
7. What if the manipulator grabs something hanging on the monorail?	Manipulator grips canister, debris basket, or fuel basket.	Fuel spill in basin.		Procedures and training for handling fuel elements.	S0	Not a criticality issue.

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
7. What if the manipulator grabs something hanging on the monorail?	Manipulator grips canister, debris basket, or fuel basket.	Worker injury if the hoist is being manually guided.		Procedures and training for handling fuel elements.	S1	
8. What if the manipulator contacts equipment on or near the process table (such as the water treatment hoses)?	Breaks high-pressure piping.	No significant consequences.	No high pressure without nozzle.	Procedures and training for handling fuel elements.	S1[1]	
9. What if the manipulator contacts the cable management system?	Loss of manipulator control or function.	Could be the same consequences as for questions 1 through 4 depending on which components are damaged.	Should be engineered to fail "as is" under most circumstances.	Procedures and training for handling fuel elements.	S1-S2	Fail-as-is requirement provided to manufacturer.
10. What if the manipulator picks up a basket?	Deformation of or damage to the basket.	Criticality.	Center column of basket (designed to keep geometry of fuel appropriate in MCO) is sufficiently strong to resist deformation.	Procedures and training for handling fuel elements.	S2 (if criticality)	Sufficient damage to affect criticality-prevention function of equipment (SC-1 center column) is not considered credible.
10. What if the manipulator picks up a basket?	Damage to the process table.	Increased worker dose if repairs are necessary.		Procedures and training for handling fuel elements.	S1	
10. What if the manipulator picks up a basket?	Dropping fuel.	Criticality.	Basket of fuel can be dropped anywhere on process table without causing criticality.	Procedures and training for handling fuel elements.	S2	

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
11. What if the manipulator drops fuel on the floor?	Fuel element may roll under the table.	Criticality.	A single element or a number of elements dropped on the floor will not cause a criticality.	Procedures and training for handling fuel elements.	S2	The issue that must be addressed is keeping track of how many fuel elements are dropped. This should be addressed so either criticality or accountability will not be an issue.
12. What if electricity is lost?	Manipulator grip freezes in position; arm may gradually relax.	No significant.	Manipulator is designed to fail as is.		S0	
13. What if a fire occurs?	Possibility of erratic manipulator operations caused by overheating.	See questions 1 through 4.	See questions 1 through 4.		S1-S2	
13. What if a fire occurs?	Possibility of release of manipulator hydraulic fluid.	Facility worker or fire crew exposure to irritant.		Building prefire plan Building Emergency plan	S1	
13. What if a fire occurs?	Possibility of damage to manipulator or control station.	See answers to questions 1 through 4.	Hydraulic fluid has a high flash point.		S1-S2	
14. What if the manipulator pushes itself off the rails?	Manipulator and mast fall into basin.	Airborne aerosol material from splash.	Software limits to range of motion.	Procedures and training for handling fuel elements.	S1	Consequences bounded by other equipment-drop accidents.
15. What if the manipulator hits a camera or other underwater equipment such as the basin lights?	Manipulator damages equipment.	Increased worker radiation exposure during recovery.		Procedures and training for handling fuel elements.	S1	

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
15. What if the manipulator hits a camera or other underwater equipment, such as the basin lights?	Manipulator damages equipment.	Possibility of electric shock.	All FRS underwater equipment is low voltage (24 volts).	Procedures and training for handling fuel elements.	S1	Should include cautions about the use of extra lighting because the basin lights are 120 volt. Training should emphasize the electrical shock hazard.
16. What if the manipulator arm is dropped?	See question 15.					
17. What if the manipulator grips a fuel rack?	Lifting fuel rack.	No significant consequence because not all racks are required to be in place to maintain a safe geometry in the basin.	Manipulator can only reach 13 in. below the table—above the level of the racks. Not all racks are required to maintain a safe fuel geometry.	Procedures and training for handling fuel elements.	S0	
18. What if the manipulator rearranges fuel?	See answers to question 1 through 4.					
19. What if the manipulator is activated during maintenance?	Manipulator moves unexpectedly.	Worker safety hazard if tests are being performed above the water level.	Pendant (deadman) switch to be used for testing.	Lock and tag procedures. IEEE procedure for reactivating robots.	S1	

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
20. What if the manipulator loses one hydraulic line?	See answers to questions 1 through 4 for potential consequences of loss of control caused by loss or partial loss of hydraulics. See answer to question 22 for leak of manipulator hydraulic fluid.					
21. What if the manipulator leaks?	Hydraulic fluid spills in the basin.	Basin pH becomes higher; no significant consequence.	Limited spill volume (19 L [5 gal]).		S0	
21. What if the manipulator leaks?	Hydraulic fluid spills in the basin.	Could quickly use up an ion exchange module; extra exposure consequence from added changeouts.	Limited spill volume (19 L [5 gal]).		S1	
21. What if the manipulator leaks?	Hydraulic fluid pressurized leak above the basin.	Airborne release of hydraulic fluid (irritant).			S1	
21. What if the manipulator leaks?	Hydraulic fluid pressurized leak above the basin.	Worker injury from pressurized spray leak.			S1	
22. What if the two manipulators interfere with each other?	See answers to questions 1 through 4.		Software function prevents interference.			
23. What if the manipulators interfere with dumping the canisters?	See answers to questions 1 through 4.					

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
24. What if the manipulator picks up a scrap or debris basket?	See answers to questions 1 through 4 and 10.					
25. What if an earthquake occurs?	See other scenarios.		Process table is seismically supported. The manipulator bridge is designed to withstand an earthquake.			Loss of function, leakage, etc., would be possible during the seismic event.
26. What if the manipulator is dropped during installation?	See other scenarios.					
27. What if the weather is cold (or very warm)?	See loss of manipulator function and fire.					
28. What if fuel chips lodge in the arm?	See loss of manipulator function.					
28. What if fuel chips lodge in the arm?	Manipulator becomes more radioactive.	Potential high dose rates during maintenance.	Area radiation monitors activated if dose rate is too high during removal of manipulator from basin.	Maintenance procedures and work plan.	S1	Konan manipulator has a number of articulating joints in which fuel pieces could lodge.
29. What if hydraulic power is lost?	See loss of manipulator function.					
30. What if the manipulator hits the center column of the basket?	See answer to question 10.					

Table 3A-3. What-If Analysis – November 22, 1996, Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (8 sheets)

What-If?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
31. What if the manipulator exerts excessive force on the fuel?	Fuel rod could be bent or broken if the fuel is in poor condition.	No significant consequences.[1]	Manipulator is derated through software or other means.		S0	Manipulator can exert 454 kg (1,000 lb) of grip when not derated. This would not be expected to cause extensive damage to a relatively intact fuel rod.
32. What if the manipulator is used as a club or a hammer?	Potential damage to manipulator.	No significant consequences.[1]		Procedures and training for fuel handling.	S0	Manipulator could damage the process table or the secondary cleaning station.

[1]Changed from original.

ALARA = as low as reasonably achievable.
DOE = U.S. Department of Energy.
FRS = fuel retrieval system.
IEEE = Institute of Electrical and Electronic Engineers, Inc.
MCO = multi-canister overpack.

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
Stuck fuel equipment						
1. What if the fuel is cut?	A fuel assembly is positioned tangent to the cutter so the fuel is scored when the canister is cut. Underwater zirconium and uranium fines and heat are generated. Fuel or fines could undergo a partial or complete energetic chemical reaction (oxidation), producing a gas bubble.	Uncontrolled spread of hydrogen, contamination to the air.	The stuck fuel station will process only one canister of fuel at a time. Only two canisters will fit in the station at a time.	The station will be routinely cleaned with a suction wand to prevent accumulation of fines.	up to S2	An action plan is needed to address this potential scenario.
2. What if fuel is spilled or dropped?	A canister of fuel is spilled or dropped into the stuck fuel station.[1]	Criticality, damage to equipment, loss of use, delay in throughput.	The stuck fuel station will hold only two canisters at a time. Spilling a third canister on top of two canisters is below the mass needed for criticality according to the draft FRS CSER.[2]	Inventory of fuel in the equipment is controlled.	S0	
3. What if the fuel remains stuck in the canister after the canister is slit?	This would not be an accident, but an operating problem.	No safety consequences.	N/A	Procedures will address additional fuel handling techniques.	S0	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
4. What if the cutter makes scrap out of the fuel?	Scrap and fines accumulate in the equipment and undergo spontaneous energetic chemical reaction or oxidation, producing a gas bubble.	Uncontrolled spread of hydrogen and contamination to the air; criticality.	Criticality is prevented because the equipment is limited to one canister.[1]	CSER will have a scrap accumulation limit. Procedures will call for routine equipment cleaning.[2]	Up to S2	An action plan is needed to address this potential scenario.
5. What if equipment falls from the grating into the pool?	Equipment is dropped during construction or operations.	Splash of pool water exposes operators; damage to fuel racks; damage to basin.[1]	Standard lifting equipment. The equipment that could fall during operations is limited.	Normal equipment lifting and handling procedures	S1	Safety assessment needs to verify that the stuck fuel station is within the envelope of equipment drops evaluated for construction and operation.
6. What if two canisters are accumulated in the stuck fuel station?	Stuck fuel is removed to a clean canister. A new canister of stuck fuel is added to the station before the newly filled clean canister is removed.	Criticality.	Stuck fuel station will not hold more than two canisters of fuel plus a limited quantity of fuel scrap in the support tray. The sum of the contents is below that needed for criticality.	Mass limits for criticality control in the stuck fuel station will be established per the FRS CSER.[1,2]	S0	
7. What if a seismic event occurs?	Equipment falls. Fuel spills to the floor.	Criticality, damage to seismic supports, damage to fuel racks, damage to basin.	Stuck fuel station can hold only two canisters. The contents of two canisters is below that needed for criticality.[1]	CSER will provide mass limits for criticality control.[1,2]	S1	
8. What if the cutter wheel sticks or binds?	This is not an accident, but an operations problem.[1]	No safety consequences.			S0	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
9. What if the vertical drive sticks?	This is not an accident, but an operations problem.[1]	No safety consequences.			S0	
10. What if scrap accumulates in the stuck fuel station?	See question 4.				Up to S2	
11. What if the hydraulic line breaks?	Cutter motor stops. Hydraulic fluid leaks to basin water.	Basin pH increases with no significant impact. Water treatment may more rapidly use up an ion exchange module, extra exposure consequence from added changeouts.	Spill volume is limited to 19 L (5 gal).	Operating procedures.	S1	Details of pressure cutoff valves and flow prevention are needed.
12. What if a loss of power to the hydraulic power unit occurs?	Cutting operation would stop.	No safety consequences.			S0	
13. What if excessive temperatures are generated?	See question 1.				Up to S2	
14. What if a collision occurs with a canister hung from the telescoping stiffback, a canister collides with the stuck fuel equipment?	See questions 2, 5, and 6.				S1	
15. What if the cutter motor starts during a change of cutter blades?	The motor spins, causing equipment to strike the operator.	Bodily injury.		Standard lock and tag procedures.	S1	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
16. What if the cutter encounters a sludge pocket?	The cutting action stirs the sludge, adding alpha contamination to the basin water.	Increased dose rate in the basin.	Suction wand is available to remove sludge. The number of canisters in the equipment is limited.	Procedures will require canisters to be washed in the PCM before being placed in the stuck fuel station. Operate wand according to procedures.	S1	
17. What if the water in the stuck fuel box becomes contaminated?	See question 15.				S1	
Decapping Equipment						
18. What if a seismic event occurs?[1]	Equipment falls, fuel spills to the floor.	Criticality; damage to fuel racks; damage to basin.[1]	Decapping station can locate only one canister of fuel.	Mass limits to address criticality control for decapping station will be established per the FRS CSER.[1,2]	S1	
19. What if the downdraft pump fails?	Canister liquid containing cesium is released to the basin water.	Increased dose rate because of increase in the basin activity level.		Procedures will require the downdraft pump to be available during decapping.	S1 at worst	
20. What if the enclosure leaks?	Canister gas and/or cesium are released to the basin water.	Gas accumulates near operators and diffuses. (Cesium addition to basin dose is same as for question 2.)		Procedures address radiological controls, monitoring, and protection.	S1 at worst	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
21. What if hydrogen builds up in a canister after the gas trap tube is crimped?	Event is addressed in the K Basins SAR.[3]					
22. What if hydrogen burns in the canister or the decapping station?	Event is addressed in the K Basins SAR.[3]					
23. What if the inlet to the downdraft pump becomes blocked?	See question 18.				S1 at worst	
24. What if too much scrap and fines accumulate in the decapping station?[1]	See question 4.		Only one canister of fuel can be located in the decapping station. The station is equipped with downdraft.		Up to S2	
25. What if fuel is spilled or dropped into the decapping station?	See question 2.		Only one canister of fuel will fit in the decapping station.		S0	
26. What if equipment falls into the pool?	Equipment is dropped during construction or operations.	Splash of pool water exposes operators, damage to fuel racks, damage to basin.[1]	Standard lifting equipment. The equipment that could fall during operations is limited.		S1	Safety assessment needs to verify that the decapping station is within the envelope of equipment drops evaluated for construction and operations.
27. What if the hydraulic line breaks?	See question 11.				S1	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
28. What if the retractable cover opens too soon?	See question 19.				S1	
29. What if the retractable cover closes on a tool?	The cover may hit the tool and cause a slight injury to the operator.	None.	None.	Operating procedures.	S0	
30. What if there is a loss of power to the hydraulic power unit?	See question 12.				S0	
31. What if there is a collision between pieces of canister handling equipment?[1]	See question 14.				S1	
32. What if the retractable cover is stuck open?	See questions 19 and 20.				S1	
33. What if the gas collection system fails?	Hydrogen accumulates in the vent system. Krypton accumulates.	Fire or explosion. Increased dose to operators.	Use of design features (T-vent, etc.) to minimize hydrogen accumulation. None.	Procedures address radiological controls, monitoring, and protection.	S1 S1	

Table 3A-4. What-If Analysis – May 1997 Supplementary Hazards Analysis. Consequence category has been updated to latest schema. (7 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
34. What if roof vent 10 fails?	Basin air is not exhausted through this roof vent. (There are other roof vents.)	Potential accumulation of heavier than air krypton gas. Accumulation of gas would cause increased operator exposures.[1]		Procedures will address response to loss of ventilation.	S1	

Note: [1]Changed from original.
[2]FDNW, 1998, *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*, HNF-SD-SNF-CSER-010, Rev. 0, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.
[3]DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3B, DE&S Hanford, Inc. for Fluor Daniel Hanford Company, Richland, Washington.

CSER = Criticality Safety Evaluation Report.
FRS = fuel retrieval system.
N/A = not applicable.
PCM = primary clean machine.
SAR = safety analysis report.

Table 3A-5. What-If Analysis – August 1997 Supplementary Hazards Analysis. Consequence Category has been updated to latest schema. (3 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
Gas collection system						
1. What if the knit mesh pad is clogged?	Contaminants accumulate and no gas flows through the system. Gas bubbles up through the basin water.	Increased dose to operators (ALARA) from gas bubbles and maintenance work.	Knit mesh pad has back flush capability and the mesh can be replaced via contact maintenance if required.	System will be surveyed for dose rate, and flushed periodically.	S0 to S1	
2. What if the gas collection pipe breaks?	If below the water, the gas bubbles through the basin water. If above the water, the mesh pad of demisters would be bypassed.	Increased dose to operators.	None.	Normal system operations checks.	S0 to S1	
3. What if reverse flow occurs?	The decapping station discharge pump fails. Water contaminated with sludge flows back into the decapping station.	Uncontrolled spread of contamination to the basin; increased personnel dose.	Pumps are all interlocked. Failure of one pump shuts down all pumps.	N/A	S1	
4. What if gas collection system fan stops?[1]	Hydrogen is not diluted and accumulates in the system. Burnable mixture ignites. Condensate builds up.	Increased personnel dose.	Gas line is vented (not a closed system). The volume of hydrogen that could accumulate is limited. Above-water vent ducts are about 507 L. Gas from one barrel is about 3.47 L at atmospheric pressure and 43 °C (110 °F). Fan will be selected for hydrogen service to prevent ignition.[1]	Fan will have indicator lights. Decapping system operating procedure will require the fan to be running as a prerequisite to decapping.[1]	S1	Hydrogen would continue to diffuse into the basin under the loss-of-fan condition.
5. What if demister pads are clogged?	Gas flow through the system is stopped. See question 1.[1]				S0 to S1	Demister pads eliminated from design by DESH.

Table 3A-5. What-If Analysis – August 1997 Supplementary Hazards Analysis. Consequence Category has been updated to latest schema. (3 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
6. What if air suction or discharge is plugged?	System pulls a vacuum to the limit of the fan (around a few inches of water).	Hydrogen is not diluted. See question 4.[1]	Fan selected will not be able to suck the water very far up the piping; the length of pipe from the water surface to the grating is 1.4 m (4 ft-9 in.).[1]	Normal system operational checks.	S1	
7. What if the water inlet holes to the gas collection pipe are plugged?	Water flow into the decapping station through the other inlets increases.[1]	Gas bubbles are not scrubbed as planned. Slight rise in contaminants in the gas stream.	Pipe has redundant holes.	None.	S1	Standing water column provides scrubbing without counterflow. Below-water 2-in. pipe is about 7.4 m (24.25 ft) long.[1]
8. What if contaminants accumulate in the vent system?	Material plates out in the piping caused by evaporation of water.	Increase in dose rate from equipment.	None.	Normal equipment surveys.	S0 to S1	
9. What if condensate forms in the upper ductwork?	See question 8.[1]				S0 to S1	
10. What if the system fills with hydrogen, which burns?	See question 4.[1]				S1	
11. What if an earthquake occurs?	See previous items. Also, equipment tips over.[1]	Worker dose, injury. Damage to basin.[1]	None.	None.	S1	

Table 3A-5. What-If Analysis – August 1997 Supplementary Hazards Analysis. Consequence Category has been updated to latest schema. (3 sheets)

What if?	Accident	Consequences	Engineered safety features	Administrative controls	Consequence category	Remarks
12. What if mesh demister pads cannot be disposed of (no solid waste path)?	No solid waste path.	Units must be taken out and stored, causing increased dose to personnel.	None.	None.	S1	Demister pads were eliminated.[1]
13. What if roof vent 10 fails?	Some gas reenters the basin work area. Some of the gas is exhausted by other roof vents.	If event lasts long enough, krypton could accumulate, increasing dose to basin personnel.[1]	Basin has other roof vents and is not airtight. Additional air turnover is expected when casks are moved through roll-up doors.[1]	Visual check of roof vent operation.[1]	S0, S1	
14. What if water suction is lost at the decapping station?	See question 3, reverse flow.[1]				S1	
15. What if a criticality occurs in the decapping station?	Probably not a credible accident. If it did occur, gas would be released, then scrubbed [1] and shielded by the basin water.*	Personnel radiation exposure.	Capacity of the decapping station is limited.	To be determined by the criticality safety evaluation report.	S1	* This event may not be possible even if decapping station is filled with scrap.[1]
Decapping station modifications						
16. What if the pipe between the decapping station and the pump strainer breaks?	Some scrap is spilled to the floor, canister liquid is discharged directly to the basin instead of to water treatment.	Small increase in dose to personnel.	None.	None.	S0 to S1	

Notes: [1]Changed from original.
ALARA = as low as reasonably achievable.
DESH = Duke Engineering & Services Hanford, Inc.

APPENDIX 3B

BASES FOR ACCIDENT DOSES

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APPENDIX 3B

BASES FOR ACCIDENT DOSES

3B1.0 PURPOSE

This appendix provides technical information in support of the accidents addressed in Section 3.4.

3B2.0 INTRODUCTION

Inhalation dose consequences from airborne hazardous materials depend on the following variables.

- Quantity of hazardous material released
- Resuspension rate or aerosolization of radionuclides and/or toxic materials from respirable particles
- Dispersion of the airborne particles before they reach exposed individuals
- Length of time that individuals are exposed to the particles, breathing rates, and other factors.

3B3.0 HAZARDOUS INVENTORIES

This section describes the estimated radiological and nonradiological hazardous material inventories associated with the fuel retrieval system (FRS). Spent nuclear fuel is the radiological material of concern in the K Basins related to FRS. The manipulator hydraulic fluid is reviewed as a potential nonradiological hazardous material. The material types are described in the following sections.

3B3.1 K BASINS FUEL RADIOLOGICAL INVENTORIES

Most of the fuel in the K Basins is from the N Reactor. A small amount is from older reactors. The total inventory of N Reactor fuel at the Hanford Site is approximately 2130 metric tons of uranium (MTU). The inventory contains approximately 1800 MTU of fuels-grade fuel and approximately 330 MTU of weapons-grade fuel. This inventory also contains 0.3 MTU of fuel with an uncertain ^{240}Pu content. The fuels-grade fuel was discharged from N Reactor between 1970 and 1980; the weapons-grade fuel was discharged between 1986 and 1989, although reactor operation ceased in 1987. The K East Basin holds approximately 3,670 canisters containing approximately 50,700 Mark IV fuel assemblies. The K West Basin holds approximately 3,800 canisters containing 53,000 Mark IA and Mark IV fuel assemblies.

A small quantity of single pass reactor (SPR) fuel also is stored in the basins. The K West Basin contains approximately 788 pieces of 0.95 wt% or less enriched SPR fuel and 47 pieces of unknown enrichment SPR fuel. The K East Basin contains approximately 138 pieces of 0.95 wt% or less enriched SPR fuel.

The fuel inventory in the K Basins includes many elements with breached cladding caused by reactor discharge, subsequent handling, or deterioration during storage. The cladding failures range from cracks to severed fuel elements. The exact number of damaged elements is unknown (Bergsman 1993). Video imaging in the K East Basin from the summer of 1994 indicated that approximately 40 percent of the outer elements and 20 percent of the inner elements have breached cladding. As a result of the cladding damage, the uranium in some elements was exposed to the water and has oxidized during storage. The uranium oxidation causes the fuel to swell and leads to further damage to the cladding, exposing fresh uranium to the basin water and oxidation (Willis 1995 and 1997). Fuel in the K West Basin was expected to be in better condition because the K West Basin fuel is stored in sealed canisters that included a corrosion inhibitor. Based on examination of fuel in canisters in the K West Basins, this expectation was not accurate. The K East Basin fuel is stored in open-top canisters exposed to water in the basin.

3B3.2 FUEL RADIOLOGICAL COMPOSITION

The radiological composition of the fuel used for the analysis is taken from Table 4 of FDNW (1998a). The total unit dose used for analysis is 4.38 E+05 rem/gram of fuel.

3B3.3 INITIAL FUEL CHEMICAL COMPOSITION

The fuel is made up of three hazardous elements: beryllium, uranium, and zirconium. The following discussion is based on the *Purex Technical Manual* (RHO 1983).

The N Reactor fuel elements are metallic uranium clad in Zircaloy-2, and fabricated in two basic designs (Mark IV and Mark IA), differentiated primarily by diameter and ^{235}U content. They are a tube-in-tube design and are of two different enrichments. The two fuel elements have different diameters and various lengths. The specifications of size and weight are given in Table 3B-1.

Table 3B-1. N Reactor Fuel Element Description.[a]

	Mark IV				Mark IA		
Preirradiation enrichment of ^{235}U	0.947% enriched				1.25 (outer)-0.947% (inner) enriched "spike"		
Type - length code	E	S	A	C	M	T	F
Length (cm)	66.3	62.5	58.9	44.2	53.1	49.8	37.8
Diameter of element (cm)							
1. Outer of outer element	6.15				6.10		
2. Inner of outer element	4.32				4.50		
3. Outer of inner element	3.25				3.18		
4. Inner of inner element	1.22				1.11		
Cladding mass (kg)							
1. Outer element	1.09	1.04	0.99	0.79	0.88	0.83	0.66
2. Inner element	0.55	0.52	0.50	0.40	0.54	0.51	0.40
Mass of uranium in outer (kg)							
1. (0.947% ^{235}U)	16.0	15.0	14.1	10.5			
2. (1.25% ^{235}U)					11.1	10.4	7.85
Mass of uranium in inner (kg) 0.947% ^{235}U	7.48	7.03	6.62	4.94	5.49	5.12	3.90
Weighted average of uranium in element (kg)	22.7				16.3		
Ratio of zircaloy-2 to uranium (kg/MTU)	70.0	70.8	71.6	77.1	85.5	86.3	90.4
Weighted average (kg/MTU)	70.3				85.7		
Displacement volume (l/MTU)	67				67		

[a]From Willis, 1995, *105-K Basin* Material Design Basis Feed *Description for Spent Nuclear Fuel Project Facilities*, WHC-SD-SNF-TI-009, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

The use of zirconium-beryllium braze rings to close the fuel is unique to N Reactor fuel (RHO 1983 and Schulz 1972). This unique construction appears to have contributed to cladding fires ignited by mechanical shock when N Reactor fuel was processed by shear-leach methods (Schulz 1972). The chemical compositions of the fuel elements as manufactured are given in Table 3B-2. Table 3B-2 does not account for such factors as oxidation and corrosion. As each fuel element was fabricated, it was stamped with an identification code that told the composition, length, and cladding thickness of the inner and outer components.

Uranium burns in air at 150 °C to 175 °C, forming U_3O_8. When finely divided, uranium is pyrophoric (CRC Press 1986). Massive uranium burns steadily at 700 °C (Benedict et al. 1981).

The powder form of zirconium has a very low ignition temperature and is very explosive when mixed with oxidizing agents. On prolonged heating, the compact form of zirconium combines with oxygen, nitrogen, carbon, and the halogens (Merck 1989). When finely divided, zirconium may ignite spontaneously in air, especially at elevated temperatures (CRC Press 1986).

In addition to N Reactor fuel, the basins contain a small amount of single pass reactor fuel. The single pass reactor fuel elements have machined uranium cores with bonded aluminum cladding.

The radiological and toxicological consequences of releases of spent nuclear fuel were evaluated in FDNW (1998a), which concludes that "it can be assumed that no accident involving spent nuclear fuel will lead to greater toxicological risk than radiological risk to people downwind." Based on this conclusion, specific analysis of toxicological risk for the postulated FRS spent nuclear fuel accidents have not been developed.

3B3.4 MULTI-CANISTER OVERPACK BASKET DESCRIPTIONS AND FUEL LOADING LIMITS

Four different MCO basket designs were developed; Mark IA assembly, Mark IA Scrap, Mark IV assembly and Mark IV scrap. Each Mark IA basket has a safety-class 6-in. nominal center pipe that prevents fuel from accumulating near the center of the basket. The Mark IV baskets also have a smaller non-safety-class center pipe. The Mark IV baskets are about 5 in. taller than the Mark IA baskets. The bottom plates of the assembly baskets have sockets for inserting the fuel assemblies. Fuel assemblies will be held vertically when installed in the assembly basket. The scrap baskets have radial divider plates and a cylindrical container surrounding the center pipe to contain scrap fines.

MCO basket fuel loading limits, shown in Table 3B-3, are based on the criticality analysis from the FRS Criticality Safety Evaluation Report (FDNW 1998b).

3B3.5 MANIPULATOR HYDRAULIC FLUID

The manipulator system is powered by a hydraulic fluid power unit. The system reservoir that contains the hydraulic fluid has an alarm that activates on a loss of 2.5 gal and a cut-off switch that activates when the fluid level is reduced by 5 gal (19 L). The hydraulic piping also includes hydraulic fuses to limit fluid loss if a pipe breaks. Therefore, the system could release only a limited volume before it shuts down.

Table 3B-2. Original Chemical Compositions of N Reactor Fuel Components.

Element	Uranium alloy 601 (ppm)	Zircaloy-2	Braze filler
Aluminum	700-900	75 ppm	145 ppm
Beryllium	10	—	4.75-5.25 wt%
Tin	—	1.20-1.70 wt%	1.14-1.70 wt%
Iron	300-400	0.07-0.20 wt%	0.06-0.21 wt%
Chromium	65	0.05-0.15 wt%	0.05-0.15 wt%
Nickel	100	0.03-0.08 wt%	0.28-0.08 wt%
Carbon	365-735	275 ppm	500 ppm
Uranium	Balance	2.5 ppm	4 ppm
Zirconium	65	Balance	Balance
Boron	0.25	0.5 ppm	0.5 ppm
Cadmium	0.25	0.5 ppm	0.5 ppm
Cobalt	—	10 ppm	20 ppm
Copper	75	50 ppm	60 ppm
Hafnium	—	200 ppm	200 ppm
Hydrogen	2	25 ppm	50 ppm
Lead	—	100 ppm	130 ppm
Magnesium	25	20 ppm	60 ppm
Manganese	25	50 ppm	60 ppm
Molybdenum	—	50 ppm	50 ppm
Nitrogen	75	80 ppm	200 ppm
Silicon	124	100 ppm	250 ppm
Sodium	—	20 ppm	—
Titanium	—	50 ppm	20 ppm
Tungsten	—	50 ppm	100 ppm
Vanadium	—	50 ppm	50 ppm
Oxygen	—	—	2,300 ppm

Note: Information in this table is from RHO, 1983, *Purex Technical Manual*, RHO-MA-116, Rockwell Hanford Operations, Richland, Washington. Concentrations are given in ppm maximum or ppm range unless shown as a weight percentage range.

Table 3B-3. Multi-Canister Overpack Basket Loading Limits.

Fuel/basket configuration	Fissile mass limit (see Notes 1,2,3)
Mark IA scrap basket	575 kg (1,265 lbs)
Mark IA fuel assembly basket	799 kg (1,758 lbs)
Mark IV scrap basket	980 kg (2,156 lbs)
Mark IV fuel Assembly basket	1,265 kg (2,783 lbs)

Notes:

1. Values account for uranium mass only. Mass limits for fuel element baskets may be adjusted to account for clad and end caps. Mass limit for scrap baskets shall NOT be adjusted for clad or end caps because these values cannot be determined. Mass limits do not account for basket weight.
2. Other limits on scrap mass composition may be imposed for reasons other than criticality. For example, the MCO scrap basket design includes separated volumes for small scrap (< 2.5 cm) and large scrap. Final operational controls also must consider these added requirements.
3. Mass limits are "dry weights"; measured weights must be corrected for the buoyancy effects associated with weighing in water.

The hydraulic fluid used is Houghto-Safe 620. Houghto-Safe 620 was evaluated for use in the basin as documented in the *Evaluation of Houghto-Safe 620 Hydraulic Fluid* (DESH 1997). The evaluation concludes that the material is not regulated under Federal or State regulations and that it may be disposed of as an organic waste following Site procedures. This evaluation is supported by the material safety data sheet (MSDS) for the product.

Houghto-Safe 620 is a water/glycol mixture. It is 44 percent by weight ethylene glycol. When mixed with water, it is fire resistant. As used the Houghto-Safe 620 hydraulic fluid is 59 percent water, 40 percent diethylene glycol, and 1 wt% 2-diethylaminoethanol, the potentially hazardous component. 2-diethylaminoethanol is indicated on the manufacturer's MSDS as a hazardous component with a threshold limit value of 2 ppm (skin) and a permissible exposure limit of 10 ppm (skin).

The MSDS health hazard information includes the following:

- Chronic (recurrent) exposure: unknown for this product
- Acute exposure: (left blank on MSDS; i.e., none)
- Inhalation: Avoid breathing product mists. Breathing mists may cause irritation of the upper respiratory tract. Persons with chronic respiratory disease may show increased symptoms due to irritation. First aid—remove to source of fresh air.
- Skin: mild irritant. First aid—wash with soap and water.

- Eye: moderate irritant. First aid—wash with water for 15 minutes; consult a physician.

- Ingestion: avoid ingestion. May cause nausea, dizziness, diarrhea, vomiting. Repeated overexposure may lead to liver and kidney damage. First aid—induce vomiting; consult a physician.

A hydraulic piping system failure could result in K Basin personnel being subjected to spray of fluid to the skin or eyes, slight ingestion, and breathing mists. The consequence of this exposure would be to apply the indicated first aid and perform a suitable cleanup of the spilled fluid. There is basically no detrimental effect associated with use of this hydraulic fluid, industrial safety precautions are sufficient to protect the facility worker and the environment. No further analysis is required for this fluid.

3B.6.0 ACCIDENT ANALYSIS METHODOLOGY

The radiological dose and toxic chemical exposure effects of the postulated accidents must be evaluated to determine the acceptability of the risk of proposed operations. This requires an estimation of the radiological dose and toxic chemical concentrations at the receptors' locations as a result of the accidental releases.

Inhalation dose consequences from airborne hazardous materials depend on the following variables:

- Quantity of hazardous material released

- Resuspension rate or aerosolization of radionuclides and/or toxic materials to form respirable particles

- Dispersion of the airborne particles before they reach exposed individuals

- Length of time that individuals are exposed to the particles, breathing rates, and other factors.

3B6.1 SOURCE TERM DEVELOPMENT

The source term is the amount of radioactive material, measured in grams or curies, released to the air. The initial source term is the amount of radioactive material driven airborne at the accident source. The initial respirable source term, a subset of the initial source term, is the amount of radioactive material driven airborne at the accident source that is effectively capable of being inhaled. The airborne source term is typically estimated by the following equation (DOE 1994):

$$M = (MAR)[ARF \text{ or } (ARR)(T)](RF)(LPF)$$

where:

M	=	respirable source term
MAR	=	material at risk (curies or grams)
ARF	=	airborne release fraction (or airborne release rate for continuous release)
ARR	=	airborne release rate
T	=	time
RF	=	respirable fraction
LPF	=	leak path factor

The material at risk is the material available to be acted on by accident-induced physical stresses such as temperature or pressure.

The airborne release fraction is the coefficient used to estimate the material suspended as an aerosol and thus available for transport caused by the physical stresses of a specific accident. For mechanisms that continuously act to suspend material (e.g., spray release), an airborne release rate is required. ARR and T are required to estimate the potential airborne release from postulated accident conditions.

The respirable fraction is the fraction of airborne particles that can be transported through air and inhaled into the pulmonary region of the human respiratory system, and includes particles having a 10 μm "aerodynamic equivalent diameter" and less. The aerodynamic equivalent diameter is the diameter of a sphere of unit density (1 g/cm^3) that exhibits the same terminal velocity as the particle in question. Unless a particle size distribution is known and specifically mentioned in the accident scenario development, the respirable fraction will be considered to be one. All particles made airborne are assumed to be respirable.

The leak path factor is the fraction of the material in the aerosol transported through some confinement deposition or filtration mechanism. Leak path factors are developed as applicable based on (1) established relationships among sizes of the particulate material and airborne transport mechanisms and (2) losses by deposition or specified filtration efficiencies.

3B6.2 AIR TRANSPORT FACTORS

Atmospheric transport calculations estimate air concentration resulting from atmospheric discharges and the resultant transport and dilution with meteorological conditions. These air concentrations are used to calculate doses. The air transport factor (χ/Q') represents the dilution of an airborne contaminant caused by atmospheric mixing and turbulence. The χ/Q' s have been calculated (FDNW 1998a) for the onsite and offsite receptors and are presented in Table 3B-4.

Table 3B-4. Maximum Individual Locations and Air Transport Factors for Ground Level Releases.

Receptor type	Air transport factors, s/m^3				
	< 1 hr	1 hr to 2 hr	12 hr[a]	24 hr[a]	Annual
Onsite worker 100 m E	7.32 E-02	1.24 E-02	6.28 E-03	NA	5.12 E-04
Columbia River 480 m NW	2.15 E-03	5.55 E-04	2.42 E-04	NA	1.14 E-05[b]
Hanford Site boundary 12,040 m W	3.58 E-05	2.60 E-05	8.28 E-06	5.32 E-06	1.23 E-07

[a] The 12- and 24-hour values are computed by interpolation. The rest are computed by GXQ (Hey, B.E., 1993, GXQ program Users' Guide, WHC-SD-GN-SWD-30002, Rev 0 Westinghouse Hanford Company, Richland Washington). All GXQ runs use a release height and receptor height of zero meters.

[b] For the K West Reactor and adjacent buildings, this receptor is located 520 m WNW.

3B6.3 RADIOLOGICAL DOSE CALCULATIONS

The major radioactive exposure pathway for the identified accidents is inhalation. Potential doses from the ingestion pathway also are not included in the comparison to risk guidelines because the U.S. Department of Energy, Richland Operations Office and State and Federal agencies have emergency preparedness plans in place to limit ingestion in case of an accident.

The calculation of inhalation dose from airborne radioactive material transported downwind is computed as the product of the quantity released, the air transport factor, the inhalation rate and the unit dose factor for the radionuclide mixture released. This is summarized in the following equation.

$$DE = (M)(\chi/Q')(BR)(UD)$$

where

DE = 50 - year committed effective dose equivalent, rem (S_v)
M = mass released into the air as respirable particles, grams
χ/Q' = air transport factor, s/m^3
BR = average inhalation rate during the release, m^3/s
UD = committed effective dose equivalent per gram inhaled, rem/g (S_v/g).

The quantity released depends on the accident scenario. Because only the respirable portion contributes to inhalation dose, the value of M is limited to the respirable portion. If the respirable portion cannot be determined, the entire release should be assumed to be respirable.

The air transport factor depends on which receptor is being considered, the release height, and the duration of the release.

Inhalation rates for the reference man (ICRP 1975) are used. The light-activity breathing rate (1.2 m^3/hr or 3.33 x 10^{-4} m^3/s) applies during the first 16 hours of the day when the man is assumed to be awake. The resting breathing rate (0.45 m^3/hr or 1.25 x 10^{-4} m^3/s) applies during the last 8 hours of the day when the man is assumed to be asleep. The 24-hour average breathing rate is 2.64 x 10^{-4} m^3/s. The male breathing rate is used to conservatively maximize the intake and the dose.

The total unit dose used is 4.38 E+05 rem/gram of fuel from Table 4 of FDNW (1998a).

3B7.0 REFERENCES

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APPENDIX 3C

ADDITIONAL CALCULATIONS

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APPENDIX 3C-1

CALCULATION OF MANIPULATOR THROWING FUEL

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

April 4, 1997

Mr. Eric Shen
DE&S Hanford, Inc.
2920 George Washington Way
PO Box 350
Richland, WA 99352

Dear Mr. Shen:

SCHILLING KONAN MANIPULATOR--THROWING FUEL FROM BASIN

Attached are calculations that provide evidence that a fuel element or assembly could not be thrown out of the K basin during normal operation and onto the floor grating above the water surface. Such an event could have serious safety and/or ALARA implications.

The velocity required to throw the fuel 8 feet, the distance from the arm tip (at its highest position), to the grating is 22.7 ft/sec (15.5 mph). The water resistance turns out to be very low and almost balances the buoyancy effect (for a 50 lb. fuel element or assembly). A velocity of 17 ft/sec (12 mph) is required to throw the fuel to the water surface assuming a minimum of 4.5 feet between the surface of the water and the maximum reach of the manipulator. The fuel would never exit the surface of the water at this velocity.

Based on test results provided during a teleconference communication with Schilling Robotic Systems, these velocities are an order of magnitude greater than the manipulator capability. Therefore, no further action to address this concern is required.

If you have any further questions or needs concerning these analyses, please contact David R. Jackson at 372-4923.

Sincerely,

Gary L. Ketner

Gary L. Ketner
Senior Development Engineer

cc: David Jackson, B&W, L1-03
Steve Peck, SEG, R3-85

902 Battelle Boulevard ▪ P.O. Box 999 ▪ Richland, WA 99352

Telephone (509) 372-4923 ▪ Email gl_ketner@pnl.gov ▪ Fax (509) 375-6497

K-Basin Fuel Assembly Throw Calculations

(12/13/96)

Documented here are fluid drag calculations by Hank C. Reid and dynamics calculations by Mark R. Garnich that estimate the vertical velocity required to "throw" a spent fuel assembly out of the water in K-Basin. The first calculation is for the assembly to just exit the water by traveling 4.5 feet through water from the highest point of reach of a robotic arm. The second calculation is for a total vertical travel of 8 feet to the grating above the water where the first 4.5 feet are through water. The fuel assembly is assumed to have an inner element and outer element fixed together so it weighs approximately 50 pounds and has a water displacement of approximately 121 cubic inches. This displacement corresponds to a water buoyancy of about 4.4 pounds.

Following Schlichting, (1968), "Boundary Layer Theory," page 602, the drag coefficient for axial flow along a cylinder can be approximated by:

$$C_f = \frac{0.455}{(\log(\mathrm{Re}))^{2.58}}$$

where if ρ is the density of the water, V is the flow velocity, ℓ is the characteristic length (length of the assembly), and μ is the viscosity then the Reynold's number is,

$$\mathrm{Re} = \rho V \ell / \mu \ .$$

Denoting the dynamic pressure as P and the acceleration of gravity as g then:

$$P = \tfrac{1}{2} \rho v^2 / g \ .$$

Finally, denoting the surface area as A then:

$$Drag = PAC_f = \left(\tfrac{1}{2} \rho v^2 / g\right) A \frac{0.455}{(\log(\mathrm{Re}))^{2.58}} \ .$$

Prepared by: [signature] MR Garnich | Page 1 of 3 | Reviewed by: [signature] GL Ketner

To compute the drag requires the velocity which depends on the drag. An estimate of the velocity can be obtained by assuming there is no drag or buoyancy. For vertical motion, the change in kinetic energy is then equal to the work done by gravity over the vertical distance (d) traveled. Therefore,

$$\tfrac{1}{2}m\left(v_o^2 - v_f^2\right) = mgd$$

$$\frac{1}{2}\left(\frac{50}{32.2}\right)\left(v_o^2 - 0\right) = 50d$$

$$v_o = 8\sqrt{d}$$

For a distance of 4.5 feet the initial velocity is 17 ft/s and for a distance of 8 feet the initial velocity if 22.6 ft/s. For these velocities and a calculated area of 1.28 ft^2, the calculated drag forces, shown on the attached spread sheet printout, are 1.3 and 2.2 pounds respectively. A similar calculation for assembly internal (tube) flow also based on Schlichting (p. 574) gives drag force estimates of 1.4 and 2.3 pounds respectively (see attached spread sheet printout). So the total drag estimates for the two velocities are 2.7 and 4.5 pounds. Considering these are peak drag forces (at the maximum velocity) and that the drag will decrease roughly proportional to the square of the velocity, these are negligible forces compared to the 50 pound force due to gravity. Therefore, the drag is neglected (which is conservative since it results in lower initial velocities) and only the buoyancy is accounted for. The buoyancy is conservatively assumed to act at all times so the initial velocity required to travel vertical distance d is

$$v_o = 7.7\sqrt{d}\ .$$

Then:

$$d = 4.5\,\text{ft} \;\Rightarrow\; v_o = 16\,\text{ft/s}$$
$$d = 8.0\,\text{ft} \;\Rightarrow\; v_o = 22\,\text{ft/s}$$

Note that these calculations are worst case in the sense that the assembly is assumed thrown perfectly so that its velocity is parallel to its longitudinal axis, thus minimizing drag.

Prepared by: MR Garnich   Page 2 of 3   Reviewed by: GL Ketner fdrag

Drag for a cylindrical tube with flow on the ID & OD					
Friction factors based on "Boundary Layer Theory"; Schlichting, 1968, p. 574, 602					
Fluid Material Properties					
			Flow is along axial tube length		
Water					
k	0.347	btu/hr-ft-F			
mu	2.60E+00	lbm/hr-ft			
density	62.4	lb/ft^3			
c,p	0.24	Btu/lb-F			
Dimensions	in	ft		vol (in^3)	
L	24.5	2.04166667		52	0.03009259
D,o	2.4	0.2			
D,i	1.75	0.14583333			
As	184.725492	1.28281592			
				V,grav	
Transv L		4.5		17.0182255	
	lb		time (sec)	0.5288448	
W	50				
OD calculation					
Vel (f/s)	8.5		17	22.6	
Dyn Pres (psf	70.0497203		280.198881	495.205469	
Rey	1499400		2998800	3986640	
Cf	0.00414956		0.00367008	0.0034953	
Drag (lbf)	0.37288276		1.3191876	2.22041814	
ID calculation					
Vel (f/s)	8.5		17	22.6	
Dyn Pres (psf	70.0497203		280.198881	495.205469	
Rey	107100		214200	284760	
Cf	0.00495016		0.00400016	0.00360992	
Drag (lbf)	0.4448262		1.43783348	2.29322606	
Total Drag (lb	0.81770897		2.75702108	4.5136442	

Prepared by: MR Garnich   Page 3 of 3   Reviewed by: GL Ketner

APPENDIX 3C-2

CALCULATION OF DOSE CAUSED BY MANIPULATOR RAISING FUEL TO MAXIMUM HEIGHT

DE&S HANFORD, INC.
A Duke Engineering & Services Company

Internal Memo

From: Fuel Retrieval Sub-Projects
Phone: 376-7045 R3-86
Date: December 17, 1996
Subject: SAFETY ISSUE ASSOCIATED WITH FUEL RAISED TO SURFACE BY MANIPULATOR

To: S. H. Peck R3-85

cc:	B. S. Carlisle	R3-85
	W. C. Mills	R3-85
	G. W. Reddick	N1-26
	T. L. Yount	R3-85
	EJS LB/File	R3-86
	FRS Project Files	R3-85
	SNF Project Files	R3-11

Reference: Letter, S. M. Mackay, BNFL, to T. L. Yount, "Dose Rates vs. Water Depth For SNF Sources," 9602129, dated August 12, 1996.

Based on the attached pages, a fuel assembly can approach within 2'-1" of the surface of the water. This conservatively translates to a 300 mrem/hr dose rate at the 0'-0" level in the K West Basin.

Please use this information as the basis for closing the open safety issue on this subject.

If you have any questions, please call me on 376-7045.

Very truly yours,

E. J. Shen
FRS Design Authority

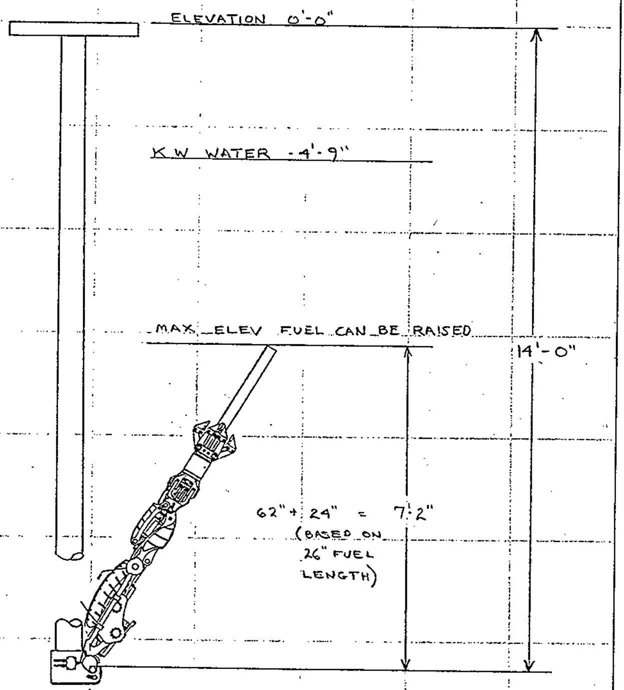
lda

Attachments 3

A-6002-082 (10/96) GEF399

ATTACHMENT 1

CALCULATIONS BY E. J. SHEN 12/13/96



MAST LENGTH	14'-0"
DISTANCE TO SURFACE OF WATER	-(4'-9")
HEIGHT FUEL RAISED BY MANIP.	-(7'-2")
MINIMUM WATER SHIELD DEPTH	2'-1"
CALCULATED DOSE RATE	300 mrem/HR

CHECKED BY
JM HENDERSON
JM Henderson
12/16/96

ATTACHMENT 2

Maximum lift capacity at full reach* .... 375 lb (170 kg)
Maximum grip opening* .... 6.0 in. (15.2 cm)
Maximum grip force* .... 1,000 lb (4,448 N)
Maximum wrist torque .... 1,400 in-lb (158.2 N-m)
Wrist rotate, continuous .... 360 degrees, 0-35 rpm

* With standard 6- in. intermeshing gripper

MASTER CONTROLLER DIMENSIONS

A master controller is provided only for the position-controlled version.

Length .... 19.1 in. (48.5 cm)
Width .... 6.0 in. (15.3 cm)
Height.. 2.7 in. (6.9 cm)
Weight .... 9.5 lb (4.3 kg)

SLAVE ARM FUNCTIONS

Function	Actuator Type	Torque or Force @ 3000 psi	Mechanical Range
Azimuth	Linear	41,300 in-lb (max) 17,500 in-lb (min)	120°
Shoulder pitch	Linear	36,500 in-lb (max) 15,500 in-lb (min)	120°
Elbow pitch	Linear	38,700 in-lb (max) 16,400 in-lb (min)	120°
Wrist pitch	Linear	10,800 in-lb (max) 4,600 in-lb (min)	120°
Wrist yaw	Linear	10,800 in-lb (max) 4600 in-lb (min)	120°
Wrist rotate	Gerotor	1,400 in-lb (158.2 N-m)	360°
Jaw	Linear	1,000 lb (4,448 N)	6.0 in. (15.2 cm)

HYDRAULIC REQUIREMENTS

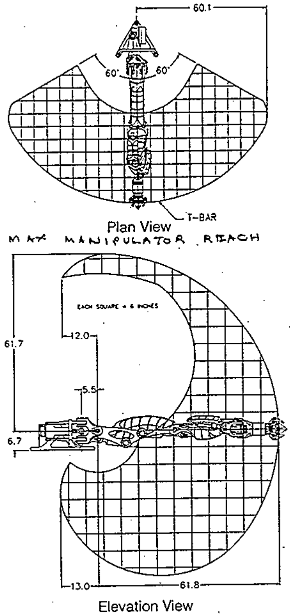
Fluid type: Petroleum-based or water/glycol-based hydraulic fluid (non-corrosive)

Viscosity .... 10-200 cSt
Flow .... 1.5-5 gpm (5.7-19.0 l/min)
Pressure, position control .... 3,000 psi (200 bar)
Rate control .... 1,000-3,000 psi (70-200 bar)

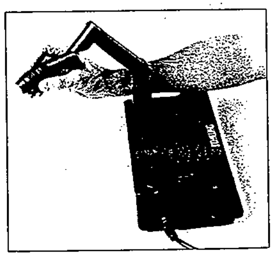
ELECTRICAL AND TELEMETRY REQUIREMENTS

100-240 VAC 50/60 Hz standard. Consult SRS for other power options.

Standard with RS-422/485 half-duplex, optional RS-422/485 full-duplex or RS-232 communication protocol. Consult SRS for other telemetry options.



CONAN range of motion (inches)

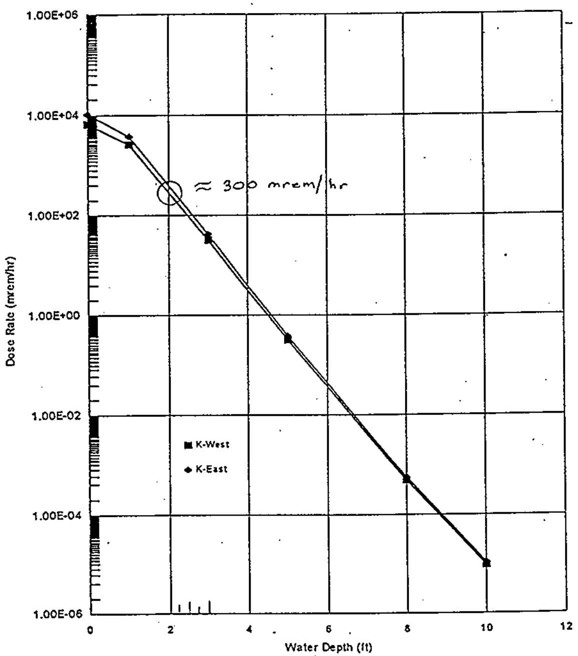


CONAN master controller with master arm

ATTACHMENT 3

BNFL GENERAL CALCULATION SHEET	CALCULATION NO. SNF-FRS-CAL-01	REV	ORIG. BY	CHK'D BY
	PRELIMINARY / FINAL	0	- DATE 7/23/96	DATE
PROJECT SNF Fuel Retrieval Sub-Project	SHEET 21 OF			
SUBJECT Dose Rates vs Water Depth for SNF Sources	TASK: Radiological Safety		DATE	DATE

Figure 6: Dose Rate versus Water Depth for the Single Fuel Assembly Model



Dose point located 57" and 45" above water level for K West and K East, respectively.

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

This chapter provides details of the safety-class structures, systems, and components (SSC) and safety-significant SSCs necessary for the fuel retrieval system (FRS) equipment to ensure the protection of the public, onsite workers, and the environment. Descriptions are provided of the attributes required to support the safety functions identified in the hazard and accident analyses and to support subsequent derivations of the technical safety requirements (TSR) (associated with FRS equipment and operation) for the facility. This chapter includes the following:

- Description of safety-class and safety-significant SSCs, including the safety functions performed
- Identification of the K Basin support system safety-class SSCs that carry out safety functions for FRS
- Identification of the functional requirements necessary for the safety-class and safety-significant SSCs to perform their safety functions, and the general conditions caused by postulated accidents under which the safety-class and safety-significant SSCs must operate
- Identification of assumptions needing TSR coverage.

4.2 REQUIREMENTS

The facility standards and criteria that apply to the FRS are found in the *SNF K Basin and Cold Vacuum Drying Facility Standard Requirements Identification Document*, HNF-SD-SNF-RD-001, (DESH 1998). The standards and requirements applicable to the FRS equipment are found in the *Specification for Design of the SNF Project Fuel Retrieval Subproject*, WHC-S-0461 (WHC 1996).

4.3 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

This section discusses engineered safety features used in the design of the FRS equipment to ensure the protection of the public, onsite workers, and the environment. The two safety designations are safety class and safety significant. Safety-class and safety-significant SSCs are selected based on the need to mitigate consequences greater than the guidelines. A safety-class SSC is "an SSC whose preventive or mitigative function is necessary to keep radiological exposure to within the offsite radiological risk guidelines or to prevent a nuclear criticality" (FDH 1997). A safety-significant SSC is "an SSC whose preventive or mitigative function is necessary to keep hazardous material exposure to within the"onsite "radiological and toxic chemical risk guidelines, or is otherwise considered significant in maintaining defense-in-depth and worker safety" (FDH 1997). Safety-class SSCs are discussed in sections 4.3.1 through 4.3.5. Safety-significant SSCs are presented in section 4.4.

The criteria for determining safety-class SSCs as applied to the FRS equipment, except for the manipulator support structure tether system, are presented in Table 4A-1 in Appendix 4A. The safety classification requirements applicable when the safety classification of the tether system was established made the tether system safety significant. The tether system was designed and procured as safety significant equipment. Based on the current safety classification requirements, the manipulator support tether system would be designed and procured as safety class rather than safety significant. However, the safety significant classification is consistent with the safety classification of the K Basin support structure to which the tether is attached. The safety-class equipment list for the FRS Subproject is presented in Table 4-1. The safety-significant equipment list for the FRS Subproject is presented in Table 4-2.

4.3.1 Primary Clean Machine Lower Half and Support Structure

The following sections describe the safety functions, structural details, functional requirements, system evaluation, and controls for the primary clean machine (PCM).

4.3.1.1 Safety Function. The safety function of the PCM is to ensure that fuel contained in the PCM will not be spilled as a result of a load drop or a seismic event. The fuel mass in the PCM is controlled to ensure criticality safety.

4.3.1.2 Description. The PCM consists of a large steel box frame containing a rotating basket used to wash fuel and a strainer to capture scrap fuel pieces that fall from the wash basket. Suction of basin water out of the PCM removes sludge as the fuel is washed. The steel box is made in upper and lower halves. Figure 4-1 shows the PCM. Only one canister of fuel can be loaded in the PCM at a time. The PCM is bolted to a structural steel frame that sits on the basin floor.

4.3.1.3 Functional Requirements. The lower half of the PCM is required to prevent fuel spills from the PCM during the postulated events, a load drop and a seismic event, and is designated safety class. The upper half and related appurtenances are not safety class. The structural support frame and the attachment bolts must be safety class to ensure that the PCM will not collapse or tip over because of a load drop or seismic event.

4.3.1.4 System Evaluation. The PCM and structural support frame are designed to withstand the impact of the postulated heavy load drops without structural failure or tipping. They also are designed to withstand the loads imposed by the design basis earthquake without structural failure or tipping.

Table 4-1. Fuel Retrieval System Safety Class Equipment List.

Equipment	Safety function	Design basis accidents	Functional requirements	Performance criteria requiring TSR coverage
Primary clean machine lower half and support structure.	Prevent criticality.	Load drop. Seismic event.	Physical strength - withstand drop loads and seismic forces without failure. Maintain fuel geometry - prevent spill of fuel from load drop or seismic event.	Basic design - covered by existing K Basin TSRs requiring change control program.
Process table support structure and MCO basket go-no-go gauge and bottom plate.	Prevent criticality.	Load drop. Seismic event.	Physical strength - withstand drop loads and seismic forces without failure. Maintain fuel geometry - prevent spill of fuel from load drop or seismic event.	Basic design - covered by existing K Basin TSRs requiring change control program.
MCO basket queue.	Prevent criticality.	Load drop. Seismic event.	Physical strength - withstand drop loads and seismic forces without failure. Maintain fuel geometry - prevent spill of fuel from load drop or seismic event.	Basic design - covered by existing K Basin TSRs requiring change control program.
MCO basket stiffback.	Prevent fuel burn/overexposure; prevent damage to basin or FRS safety class equipment by limiting drop height.	Lift fuel container too high.	Physical dimensions— length must preclude lifting fuel out of basin water with hoist at upper end of travel and must ensure that Mark IV MCO basket can be lifted no higher than 162.5 cm (64 in.) above the basin floor. Design - must not allow hoist to lift fuel out of basin water because of any failure of the stiffback.	Basic design - covered by existing K Basin TSRs requiring change control program.
Empty MCO basket grapple	Prevent fuel burn/overexposure.	Lift fuel container too high.	Design - design must prevent loading fuel into MCO basket while the basket is grappled and must prevent remotely grappling a basket.	Basic design - covered by existing K Basin TSRs requiring change control program.

FRS = fuel retrieval system.
MCO = multi-canister overpack.
TSR = technical safety requirement.

4.3.1.5 Controls (Technical Safety Requirement). The PCM and structural support stand is a passive design feature; however, the integrity of the PCM and support frame must be maintained. Because this equipment has a life of less than 5 years, it is not expected to experience significant degradation from corrosion or use while in service in the basin. The existing K Basin TSR requirement for a change control program ensures that the design features will not be inadvertently changed. The existing K Basin TSR requirement for a criticality prevention program implemented by criticality prevention specifications will ensure that mass limits are implemented. No additional controls are required.

4.3.2 Process Table Support Structure, Multi-Canister Overpack Basket Go-No-Go Gauges, and Bottom Plate

Sections 4.3.2.1 through 4.3.2.5 describe the safety functions, structural details, functional requirements, system evaluation, and controls for the process table support structure, multi-canister overpack (MCO) basket go-no-go gauge, and bottom plate.

4.3.2.1 Safety Function. The safety function of the process table support structure, MCO basket go-no-go gauges, and bottom plates is to ensure that fuel contained in the MCO basket will not be spilled as a result of a load drop onto the process table support structure or a seismic event. This ensures that the fuel in the MCO basket container will not join with other fuel that may spill from adjacent FRS equipment or fuel containers, potentially causing a criticality. Fuel masses in each piece of FRS equipment and in fuel containers are controlled to ensure criticality safety in case of a load drop or seismic event.

4.3.2.2 Description. The process table top holds fuel to allow sorting and loading into the MCO baskets. The MCO baskets are held in the MCO basket go-no-go gauges, which are installed in the process table top support structure. The process table top has three support structures fabricated from structural steel. The MCO basket go-no-go gauges are fabricated to simulate the MCO. The scrap basket loading locations under monorail 26 also have a steel bottom plate under the go-no-go gauge to contain fuel if an MCO basket should break. Figure 4-2 shows the process table.

4.3.2.3 Functional Requirements. The process table support structure with the MCO basket go-no-go gauge and bottom plates must ensure that fuel contained in the MCO basket will not be spilled because of the effects of a load drop onto the process table support structure or a seismic event. This ensures that the fuel in the MCO basket will not join with other fuel that may spill from the table, adjacent FRS equipment, or fuel containers, potentially causing a criticality. Fuel masses in each piece of FRS equipment and in fuel containers are controlled to ensure criticality safety in case of a load drop or seismic event.

4.3.2.4 System Evaluation. The process table support structure and MCO basket go-no-go gauge and bottom plate are designed to withstand the impact of the postulated heavy load drops without structural failure or tipping. They also are designed to withstand the loads imposed by the design basis earthquake without structural failure or tipping.

The structural and seismic analyses for the process table support structure, MCO basket go-no-go gauge, and bottom plate are included in HNF-2229 (BNFL 1998). This analysis demonstrates the acceptability of the design to withstand the postulated accident conditions within acceptable margins.

4.3.2.5 Controls (Technical Safety Requirement). The process table support structure with its integral MCO basket go-no-go gauge and bottom plate is a passive design feature; however, the integrity of the process table support structure and MCO basket go-no-go gauge and bottom plate must be maintained. Because this equipment has a life of less than 5 years, significant degradation from corrosion or use while in service in the basin are not expected. The existing K Basin TSR requirement for a change control program ensures that the design features will not be inadvertently changed. The existing K Basin TSR requirement for a criticality prevention program implemented by criticality prevention specifications will ensure that mass limits are implemented. No additional controls are required.

4.3.3 Multi-Canister Overpack Basket Queue

Sections 4.3.3.1 through 4.3.3.5 describe the safety functions, structural details, functional requirements, system evaluation, and controls for the MCO basket queue.

4.3.3.1 Safety Function. The safety function of the MCO basket queue is to ensure that fuel contained in the MCO basket queue will not be spilled because of the effects of a load drop or a seismic event. This ensures that the fuel in the MCO basket queue will not spill, potentially causing a criticality.

4.3.3.2 Description. The MCO basket queue is constructed in four sections. Each section is fabricated from structural steel. The MCO basket queue can hold up to 10 MCO baskets. Each MCO basket "slot" is lined with a 61 cm (24-in.) pipe section and a bottom plate. Each MCO queue section is an integral welded structure. Figure 4-3 shows the MCO basket queue sections.

4.3.3.3 Functional Requirements. The MCO basket queue must ensure that fuel contained in the MCO baskets will not be spilled because of the effects of a load drop onto the MCO basket queue or a seismic event. This ensures that the fuel in the MCO basket will not spill, potentially causing a criticality.

4.3.3.4 System Evaluation. The MCO basket queue sections are designed to withstand the impact of the postulated heavy load drops without structural failure or tipping. They also are designed to withstand the loads imposed by the design basis earthquake without structural failure or tipping.

The structural and seismic analysis for the MCO basket queue sections is included in HNF-2229 (BNFL 1998). This analysis demonstrates the acceptability of the design to withstand the postulated accident conditions within acceptable margins.

4.3.3.5 Controls (Technical Safety Requirement). The MCO basket queue is a passive design feature; however, the integrity of the MCO basket queue must be maintained. Because this equipment has a life of less than 5 years, it is not expected to experience significant degradation from corrosion or use while in service in the basin. The existing K Basin TSR requirement for a change control program ensures that the design features will not be inadvertently changed. The existing K Basin TSR requirement for a criticality prevention program implemented by criticality prevention specifications will ensure that mass limits are implemented. No additional controls are required.

4.3.4 Multi-Canister Overpack Basket Stiffback Grapple

Sections 4.3.4.1 through 4.3.4.5 describe the safety functions, structural details, functional requirements, system evaluation, and controls for the MCO basket stiffback grapple.

4.3.4.1 Safety Function. The safety functions of the MCO basket stiffback grapple are to ensure that the loaded MCO basket will not be allowed to be raised to the surface of the basin pool water and to limit the drop height for the MCO basket. This prevents the possibility of fuel in the MCO basket igniting and ensures the maximum drop height for an MCO basket if bounded by the drop analysis. It also protects facility workers from an excessive radiation dose because the basket cannot be raised out of the basin water, which provides shielding.

4.3.4.2 Description. The MCO basket stiffback grapple is a lifting device with a ball detent grapple built to fit inside the MCO basket center pipe. The balls are pushed out to engage a fit in the MCO basket center pipe, allowing the MCO basket to be lifted and moved around in the basin. A grapple-operating device on the upper end of the stiffback allows remote engaging and disengaging of the MCO basket. The MCO basket stiffback grapple is attached to a hoist on the monorail that raises and lowers the MCO baskets attached to the grapple. The length of the MCO basket stiffback grapple ensures that the MCO basket drop height is within the analyzed value. Figure 4-4 shows the MCO basket stiffback and grapple assembly.

4.3.4.3 Functional Requirements. The MCO basket stiffback grapple functional requirements are to be sufficiently long to prevent raising a loaded MCO basket out of the basin water regardless of the hoist design or any hoist or operator failures and to ensure that the MCO basket drop height is limited to the analyzed value. Testing of the MCO basket stiffback grapple shall verify that the maximum lift height of the bottom of a Mark IV MCO basket is no more than 162 cm (64 in.) above the basin floor under any faulted conditions.

4.3.4.4 System Evaluation. The MCO basket stiffback grapple is designed to be sufficiently long to prevent raising a grappled MCO basket out of the water at the full lift height of the hoist under any condition and to ensure that the maximum drop height is within the value analyzed.

Suitable design allowables are applied to the design to ensure that it will have sufficient strength to prevent failure with maximum MCO basket loading.

4.3.4.5 Controls (Technical Safety Requirement). The MCO basket stiffback grapple is a passive design feature. The existing K Basin TSR requirement for a change control program ensures that the design features are not inadvertently changed. The existing K Basin TSR requirement for a criticality prevention program implemented by criticality prevention specifications will provide adequate controls over MCO basket movements to ensure that only MCO stiffback grapples are used to lift and move loaded MCO baskets. No additional controls are required.

4.3.5 Empty Multi-Canister Overpack Basket Grapple

Sections 4.3.5.1 through 4.3.5.5 describe the safety functions, structural details, functional requirements, system evaluation, and controls for the empty MCO basket grapple.

4.3.5.1 Safety Function. The safety function of the empty MCO basket grapple is to ensure that fuel cannot be inadvertently loaded into a grappled MCO basket and that a loaded MCO basket cannot be remotely grappled and raised to the surface of the basin pool water. This prevents the possibility of raising a loaded MCO basket out of the basin water causing fuel in the MCO basket to ignite. It also protects facility workers from an excessive radiation dose because the basket cannot be raised out of the basin water, which provides shielding.

4.3.5.2 Description. The empty basket grapple is a steel lifting tube with a ball detent device built to fit inside the MCO basket center pipe. The balls are pushed out to engage a fit in the MCO basket center pipe. The grapple must be engaged manually, but may be disengaged remotely. This prevents reengagement of the grapple in the basin. The grapple can be attached to a standard hoist, allowing the MCO basket to be lifted. In addition, the grapple has a cover that covers the MCO basket when the grapple is in place and prevents loading fuel into the basket while the grapple is in place. Figure 4-5 shows the empty basket grapple.

4.3.5.3 Functional Requirements. The empty MCO basket grapple functional requirements are that it must prevent remote grappling of an MCO basket and prevent loading fuel into a basket that is grappled by the empty MCO basket grapple.

4.3.5.4 System Evaluation. The empty MCO basket grapple has been designed to ensure that it cannot be attached to an MCO basket remotely (i.e., under the basin water) and that fuel cannot be loaded into a basket attached to the empty basket grapple. These design features prevent inadvertently loading fuel into a grappled MCO basket or grappling an MCO basket containing fuel and subsequently raising the loaded MCO basket out of the water.

4.3.5.5 Controls (Technical Safety Requirement). The empty MCO basket grapple is a passive design feature. The existing K Basin TSR requirement for a change control program ensures that the design features will not be inadvertently changed. The existing K Basin TSR requirement for a criticality prevention program implemented by criticality prevention specifications will provide adequate controls over basket movements to reasonably ensure that only the empty MCO basket grapple is used to place empty MCO baskets into the basin. No additional TSRs are required.

4.4 SAFETY-SIGNIFICANT STRUCTURES, SYSTEMS, AND COMPONENTS

Safety-significant SSCs for the FRS equipment and its operation are summarized in Table 4-2.

4.4.1 Manipulator Rail Support Structure Tether System

Sections 4.4.1.1 through 4.4.1.5 describe the safety-significant functions, structural details, functional requirements, system evaluation, and controls for the empty MCO basket grapple.

4.4.1.1 Safety-Significant Function. The safety-significant function of the manipulator rail support structure tether system is to prevent the manipulator rail support structure from falling into the basin if it fails during a seismic event.

4.4.1.2 Description. The manipulator rail support structure tether system is a series of cables and attachments installed inside the manipulator rail support columns and attached to the K Basin superstructure. The cables and attachments prevent the structure from falling if attachment welds or the structure itself fails. Figure 4-6 shows the manipulator rail support structure tether system.

4.4.1.3 Functional Requirements. The manipulator rail support structure tether system is required to prevent the manipulator rail support structure from falling into the basin with the manipulator if the manipulator rail support structure fails because of overstress resulting from a seismic event. The tether system must be able to withstand the impact load from a drop of the manipulator rail support structure and maintain the load of the structure.

4.4.1.4 System Evaluation. The manipulator rail support structure tether system has been designed and analyzed to demonstrate that it can withstand the loads imposed by a failure of the manipulator rail support structure. The stress analysis is contained in *Fuel Retrieval Subproject K-Basin Facility Modification Calculations*, HNF-SD-SNF-CN-009 (FDNW 1997).

4.4.1.5 Controls (Technical Safety Requirement). The manipulator rail support structure tether system is a passive design feature. The existing TSR requirement for a change control program will reasonably ensure that the design features are not inadvertently changed. No additional controls are required.

Table 4-2. Fuel Retrieval System Safety Significant Equipment List.

Equipment	Safety function	Design basis accidents	Functional requirements	Performance criteria requiring TSR coverage
Manipulator support structure tether system.	Prevent drop of manipulator support structure into basin following failure caused by a seismic event.	Seismic event.	Physical strength - withstand drop loads and seismic forces without failure.	Basic design - covered by existing K Basin TSRs requiring change control program.

TSR = technical safety requirement.

4.5 REFERENCES

BNFL, 1998, *Fuel Retrieval Subproject Safety Class Design Analysis Report*, HNF-2229, Draft, prepared by British Nuclear Fuels Limited, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document*, HNF-SD-SNF-RD-001, Rev. 1, prepared by DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

FDH, 1997, *Safety Analysis Program Glossary*, HNF-PRO-517, Rev. 0, Fluor Daniel Hanford, Inc., Richland, Washington.

FDNW, 1997, *Fuel Retrieval Subproject K-Basin Facility Modification Calculations*, HNF-SD-SNF-CN-009, Rev. 0, prepared by Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

WHC, 1996, *Specification for Design of the SNF Project Fuel Retrieval Subproject*, WHC-S-0461, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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Figure 4-1. Primary Clean Machine.

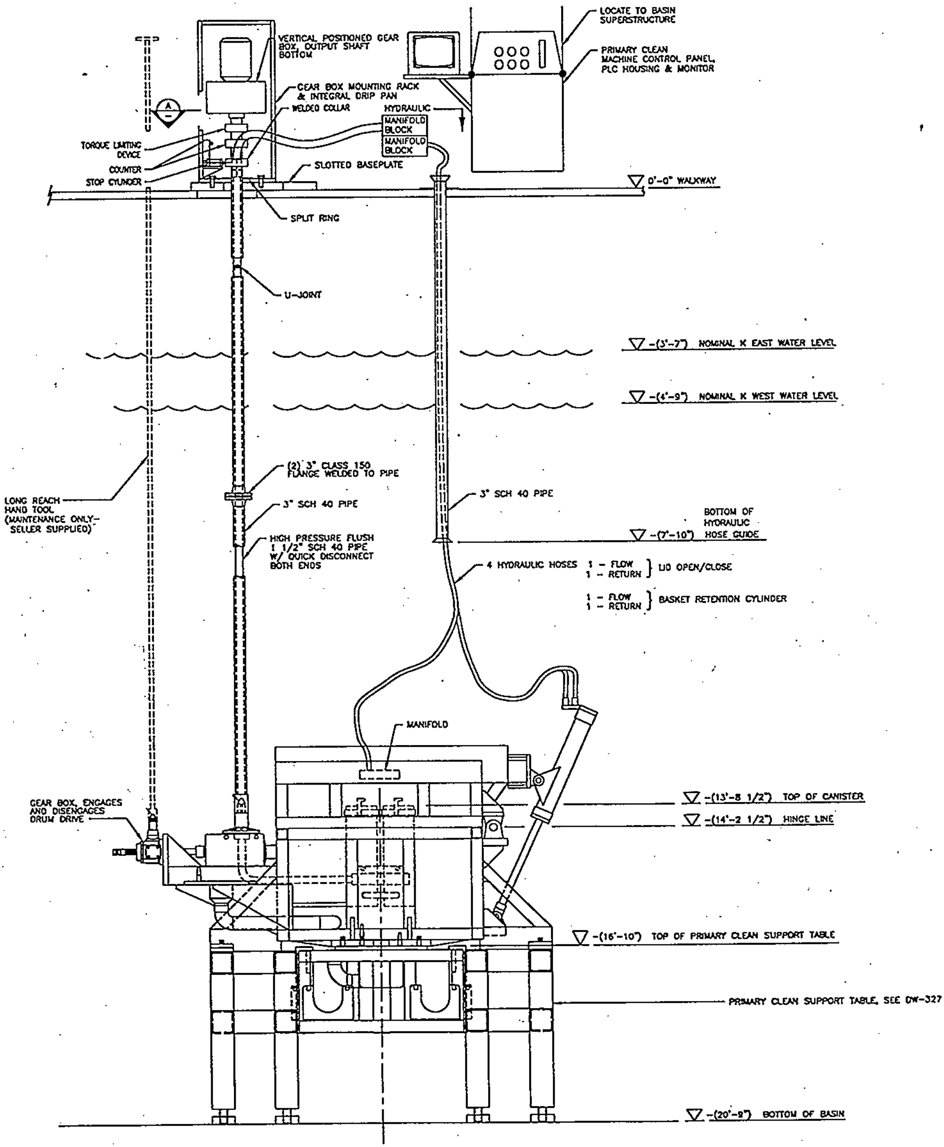


Figure 4-2. Process Table.

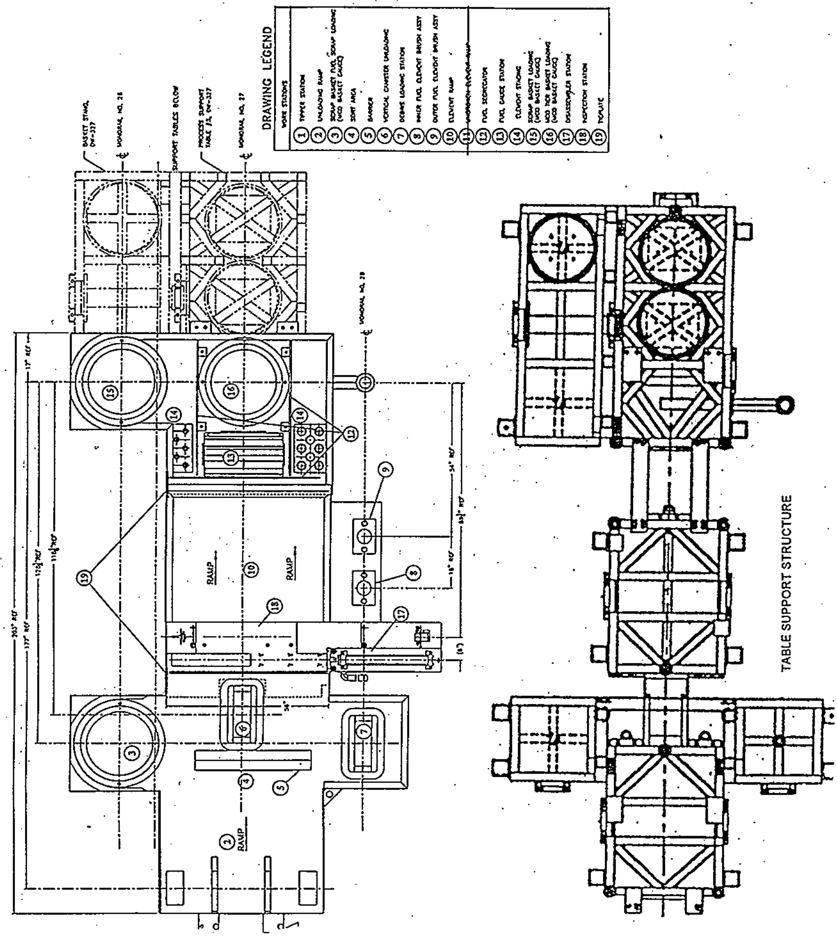


Figure 4-3. Multi-Canister Overpack Basket Queue.

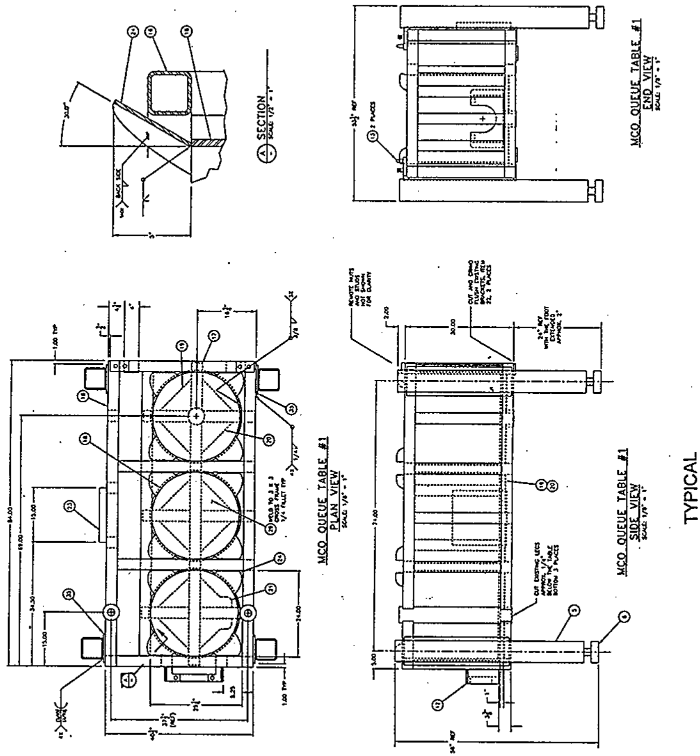


Figure 4-4. Multi-Canister Overpack Basket Stiffback Grapple.

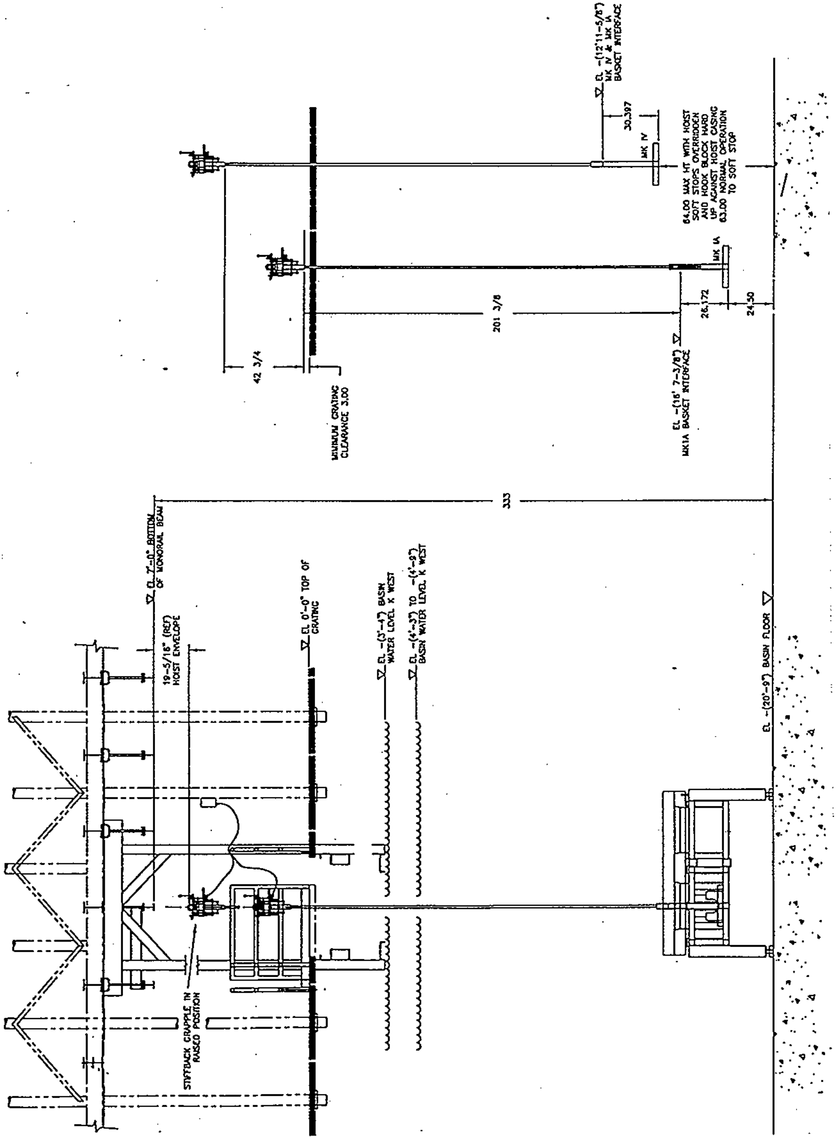


Figure 4-5. Empty Multi-Canister Overpack Basket Grapple.

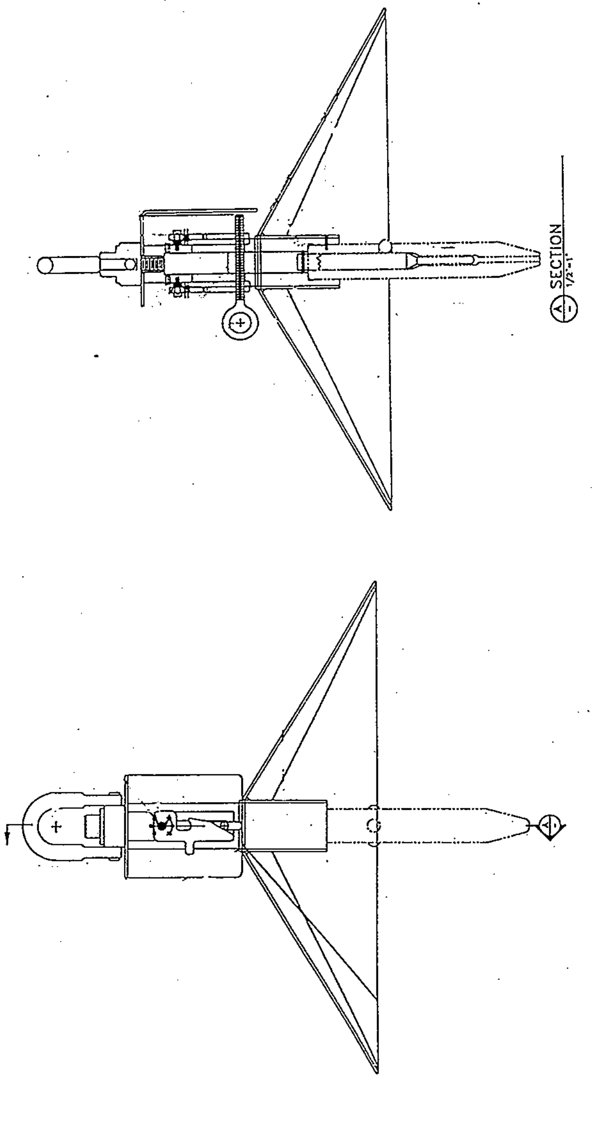
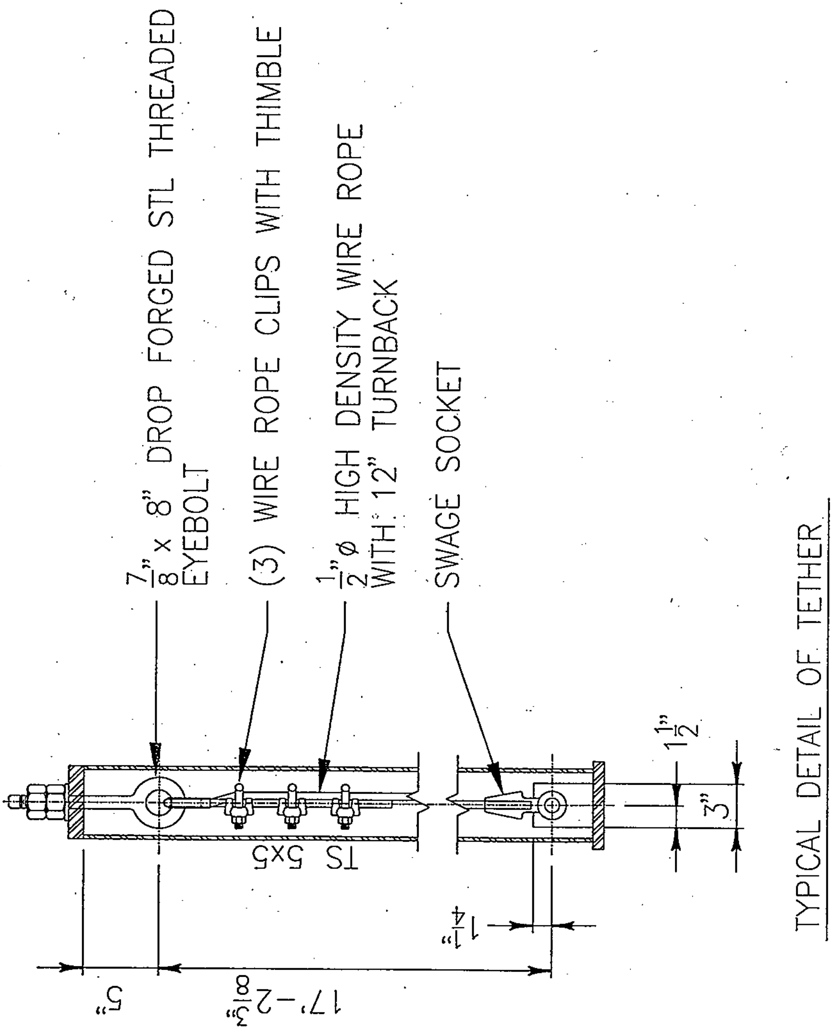


Figure 4-6. Manipulator Rail Support Structure Tether System.



APPENDIX 4A

SAFETY CLASSIFICATION CRITERIA

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Table 4A-1. Safety Structures, Systems, and Components Criteria for Fuel Retrieval System.

Safety structures, systems, and components		SSC designation
1.	Prevent or mitigate offsite dose in excess of 5 mSv (500 mrem) TEDE	Safety class
2.	Place or maintain an operating process in a safe condition that prevents or mitigates offsite dose in excess 5 mSv (500 mrem) TEDE.	Safety class
3.	Monitor the release of radioactive materials to the environment during and after accidents where the monitor's output initiates Emergency Response Plan or operator actions to place the operating process in a safe condition per criterion 2.	Safety class
4.	Maintain double contingency protection against an accidental nuclear criticality.	Safety class
5.	Support the safety function of a safety-class SSC. This includes control and monitoring functions (operating air, electrical power, instrumentation, etc.).	Safety class
6.	Prevent or mitigate a radiological dose or chemical exposure that challenges the risk evaluation guidelines of Appendix D.	Safety significant
7.	Place or maintain an operating process in a safe condition that prevents or mitigates consequences that exceed criterion 6.	Safety significant
8.	Prevent or mitigate exposure in excess of 50 mSv (5 rem) TEDE or an airborne chemical concentration in excess of ERPG-2 limit to facility operators who are relied on to achieve the safe condition of criterion 2 or 7.	Safety significant
9.	Monitor the release of radioactive and/or hazardous materials to the environment during and after accidents where the monitor's output initiates Emergency Response Plan or operator actions to place the operating process in a safe condition per criterion 7.	Safety significant
10.	Support the safety function of a safety significant SSC. This includes control and monitoring functions (operating air, electrical power, instrumentation, etc.).	Safety significant
11.	Prevent or mitigate an acute fatality to a facility worker or serious injury to a group of workers, except where the SSCs are controlled through an implemented institutional safety or radiation protection program.	Safety significant
12.	Provide defense-in-depth prevention or mitigation of an uncontrolled release of radioactive and/or hazardous material deemed significant in the safety analysis	Safety significant

Notes:
1. Consider initiating events with a frequency greater than 10^{-1} per year to be planned events and mitigate their consequences to within normal operational limits.
2. Where a postulated accident can cause multiple system failures, evaluate bounding consequences at a common receptor location. Select safety SSCs and determine residual consequences for the purpose of designating other structures or systems.
3. For criteria 6-10, the previous designation was SC-2 except for cases where SC-1 designation was applicable to the prevention or mitigation of toxic chemical exposures in excess of the offsite risk guidelines.
4. Designate SSCs that may prevent the adequate function of safety SSCs through physical interaction (seismic, pipe whip, jet impingement, water damage, environmental changes, etc.) as the same level of importance as those potentially affected SSCs.
5. Water treatment systems that use chlorine are considered to pose a risk commonly accepted by the public, provided that their design is consistent with public water treatment plants. Do not designate such systems as SC or SS.
6. See Section 2.4 of HNF-PRO-704 for the procedural steps that this table supports. In May 1995, this procedure descoped environmental and standard industrial SSCs from designation as safety SSCs. These and other balance-of-plant SSCs are considered to be "general service" SSCs.

SEL = safety equipment list.
TEDE = total effective dose equivalent.

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5.0 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

There are no new candidate technical safety requirements (TSR) defined in Chapters 3.0 and 4.0. for the support of FRS. TSRs or administrative controls covering FRS operational inspection requirements to support the Cold Vacuum Drying and Canister Storage Building facility safety requirements will be derived as part of the integration of the fuel retrieval system (FRS) subproject and other subprojects in the update of the K Basins safety analysis report (SAR) (DESH 1998).

As of March 1998, the inspection requirements placed on FRS operations by other Spent Nuclear Fuel (SNF) subproject or facility safety analysis requirements are defined in Table 5-1. The inspection requirements are not be driven by FRS operations safety concerns. Changes to the inspection requirements will be implemented as part of the update to the K Basins SAR for authorization of FRS operation. Changes to the inspection requirements are not expected to change the design or the conclusion of acceptable risk for installing or operating the FRS, but they may affect the overall fuel retrieval operation process.

Table 5-1. Fuel Inspection Criteria for Fuel Retrieval Operations.

Fuel Condition	Inspection Requirement	Inspection Method	Source for Requirement[3]
Fuel oxide and aluminum hydroxide	Visually clean,[1] limited to that clinging to fuel elements after cleaning	Periodic visual inspection via CCTV following validation of cleaning parameters	Pajunen and Sederburg 1998, Shen 1997
Scrap loading - scrap <1 in and ≥1/4 in.	Placed in fine area of scrap basket	Visual inspection via CCTV during loading	Pajunen and Sederburg 1998
Scrap loading - scrap >1 in.	Placed in scrap basket	Visual inspection via CCTV during loading	Pajunen and Sederburg 1998
Fuel loading	Fuel and fuel pieces must remain in sockets	Visual inspection	Pajunen and Sederburg 1998
Fuel queueing	Fuel basket queue storage <30 days	Administrative controls	Pajunen and Sederburg 1998
Organic loading[2]	None added by process	Visual inspection via CCTV during loading	Pajunen and Sederburg 1998

[1] Visual acceptance standards currently not defined.

[2] No specific criteria defined for FRS activities, this criteria is derived from Cold Vacuum Drying requirements specified in Pajunen and Sederburg (1998)

[3] See Pajunen and Sederburg (1998) for guidance and technical basis for these requirements.

The passive safety-class SSCs identified in Chapter 4 represent the design features as defined in DOE Order 5480.22.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report,* WHC-SD-WM-SAR-062, Rev. 3B, DE&S Hanford, Incorporated, Richland, Washington.

Pajunen, A. L. and J. P. Sederburg, 1998, *Spent Nuclear Fuel Project Product Specification,* HNF-SD-SNF-OCD-001, Rev 2, prepared by SGS Eurisys Services Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.

Shen, E. J., 1997, *Fuel Retrieval System Process Validation Plan,* HNF-SD-SNF-PAP-003, Rev. 0, prepared by Duke Engineering & Services Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland Washington.

6.0 PREVENTION OF INADVERTENT CRITICALITY

The criteria used in the criticality prevention program and the engineered and administrative controls to be used for prevention of criticality accidents are consistent with those currently defined in Chapter 6 of the K Basins safety analysis report (SAR) (DESH 1998). Potential changes to the program required for fuel retrieval system (FRS) operation will be addressed in the updated and upgraded K Basins SAR. No changes have been identified to date. The FRS criticality-related accidents and a probabilistic evaluation of accident scenarios are provided in Appendices 6A and 6B.

6.1 OVERVIEW OF FRS CRITICALITY ANALYSIS

The FRS was evaluated for potential nuclear criticality accidents and found to be safe. This evaluation is documented in the criticality safety evaluation report (FDNW 1998). The basis of the nuclear safety limit at the K Basins facility is that the neutron multiplication factor, k-effective (k_{eff}), will remain below 0.98 for all postulated accidents. A k_{eff} of less than or equal to 0.98 means that the system has at least a 2-percent margin of reactivity, which has been determined to be satisfactory for this application.

A comprehensive evaluation of FRS equipment and operational activities was performed during the criticality safety evaluation to identify any events that could lead to an accidental criticality. Event precursors considered included seismic events, dropping of heavy loads that damaged or tip equipment, and misoperations, such as exceeding load limits and double batching. Each piece of equipment was evaluated in relation to fuel movements and other equipment in the vicinity to establish the combinations of fuel masses that could be at risk. Some events were determined to be beyond extremely unlikely because of specific probabilistic evaluations or physical impossibility. The remaining events were analyzed to demonstrate the event was acceptable or safety-class equipment or controls were specified to prevent a criticality accident. The criticality safety evaluation analyzed the following types of accidents:

- Spill Additional Canister of Fuel into Fuel Retrieval System Equipment
- Spill Normal Fuel Load onto the Floor
- Tip or Rearrangement of Fuel Causes an Optimal Geometry of Normal Fuel Load in the Equipment
- Combined Spills on Sludge on the Floor
- Combined Fuel Spill or Drop Resulting in Unfavorable Geometry
- Double Batching in the Primary Clean Machine

- Double Batch on the North Table Canister-Dumping Area
- Multi-Canister Overpack Basket Spills and Drops
- Multi-Canister Overpack Basket Combined Spills
- Misload a Mark IA Canister into a Mark IV Basket
- Overloading Multi-Canister Overpack Baskets and Subsequent Spill
- Drops of Multi-Canister Overpack Basket Fuel Causing Unfavorable Geometry.

See Appendix 6A for a more complete description of the criticality accident analysis.

6.1.1 Summary of Conservatism

The FRS criticality analysis includes the following conservative assumptions:

- Optimal moderation
- Optimal scrap size
- Maximum enrichment
- Green fuel (no burnup)
- Optimal spacing
- Optimal geometry (spheres, hemispheres)
- Sludge modeled as optimal scrap; no reduction in moderation for sludge.

6.1.2 Summary of Conclusions

Conservative assumptions were made for determining "worst case" normal and accident conditions. The analysis shows that the double contingency principle is met, i.e., at least two unlikely, independent, and concurrent changes in process conditions are necessary before a criticality accident is possible. The analysis established the need for some safety-class equipment and some controls on fuel handling.

6.1.3 Mass Limits

The analysis determined that the mass of fuel allowed to be in the FRS equipment must be controlled to ensure criticality safety. The mass limits are summarized in Tables 6-1 and 6-2.

Table 6-1. Fuel Mass Limits.

FRS equipment	Limit
Canister decapper	1 canister
Decapper	1 canister
Primary clean machine	1 canister and 150 kg scrap and sludge
Stuck fuel	1 canister
Process table sort area	2 canisters
Process table ramp	34 fuel assemblies
Process table south loading area	20 fuel assemblies
Process table MCO basket loading areas	3 loaded MCO baskets
MCO basket queue	10 loaded MCO baskets

FRS = fuel retrieval equipment.
MCO = multi-canister overpack.

Table 6-2. MCO Basket Loading Limits.

Fuel and basket configuration	Fissile mass limit[1, 2, 3]
Mark IA scrap basket	575 kg scrap (1,265 lb)
Mark IA fuel assembly basket	799 kg assemblies (1,758 lb)
Mark IV scrap basket	980 kg scrap (2,156 lb)
Mark IV fuel assembly basket	1,265 kg assemblies (2,783 lb)

[1]Values account for uranium mass only. Mass limits for fuel assembly baskets may be adjusted to account for clad and end caps. Mass limits for scrap baskets shall NOT be adjusted for clad or end caps because these values cannot be determined. Mass limits do not account for basket weight.

[2]Other limits on scrap mass composition may be imposed for reasons other than criticality. For example, the MCO scrap basket design includes separated volumes for small scrap (< 2.5 cm long) and large scrap. Final operational controls also must consider these added requirements. See Chapter 5 of this SAD.

[3]Mass limits are dry weights; measured weights must be corrected for the buoyancy effects associated with weighing in water.

MCO = multi-canister overpack.

6.1.4 Summary of Controls

The analysis determined that operational controls were needed to ensure criticality safety. These controls are summarized in the following paragraphs. See Appendix 6A for the basis of the limits.

Limit 1. The 0.95 wt% ^{235}U or less single-pass reactor (SPR) fuel will be handled in the same manner as Mark IV scrap. SPR fuel of unknown enrichment in the K West Basin will be handled in the same manner as Mark IA scrap.

Limit 2. If Mark IV and Mark IA fuel are handled at the same time in the K West Basin, Mark IA limits will be applied to the Mark IV fuel.

Limit 3. Floor sludge in the FRS equipment and MCO basket spill areas must be limited to 3.8 cm (1.5 in.) deep when handling Mark IA fuel and 12.7 cm (5 in.) deep when handling Mark IV fuel.

Limit 4.

A. Only one canister may be moved into the west bay at a time using the flexible transfer crane.

B. Only one canister of Mark IA fuel may be moved on monorails in the west bay at a time.

C. In the west bay of the K West Basin, Mark IA canisters are limited to monorail 27; other monorails in the west bay are not to be used to transport Mark IA canisters.

D. When only Mark IV fuel is in the west bay, no more than two canisters of Mark IV may be moved on monorails in the west bay at a time.

Limit 5. Canisters or wash baskets containing fuel may not be moved in the west bay when MCO baskets are being moved.

Limit 6. Fuel canisters shall be stored at least 180 cm (6 ft nominal) away from the primary clean machine (PCM), the process table edges, the MCO basket movement path, and the MCO basket queue.

Limit 7. Decapper mass limit—see Table 6-1 and section 6A.3.3.

Limit 8. PCM mass limit—see Table 6-1 and section 6A.3.4.

Limit 9. Stuck fuel mass limit—see Table 6-1 and section 6A.3.5.

Limit 10. Process table mass limit—see Table 6-1 and section 6A.3.6.

Limit 11. Three MCO baskets may be loaded in the table to the fissile mass limit as shown in Table 6-2.

Limit 12. Only one MCO basket containing fissile material may be out of controlled storage at a time.

Limit 13. Loaded MCO baskets are prohibited from monorail 27 when an MCO basket containing fuel is installed in the MCO loading location (position 16 on Figure 2-11) of the south table.

6.1.5 Safety Class Equipment for Criticality Prevention

The criticality analysis determined that some of the FRS equipment must be safety class to ensure criticality safety. This equipment is listed in Table 6-3.

Table 6-3. Fuel Retrieval System Criticality Control Safety Class Equipment List.

Equipment	Safety function
Primary clean machine lower half and support structure	Prevent criticality
Process table support structure and MCO basket go-no-go gauge and bottom plate	Prevent criticality
MCO basket queue	Prevent criticality

MCO = multi-canister overpack.

6.2 REFERENCES

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3B, DE&SH Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

FDNW, 1998, *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*, HNF-SD-SNF-CSER-010, Rev. 0, Fluor Daniel Northwest, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

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APPENDIX 6A

FUEL RETRIEVAL SYSTEM CRITICALITY RELATED ACCIDENTS/ANALYSIS

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APPENDIX 6A

FUEL RETRIEVAL SYSTEM CRITICALITY RELATED ACCIDENTS/ANALYSIS

6A.1 INTRODUCTION

The criticality safety analysis associated with the fuel retrieval system (FRS) equipment normal loading and for accidents during fuel handling are summarized in the following paragraphs. The FRS equipment was evaluated for potential nuclear criticality accidents and found to be safe (FDNW 1998). The basis of the nuclear safety limit at the K Basins facility is that the neutron multiplication factor, k-effective (k_{eff}), will remain below 0.98 for all postulated accidents. A k_{eff} of less than or equal to 0.98 means that the system has at least a 2-percent margin of reactivity, which has been determined to be satisfactory for this application.

The criticality safety evaluation looked at the following forms of fissionable material:

- Assemblies including both inner and outer elements in the tube-in-tube configuration
- Elements that are inners or outers, which are separate
- Scrap fuel pieces too small to be manipulated with tongs and/or too small to be packaged with the associated fuel assemblies or elements
- Sludge, which is oxidized uranium and metallic fuel fragments resulting from damaged fuel that has accumulated in canisters or on the basin floor or in other areas where canisters are emptied. Sludge was modeled as optimized scrap.

The criticality analysis supporting the FRS fuel configurations is based on calculations assuming unirradiated fuel of the highest authorized enrichment in the normal storage arrangements and postulated accident conditions. The assumption of unexposed optimally configured Mark IA fuel in these calculations is the most conservative and most limiting basis for the calculations from a standpoint of nuclear criticality safety.

The FRS fuel storage equipment is discussed in Chapter 2. The FRS engineered controls that provide criticality safety by containing the fuel and controlling the fuel geometry are as follows:

- The primary clean machine (PCM) supports and lower half of PCM
- The process table support stands and multi-canister overpack (MCO) go-no-go gauges including the bottom plates
- The MCO basket queue.

The FRS administrative controls to be applied to FRS activities are specified as limits in Section 6A.3.1. These limits will be imposed by the K Basin criticality prevention program through criticality protection specifications (CPS).

The prevention of accidental formation of critical masses in the FRS equipment is based primarily on limiting the fuel mass and confining the fuel in a critically safe geometry. The control is based on the double contingency criterion—at least two unlikely, independent, and concurrent changes (contingencies) in processing and/or operating conditions must happen before a criticality accident is possible. No single contingency shall result in criticality.

As described in Chapters 2 and 4, the FRS structures are designed to perform the safety function of providing protection for MCO baskets to maintain structural integrity before, during, and following all accidents identified as design basis accidents (DBA) in Section 6A.2. Hypothetical failure of the controls is postulated to ensure criticality safety. No engineered safety features or controls are provided to prevent misloading of the fuel baskets (such as Mark IA fuel loaded in Mark IV baskets). The administrative controls (criticality prevention specifications) are assumed to prevent such an occurrence. The defined single-contingency misloads are all acceptable.

A series of scenarios associated with FRS operation with a potential for accidental nuclear criticality were evaluated in the criticality safety analysis associated with FRS fuel-handling operations (FDNW 1998). In all instances, at least two unlikely, independent, and concurrent changes (contingencies) in processing and/or operating conditions must happen before a credible criticality accident is possible. Additional beyond extremely unlikely single-contingency accidents were analyzed. Because so many accidents were analyzed to cover the possible accident combinations and different mass cases, the accident types analyzed are summarized in the following sections.

6A.2 CRITICALITY-RELATED ACCIDENT SCENARIOS

6A.2.1 Spill Additional Canister of Fuel into Fuel Retrieval System Equipment.

The FRS equipment was analyzed to determine the impact of an additional canister spilling into or onto the normal maximum fuel load. In all cases, these spills were determined to be acceptable.

6A.2.2 Spill Normal Fuel Load onto the Floor

Each piece of FRS equipment was assumed to spill the normal maximum fuel load onto a layer of sludge on the floor. The spill configuration assumed that the fuel formed an optimal hemisphere on top of the sludge layer. In all cases, these spills were determined to be acceptable.

6A.2.3 Tip or Rearrangement of Fuel Causes an Optimal Geometry of Normal Fuel Load in the Equipment

Each piece of FRS equipment was assumed to tip or rearrange the normal maximum fuel load into an optimal (generally spherical) shape, typically with the equipment resting in a layer of floor sludge. Some cases were assumed not to be in sludge where safety-class equipment precluded a tip over. The effects of fuel rearrangement in the equipment was then considered to be the accident. In all cases, these events were determined to be acceptable.

6A.2.4 Combined Spills on Sludge on the Floor

Numerous cases were evaluated with combinations of spills of multiple pieces of equipment and fuel in transit. These cases assumed that any fuel that was allowed to be in transit in an area where a piece of equipment could spill was spilled in combination with the fuel from one or more pieces of equipment. The combinations were systematically defined and analyzed. The results of the analyses established the need for several pieces of equipment to be safety class, as defined in Table 6-3, to prevent some unacceptable spill combinations and/or established the need for limits on fuel movements or fuel masses. Some combinations of spills were eliminated because they were not credible. Also, some locations of spills were eliminated because they were not possible. In all cases, the credible single-contingency combined spills were acceptable.

6A.2.5 Combined Fuel Spill or Drop Resulting in Unfavorable Geometry

Several cases were analyzed where a fuel spill or drop, in combination with a seismic event or drop impact, caused the combined fuel to create an unfavorable geometry, with the equipment tipped into a layer of sludge where appropriate. In all cases, the credible single- contingency accidents were acceptable.

6A.2.6 Double Batching in the Primary Clean Machine

The PCM is limited to cleaning a single canister at a time, along with an allowable buildup of sludge and scrap. The PCM was assumed to have the SNF from a second canister (double batch) loaded before the fuel from the first canister was removed. Then the combined fuel was washed, causing the fuel to rubblize into scrap. This case was found to be acceptable.

6A.2.7 Double Batch on the North Table Canister-Dumping Area

The maximum north table fuel load is limited to two canisters of fuel. This accident assumes that a third (double batch) canister also is dumped onto the table in an optimal hemispherical arrangement. This case was found to be acceptable.

6A.2.8 Multi-Canister Overpack Basket Spills and Drops

The FRS equipment was analyzed to determine the impact of the spill of an MCO basket into or onto the normal maximum fuel load of the FSR equipment. It was determined that it was not possible to spill in some locations. The results of the analyses established the need for several pieces of equipment to be safety class to prevent some unacceptable spill combinations and/or established the need for limits on fuel movements or fuel masses. In all cases, the credible single-contingency spills were acceptable.

6A.2.9 Multi-Canister Overpack Basket Combined Spills

Spilling MCO baskets with other fuel can exceed the criticality limit. The mass limits in the MCO scrap baskets are set based on a single MCO basket spilling by itself. Because a spill of an MCO basket in combination with other fuel may exceed the limit, this accident established the need for controls on fuel movements and allowable masses. Some design changes were made to the FRS equipment to ensure that these spills would be acceptable. All single-contingency MCO basket spills were acceptable.

6A.2.10 Misload a Mark IA Canister into a Mark IV Basket

This accident involves accidentally loading a single canister of Mark IA fuel into a Mark IV basket. This single contingency event is acceptable for FRS and for subsequent MCO loading.

6A.2.11 Overloading Multi-Canister Overpack Baskets and Subsequent Spill

This accident involves accidentally loading more fuel into an MCO scrap basket than the mass limits allow, failing to weigh the basket, then spilling the basket. Overloading an MCO basket is not a problem as long as the fuel stays in the MCO basket because this represents an under-moderated condition and all analyses assumed optimal moderation and spacing. Spilling the MCO basket when it is overloaded with fuel in an optimal configuration exceeds the limit. This accident is a double-contingency event: (1) overload, (2) failure to weigh, and (3) spill and therefore meets the double-contingency principle.

6A.2.12 Drops of Multi-Canister Overpack Basket Fuel Causing Unfavorable Geometry

Drops of an MCO basket onto the table surface could be postulated to cause a significant depression, resulting in an unfavorable (more spherical) geometry. This accident requires a concurrent seismic event to provide sufficient motive force to potentially move the basket over an area of the table where such a spill could result in this type of damage. In some cases, this event could exceed the limit. It was concluded that this event is beyond extremely unlikely because the probability of occurrence is $< 10^{-6}$.

6A.3 FUEL RETRIEVAL SYSTEM ADMINISTRATIVE FUEL HANDLING LIMITS

The criticality safety evaluation report (CSER) (FDNW 1998) analysis must demonstrate that the allowed fuel configuration and any credible single-contingency accident conditions will not exceed the k_{limit}. The analysis, described in HNF-SD-SNF-CSER-010, *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject* (FDNW 1998), concludes that it is not possible to have unacceptable fuel configurations under single-contingency conditions because of the use of engineered safety features and mass limits for the FRS equipment and MCO baskets and other operational limits.

The CSER established a number of fuel handling limits either to address unacceptable accident conditions or to enforce assumptions of the analyses. These limits are restated in Section 6.A.3.1 for convenience. These limits will be imposed on the facility through criticality prevention specifications (CPS).

This section describes the limits imposed to ensure criticality safety for each stage of fuel retrieval operations. Each limit is numbered and the bases for the limits are provided below the limit. The bases also include information regarding implementation methods associated with the limit, including design features, engineered safety features, mass controls, and administrative controls. Additional information may be found in the CSER (FDNW 1998) section covering the specific analysis for each operation.

6A.3.1 General Limits

Limit 1. The 0.95 wt% ^{235}U or less single-pass reactor (SPR) fuel will be handled in the same manner as Mark IV scrap. SPR fuel of unknown enrichment in the K West Basin shall be handled in the same manner as Mark IA scrap.

Basis. The 0.95 wt% ^{235}U or less enrichment of SPR fuel is bounded by Mark IV scrap. Limits identified for Mark IA fuel scrap are to be applied to the unknown enrichment SPR fuel in accordance with the latest revision of FDNW (1997). The K West Basin contains only 47 pieces of this fuel. This limit will be implemented by administrative controls.

Justification for use of administrative controls. No practical way has been found to provide engineered features to implement this limit. The amount of SPR fuel is relatively small and will be processed at the same time in each basin, minimizing confusion associated with this limit. Because the fuel will be handled in accordance with normal control requirements for Mark IA or Mark IV fuel, confusion is further minimized. Use of administrative controls alone does not present a significant challenge to criticality safety and is judged to be reasonable.

Limit 2. If Mark IV and Mark IA fuel are handled at the same time in the K West Basin, Mark IA limits will be applied to the Mark IV fuel.

Basis. Mark IV fuel is significantly less reactive than Mark IA fuel, so treating any combination of the fuel as Mark IA is conservative. This also minimizes the possibility of misloading Mark IA fuel into a Mark IV basket. This limit will be implemented by administrative controls.

Justification for use of administrative controls. No practical way has been found to provide engineered features to implement this limit. Because this "transition" fuel will be handled in accordance with normal control requirements for Mark IA fuel, confusion will be minimized. These activities are controlled by campaign plans and will be well controlled. Use of administrative controls alone does not present a significant challenge to criticality safety and is judged to be reasonable.

A single MCO basket design could be used to prevent misloading a basket. This would require that all MCOs contain only five MCO baskets, significantly increasing the number of MCOs. It also would require that all MCO baskets be provided as safety class. Both impacts would result in significant project impact and subsequent delays in removing the fuel from the K Basins. On the risk side, a single administrative limit could be eliminated. A single contingency violation of the this limit does not exceed the k_{limit}. From a practical perspective, this limit is necessary only during the transition from Mark IV to Mark IA. This equipment design solution is impractical based on an evaluation of the improvement in criticality safety (reduction of risk is small) compared to the significant impact to the project.

Limit 3. Floor sludge in the FRS equipment and MCO basket spill areas must be limited to 3.8 cm (1.5 in.) deep when handling Mark IA fuel and 12.7 cm (5 in.) deep when handling Mark IV fuel.

Basis. The analysis performed assumed these levels of sludge to be on the floor before the accidents. This configuration will not exceed the k_{limit} for the analyzed accidents. Allowing deeper sludge limits would require decreasing the mass of scrap allowed in the MCO scrap baskets and the FRS equipment. The FRS equipment is designed to minimize the buildup of sludge from fuel handling operations. This limit is implemented by administrative controls on the allowable sludge buildups in conjunction with some measuring or depth-indicating devices. This limit is based on MCO basket Movement Accident 2 of the FRS CSER (FDNW 1998).

Justification for use of administrative controls. No practical way has been found to provide engineered features to implement or eliminate this limit. The limits on mass for scrap baskets and the conservative assumptions associated with the composition of the scrap provide reasonable protection. The controls are simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, especially considering the conservatism in the criticality analysis. A single limit could be defined for both basins, but this would require a significant sludge cleanup effort in the K East Basin, which is not considered to be practical.

6A.3.2 Fuel Retrieval System Canister Movement and Staging Limits

Movement and placement of canisters in normal storage in the basin is subject to the existing K Basin controls (Jensen 1996). The limits specific to staging canisters in the fuel retrieval equipment area are as follows.

Limit 4:

A. Only one canister may be moved into the west bay at a time using the flexible transfer crane.

B. Only one canister of Mark IA fuel may be moved on monorails in the west bay at a time.

C. In the west bay of the K West Basin, Mark IA canisters are limited to monorail 27; other monorails in the west bay are not to be used to transport Mark IA canisters.

D. When only Mark IV fuel is in the west bay, no more than two canisters of Mark IV may be moved on monorails in the west bay at a time.

Basis. This limit is intended to prevent handling more than a single canister of Mark IA fuel near the FRS equipment. Handling two Mark IA canisters near the north end of the bay by the flexible transfer crane is acceptable. Movement of strainer baskets from the primary cleaning machine and pump stand containing Mark IA scrap on other than monorail 27 is necessary and acceptable to support operations; however these strainers must not be moved at the same time that other fuel containers are moved. (This is an addition to the limitation found in the CSER; the CSER will be revised to include this change.)

K Basin existing limits allow three canisters, only one of which may be scrap, to be moved at the same time. Fuel canisters can be moved by existing stiffback canister hooks or a single new telescoping stiffback canister hook. The existing stiffback canister hooks cannot raise fuel high enough to cause it to spill into the FRS equipment. Only the telescoping stiffback canister hook can place fuel into FRS equipment, so only single-canister spills into the FRS equipment have been deemed credible. Canisters on the existing stiffback canister hooks or the telescoping stiffback canister hook could spill fuel onto the floor in combination with fuel spilled from the FRS equipment. Some of these spills could exceed the k_{limit}. Therefore, the number of canisters allowed to be moved near the FRS equipment must be limited.

This limit requires that a single canister be in transit on the existing flexible transfer crane to bring canisters into the west bay and that only a single telescoping stiffback be used to move canisters or wash baskets on the monorails in the west bay. If more than a single telescoping stiffback is installed on the monorails, all but one must be locked out of service. Fixed-length stiffbacks may be used in conjunction with the existing flexible transfer crane to bring canisters of Mark IA fuel into the west bay, but the existing stiffback canister hooks may not be used on the monorails when handling Mark IA fuel in the west bay. A single existing stiffback canister hook may be used in addition to the telescoping stiffback when handling only Mark IV fuel.

This limit is based on Canister Movement and Staging Accident 1 of the FRS CSER (FDNW 1998). This limit will be implemented by administrative controls and the monorail control system.

Justification for use of administrative controls. No practical way has been found to provide engineered features to implement this limit. Each transition from the flexible transfer crane to the monorail system is controlled. Failure to adhere to the limit will not cause an accident that would exceed the limit without another failure. Use of administrative controls alone does not present a significant challenge to criticality safety and is judged to be reasonable.

It is not possible to eliminate this limit. Even if the FRS equipment and MCO basket contain no fuel, an unacceptable condition could be created with canisters alone. Therefore, limits must be applied to prevent moving too many canisters at the same time. The only way to simplify the limit is to require that only a single canister telescoping hook and no other fixed canister hooks be allowed in the basin. Currently, the basin successfully operates with canister handling limits that are similarly complex.

Limit 5. Canisters or wash baskets containing fuel may not be moved in the west bay when MCO baskets are being moved.

Basis. Combined spills of canisters or wash basket and MCO baskets exceed the k_{limit} (refer to MCO Basket Movement Accident 5 of the FRS CSER (FDNW 1998)). Because the frequency and duration of MCO basket movement is expected to be low, this limit should have minimal impact on operations and provide a positive way to prevent this combined spill. Spilling a single canister and a Mark IV MCO basket is acceptable; spilling two canisters and a Mark IV MCO basket is not acceptable, so this limit is also applied to Mark IV fuel. This also provides for operational consistency. This limit is based on MCO Basket Movement Accident 2 of the FRS CSER (FDNW 1998).

This limit will be implemented by administrative controls.

Justification for use of administrative controls. No practical way has been found to provide engineered features to implement this limit. Use of administrative controls alone does not present a significant challenge to criticality safety and is judged to be reasonable.

Limit 6. Fuel canisters shall be stored at least 180 cm (6 ft nominal) away from the primary clean machine, the process table edges, the MCO basket movement path, and the MCO basket queue.

Basis. Staging canisters refers to locating canisters in existing basin fuel racks. The analysis assumed that no interaction occurred between staged fuel and fuel being repackaged or transported by the fuel retrieval equipment under normal and accident conditions. The staging limit effectively eliminates interaction between the fuel masses in or on the FRS equipment, the basket movement paths, and the queue. Because the stuck fuel equipment and decapper contain only a single canister, spilling this fuel into canisters is no worse than allowed for canister movement in the existing K Basins safety analysis report (DESH 1998). The PCM design and construction (safety class lower half and support table) precludes fuel spills, so staging limits near this equipment are not needed but will be applied as good practice.

Because of the number of canisters and the limited storage space, some Mark IV canisters may need to be stored south of the PCM until sufficient fuel is repackaged to free up space north of the PCM. The 180 cm (6-ft nominal) space provides sufficient margin to preclude any interaction between the stored fuel in canisters and the fuel on the process table, fuel in MCO baskets while moving, or fuel in the MCO basket queue, during normal operation and postulated accidents (drops, spills, and loss of fuel from process table and MCO basket).

This limit is implemented by use of the existing safety-class storage racks, by design features of the repackaging equipment (physical dimensions and location of staging area), and by administratively controlling canister staging locations.

This limit is based on MCO Basket Movement Accident 2 of the FRS CSER (FDNW 1998).

Justification for the use of administrative controls. A design feature could be implemented to preclude staging the canisters in the prohibited areas. Such a control could be implemented by placing barriers (bars or sheet metal) over the rack locations of concern to prevent setting a canister into the racks. This would not prevent canisters from being set on top of these simple barriers. An alternative solution would be to place empty canisters into these locations. However, this limit is only a concern during the beginning of the fuel repackaging effort. As canisters are moved out of the west bay of each basin, canisters of fuel will be staged only in the area directly north of the PCM. It is judged that the benefit of such design features is not worth the dose, effort, and expense to install the controls, particularly in the K East Basin. The control is simple to administer and consistent for both basins. Use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable.

6A.3.3 Canister Decapping Limits

Limit 7. Only one canister of fuel may be contained in the decapping station.

Basis. The canister decapping equipment design only allows a single canister to be properly loaded into the decapping station at one time; fuel will not be removed from the canisters while they are in the decapping station. The decapping station includes a remotely mounted strainer to capture fuel scrap pieces greater than a 0.63 cm (0.25 in.). Normal decapping operations may generate a thin layer of fine sludge on the bottom of the decapping station. The decapping station shall be inspected after each use and any sludge accumulation shall be removed.

This limit is based on the analysis of the decapping equipment from Section 4.2 of HNF-SD-SNF-CSER-010 (FDNW 1998). This limit will be implemented by design features of the decapping equipment (will hold only one canister) and administrative controls on monitoring and cleaning the sludge accumulation.

This limit is based on Canister Decapping Accident 3 of the FRS CSER (FDNW 1998).

Justification for the use of administrative controls. A design feature that precludes a buildup of sludge does not appear to be feasible. The system is designed to flush away sludge expelled from the canister, but some sludge still may accumulate in the bottom of the equipment. The only practical solution appears to be manual removal of buildup as needed. There is significant conservatism and large margins to the limits in the canister decapping analysis and the accumulation area is small. Any significant accumulation of scrap would interfere with canister installation.

Inspection is required to ensure that sludge is not accumulating. It is relatively easy to inspect the area and clean out sludge without sophisticated tools or design changes. The control is simple to administer. Use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable.

6A.3.4 Primary Cleaning of Fuel Limits

Limit 8. The PCM is allowed to hold one canister worth of fuel in the wash basket and 150 kg (0.8 cm (0.3 in.) of scrap and sludge on the bottom of the PCM if evenly spread out over the surface).

Basis. This limit is based on the fuel masses assumed in the analysis of the PCM. By design, only a single canister may be properly loaded into the PCM. More than a single canister of fuel can be loaded into the wash basket if the fuel is not in a canister. The PCM includes a strainer to capture fuel scrap pieces larger than a 0.63 cm. (0.25 in.). The PCM strainer scrap accumulation was assumed to be 78 kg of scrap for optimal conditions. The strainer can hold considerably more than this, but it would be in an under-moderated (safer) condition. Normal operations may generate a layer of sludge on the bottom of the PCM. This normally allowed amount of fuel, including a contingency of another canister (233 kg of fuel scrap), does not exceed the k_{limit}.

It is recommended that sludge accumulation be cleaned as needed to ensure that the limit is met, rather than attempting to measure the sludge depth. If sludge buildup tends to be a problem during operation, the bottom of the PCM will need to be cleaned out to control the sludge depth. Inspection frequencies should be established based on operational experience. The sludge mass limit is based on the assumed sludge (scrap) mass as a uniform covering over the bottom of the PCM. Any actual buildup is not likely to be uniform. It is acceptable to evaluate accumulated local buildup and compare it to the 0.8 cm (0.3-in.) sludge depth limit to determine the acceptability of continued operation before the sludge is cleaned up, but it is preferred to clean out the sludge if the level is questionable. It is also good practice to clean out any significant sludge buildup before removing the PCM strainer to prevent pieces of fuel scrap in the sludge from bypassing the strainer and entering the water treatment system.

This limit is based on Primary Cleaning Accident 2 of the FRS CSER (FDNW 1998).

This limit will be implemented by the design features of the PCM (can hold only a single canister) and administrative controls on sludge cleanup and fuel masses.

Justification for the use of administrative controls. The PCM was designed to enable washing fuel in a canister and separate from a canister, which necessitates a large wash basket. It is relatively easy to inspect and clean out sludge without sophisticated tools or design changes. The control is simple to administer and consistent for both basins. Use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable.

6A.3.5 Stuck Fuel Removal Limits

Limit 9. A maximum of one canister of fuel at a time shall be contained in the stuck fuel removal station.

Basis. This limit is based on the analysis of the stuck fuel equipment from Section 4.4 of the CSER (FDNW 1998). The design only allows one canister to be loaded into the stuck fuel station for the cutting operation, with a second canister available to receive loosened fuel assemblies. Even though two canisters can be installed into the stuck fuel equipment, the combined inventory of both canisters is limited to the equivalent of 14 assemblies, a single canister worth of fuel. Normal stuck fuel removal operations may generate a layer of sludge on the bottom of the stuck fuel removal station. This sludge accumulation will be cleaned, as needed, to ensure that no significant accumulation of sludge builds up. This normally allowed amount of fuel, including a contingency of another canister (233 kg) of fuel scrap, does not exceed the k_{limit}. This limit is based on Stuck Fuel Removal Accident 2 of the FRS CSER (FDNW 1998).

This limit will be implemented by administrative controls on monitoring fuel and cleaning the sludge accumulation.

Justification for the use of administrative controls. The design requires a means to transfer fuel assemblies back to the process table after they have been released from the stuck canister. Use of an empty canister is a reasonable solution. A design feature that precludes a buildup of sludge does not appear to be feasible. The only practical solution appears to be manual removal of buildup as needed. Inspection is required to ensure that sludge is not accumulating. Inspecting and cleaning out sludge without sophisticated tools or design changes is relatively easy. There is significant conservatism in the stuck fuel analysis and the accumulation area is small. Any significant accumulation of optimized scrap would interfere with canister installation. The control is simple to administer and consistent for both basins. Use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable.

6A.3.6 Process Table Limits

Limit 10. Fuel mass accumulation on the north table is limited to two canisters (including fuel in the tipper and vertical canister unloading bin). Fuel accumulation on the ramp on the south end of the table is limited to 34 assemblies on the ramp (a single layer of assemblies or elements covering the ramp). Fuel accumulation on the MCO basket loading area of the south table is limited to 20 assemblies total. These 20 assemblies can include 4 assemblies in the gauging station, no more than 8 vertical outer elements in the outer element jig, and no more than 5 vertical inner elements in inner element jig. Single assemblies or elements are also acceptable in the disassembler and inspection station and the secondary cleaning station.

This limit is based on several of the accidents associated with the process table.

This fuel limit is in addition to the fuel allowed to collect in the MCO baskets in the three loading stations (see MCO Basket Loading Limits).

Basis. A two-canister batch control was chosen for the north half of the table because any limit based on depth of fuel or assemblies and elements and scrap was too complicated to administer. The two-canister limit allows for another canister (a contingency) to spill on the table in a optimal hemispherical configuration, along with the two canisters of fuel allowed on the table, without exceeding the k_{limit}. Rearranging two canisters of fuel to form a slab over the MCO scrap basket is also within the k_{limit}. Loss of the two canisters to the floor during a seismic event is within the k_{limit}. Thus all postulated single-contingency events are acceptable.

This limit assumes that fuel in the tipper or the vertical canister unloading area is counted as part of the two-canister limit on the north half of the table. Allowing fuel to be loaded in the tipper while two canisters of fuel are on the table creates a situation where the k_{limit} could be exceeded by an error or seismic event that results in spilling the fuel from the tipper and spilling fuel from a canister in transit.

Regularly cleaning accumulated scrap and fuel before dumping more fuel on the table is recommended to minimize the possibility of exceeding the limit and to minimize dispersal of scrap and fuel corrosion products.

The limit on the ramp is based on two rows of 17 assemblies arranged in a single layer on the ramp. Conducting normal fuel handling activities on the south end of the table should ensure that the fuel is maintained in a single layer.

The 20-assembly limit for the south table basket loading area is based on a slab of 16 assemblies in a single layer around the MCO baskets and 4 assemblies in the gauging station. A second fuel arrangement analyzed had 16 assemblies in two vertical jigs with 4 assemblies in the gauging stations. Both cases had similar k_{eff} when an MCO scrap basket was spilled on top of these normal loads. Subsequent analysis identified the need to limit the inner vertical elements on the east side of the table to five inner elements to ensure that an MCO basket drop combined with these elements was acceptable. The combination of assemblies on the table with some elements in the vertical jigs was not analyzed, but the MCO basket spill hemisphere dominates the k_{eff}. Therefore, specific analysis of different combinations of assemblies on the table and in the vertical jigs is not necessary.

No specific scrap limit has been set for the south area of the table. Scrap is not expected to accumulate in appreciable amounts on the south end of the table, although breakage of fuel during handling could create some scrap. Scrap accumulations should be cleaned off if they develop. The criticality analysis modeled the entire surface of the table as filled with 15.2 cm (6 in.) of optimized scrap, so this is conservative for normal conditions. Loss of scrap to the floor would not be a problem unless large amounts of scrap were allowed to accumulate.

Movement of canisters south of the vertical canister unloading area is limited by the monorail stop (1 ft north of "E" line) and physical interference with the manipulator trolleys. If canisters are to be moved to the south portion of the table for direct loading of fuel into MCO baskets by other means, the fuel in these canisters shall be counted as fuel on the table.

This limit will be implemented by administrative batch controls and design features of the table. The vertical canister unloading area and tipper station will not accommodate more than one canister. Both areas could contain more than a single canister worth of fuel if not in a canister. The south table ramp provides an easily identified landmark for designation of north and south operating zones.

Justification for the use of administrative controls. The process table design requirements limit the ability to establish design features that could be implemented to eliminate administrative controls for mass limits on the process table. Batch controls are common for managing fissile material. The controls are simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, especially considering the conservatism in the criticality analysis.

6A.3.7 Debris Handling Limits

No limits.

Basis. Debris is defined as nonreactor-origin material, e.g., a wrench in a canister. Debris is separated from the fuel and reactor-origin material and placed in the debris bin until it is disposed of. The debris bin should not contain any fuel. The process table design includes a height difference between the debris bin and the table surface to prevent fuel pieces from inadvertently spilling into the debris bin. The table analysis demonstrated that, even if the debris bin were full of optimized scrap, it would not cause a criticality problem. Drops of the debris bin are bounded by canister drops. As-low-as-reasonably-achievable controls will be in place to protect workers handling debris.

A single telescoping stiffback will be used to handle canisters, including the debris canister (see Limit 4). Because these canisters will not contain any significant quantity of fuel, this does not present a challenge to criticality safety.

6A.3.8 Multi-Canister Overpack Basket Loading Limits

Limit 11. Three MCO baskets may be loaded in the table to the fissile mass limit as shown in Table 6A-1.

Table 6A-1. MCO Basket Loading Limits.

Fuel/basket configuration	Fissile mass limit[1, 2, 3]
Mark IA scrap basket	575 kg scrap (1,265 lb)
Mark IA fuel assembly basket	799 kg assemblies (1,758 lb)
Mark IV scrap basket	980 kg scrap (2,156 lb)
Mark IV fuel assembly basket	1,265 kg assemblies (2,783 lb)

[1]Values account for uranium mass only. Mass limits for fuel element baskets may be adjusted to account for clad and end caps. Mass limits for scrap baskets shall NOT be adjusted for clad or end caps because these values cannot be determined. Mass limits do not account for basket weight.

[2]Other limits on scrap mass composition may be imposed for reasons other than criticality. For example, the MCO scrap basket design includes separated volumes for small scrap (< 2.5 cm) and large scrap. Final operational controls also must consider these added requirements.

[3]Mass limits are dry weights; measured weights must be corrected for the buoyancy effects associated with weighing in water.

Basis. The limit for assembly baskets is based on the assembly mass for full-length assemblies. As long as the assembly pieces that are loaded in the MCO fuel element baskets are no longer than a whole element, the basket mass limit will not be exceeded. It may be desirable to weigh assembly baskets to ensure that the mass limit is not exceeded.

The MCO scrap basket limit is based on the amount of scrap that can be spilled onto the various areas that the basket traverses and not exceed the k_{limit}. This limit is based on MCO Basket Movement Accident 2 of the FRS CSER (FDNW 1998).

Loaded scrap baskets shall be weighed before they are moved to ensure that the scrap basket mass limit has not been exceeded. Spilling an acceptable load of scrap onto an overloaded scrap basket being loaded in the table could result in exceeding the k_{limit}. Therefore, operations shall ensure that all scrap baskets are not loaded to more than the limit before they are moved. Baskets may be lifted off the base to determine mass, but not high enough to risk spilling the basket until a confirmation of mass is available. This lift to weigh the basket is not considered a basket movement. If the mass limit for any scrap basket is exceeded, fuel scrap shall be removed from the scrap basket until the basket is within the limit before moving it. Because this limit is a mass limit, and mass will be determined by weighing in water, the measured weight must be corrected for buoyancy and measurement error before it is compared to the mass limit.

This limit is implemented by the design features of the MCO baskets (limits the number of assemblies and maintains a Mark IA criticality control centerpiece diameter and height) and table (only three loading locations) and administrative controls that limit the mass of fuel allowed in the MCO scrap baskets.

Justification for the use of administrative controls. The MCO design requirements and the uncertain configuration of the scrap limit the ability to establish MCO basket design features to eliminate administrative controls for mass limits. Limiting scrap basket volume based on optimized fuel would result in baskets that can hold a larger quantity of fuel if not optimized; this fuel, when spilled, could become optimized during the spill, exceeding the k_{limit}. Determining a controllable packing fraction is not practical.

Mass control limits are common for managing fissile material. The controls are simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, considering the conservatism in the criticality analysis.

6A.3.9 Multi-Canister Overpack Basket Movement Limits

Limit 12. Only one MCO basket containing fissile material may be out of controlled storage at a time.

Basis. Movement of two MCO scrap baskets at the same time could result in the MCO baskets spilling fuel in the same area as the result of a drop accident or seismic event. This spill could exceed the criticality limit. Multiple scrap baskets need not be moved at the same time. Therefore, only one MCO basket containing fuel can be out of controlled storage at a time. This should not present any operational problems because so few MCO basket moves are required.

Controlled storage means that the MCO basket is located in one of the three table positions or in the queue surrounded by an MCO basket confinement pipe or in the MCO. The limit assumes that an MCO basket on the MCO loading equipment is out of controlled storage.

This limit assumes that the MCO loading equipment will use the FRS system MCO basket grapple to move MCO baskets to the load-out pit entrance and that MCO loading equipment will not be able to traverse into the basin. If multiple MCO basket grapples are available, a means to control concurrent use shall be available (other grapples controlled by locking out of service) to ensure that the limit will not be exceeded.

This limit is based on MCO Basket Movement Accident 2 of the FRS CSER (FDNW 1998).

The limit will be implemented by design features (only one MCO basket grapple) or administrative controls. This includes controlling the number of baskets out of controlled storage and any spare grapples locked out of service.

Justification for use of administrative controls. Because of the design of the MCO loading equipment and the fuel retrieval equipment, no practical way has been found to implement this limit by engineered features alone. Limits on the number of canisters that can be in transit have been successfully used. The analysis and limits on mass for scrap baskets and the conservative assumptions associated with the composition of the scrap provide additional protection. The controls are simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, especially considering the conservatism in the criticality analysis.

Limit 13. Loaded MCO baskets are prohibited from monorail 27 when an MCO basket containing fuel is installed in the MCO loading location (position 16 on Figure 2-12) of the south table.

Basis. A safety-class plate will be installed in the bottom of each MCO basket location where another MCO basket may traverse over a loaded MCO basket (positions 3 and 15 of Figure 2-12), to prevent loss of fuel in the event of a drop and failure of the MCO baskets. Because inspection of the loaded MCO assembly basket is necessary, the safety-class plate cannot be installed in the MCO assembly loading area (position 16 of Figure 2-12). However, there is no reason to move a basket directly over basket location 16 when a loaded basket is in place; this limit will be in place to enforce this assumption. A basket on monorail 26 cannot swing over far enough to drop directly on the basket during a seismic event (BNFL 1998). Also, the probability of a seismic event occurring when an MCO basket is being moved along monorail 26 and having it swing in the proper direction is 4×10^{-7}, so this event is considered to be beyond extremely unlikely. This limit is based on Process Table South End Accident 13 of the FRS CSER (FDNW 1998). The limit will be implemented by administrative controls.

Justification for use of administrative controls. Because of the design of the fuel retrieval equipment, no practical way has been found to implement this limit by engineered features alone. The analysis and limits on mass for scrap baskets and the conservative assumptions associated with the composition of the scrap provide additional protection. The control is simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, especially considering the conservatism in the criticality analysis.

Limit 14. Loaded MCO baskets shall be moved only in areas where the monorails and flexible transfer crane rails have been upgraded to handle the increased weight of the loaded MCO baskets.

Basis. When MCO baskets are limited to these areas, a failure of the lifting device and a subsequent drop of the fuel does not present a criticality problem. Where MCO baskets are allowed to move beyond this path, an unacceptable condition could occur where the MCO basket could spill on stored canisters during the early fuel retrieval activities. Spilling fuel on the canisters was not analyzed. Spilling fuel on canisters would be a double contingency event, requiring movement of the basket off the upgraded portion of the rail and resulting in a subsequent basket drop (1 contingency) and a violation of Limit 6, which requires that canisters not be stored within 180 cm (6 ft nominal) of the MCO basket movement paths. Because a seismic event cannot move the baskets more than 1 m (BNFL 1998) and the canister staging area is required to be 1.8 m (6 ft nominal) away from the MCO basket travel path, a spill on the canisters caused by a seismic event is not credible. This limit is based on MCO Basket Movement Accident 2 of the FRS CSER (FDNW 1998).

This limit is implemented by administrative controls on basket moves.

Justification for use of administrative controls. The control is simple to administer and consistent for both basins. Implementation by use of administrative controls does not present a significant challenge to criticality safety and is judged to be reasonable, especially considering the conservatism in the criticality analysis.

6A.3.10 Multi-Canister Overpack Basket Queue Limits

No limits.

Basis. The MCO baskets have not been analyzed to demonstrate that they can withstand a seismic event or a heavy load drop without failure. The safety-class MCO queue includes 61 cm-diameter cylinders with bottom plates to hold the fuel from the MCO baskets for all identified accident conditions (i.e., seismic and drop accidents). Maintaining the fuel in this configuration prevents a potential criticality issue caused by fuel from multiple MCO baskets piling up into joined hemispheres under the MCO basket queue. Although spilling two baskets together on sludge on concrete exceeds the limit, this double contingency event is considered to be beyond extremely unlikely.

6A.4 REFERENCES

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Jensen, 1996, *K Basins Consolidated Fuel Storage and Handling Criticality Safety Evaluation*, WHC-SD-SNF-CSER-003, Rev. 0, April 1996, Westinghouse Hanford Company, Richland, Washington.

APPENDIX 6B

PROBABILISTIC EVALUATION OF CRITICALITY ACCIDENT SCENARIOS

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APPENDIX 6B

PROBABILISTIC EVALUATION OF CRITICALITY ACCIDENT SCENARIOS

The critical safety evaluation included evaluating numerous accidents involving simultaneous spills of fuel from multiple pieces of fuel retrieval system (FRS) equipment. Many of these cases were shown to be acceptable. Some cases required safety-class equipment to prevent accumulation of sufficient fuel mass. Other cases that appeared to be beyond extremely unlikely were analyzed using probabilistic to determine if the accidents were credible.

This section includes event trees prepared to establish the frequency of some of the criticality accidents that appeared to be incredible. These event trees provide the basis that the frequency of these events is beyond extremely unlikely. The simplest possible conservative assumptions were made in preparing these trees and establishing the estimates of frequencies. Where the event tree demonstrated that the accident was beyond extremely unlikely, the accident was considered to be incredible and no further actions were taken to protect against a criticality caused by the particular accident.

The event trees include a description of the event sequence, the overall frequency of the sequence, and the basis for each event tree. The event tree number relates to the accident numbers defined in the FRS criticality safety evaluation report (CSER) (FDNW 1998).

Event Tree D7

Seismic event causes a multi-canister overpack (MCO) basket and the decapper to spill fuel in the same area.

Sequence 4

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

b) The probability that an MCO basket is moving near the north table is rounded to 2E-3. This value is based on assumptions of 1 MCO basket move per day (2 MCO scrap baskets every 2 days on monorail 26), 20 minutes per move, and 10% of the time the move is near the north table. These assumptions combine as follows to equal 1.4 E-3:

1 move/day * day/24 hr * hr/60 min * 20 min * 0.1 = 1.4 E-3.

c) The probability that the MCO basket containing fuel would spill to a specified location (position X) toward the decapper given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the MCO basket location.

d) The probability that the decapper station containing 1 canister of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the decapper station.

If a 0.2 g seismic event occurs and an MCO basket and the decapper spill one canister each to a common location (position X), criticality limits may be exceeded.

Seismic event occurs	MCO basket is not moving near position X	MCO basket remains intact and does not spill to position X	Decapper remains intact and does not spill to position X	Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
IE	MM	MS	D				
2.00E-04 IE				2.00E-04	1	IE	Safe
	2.00E-03 MM			3.00E-07	2	IE/MM	Safe
		.25 MS		7.50E-08	3	IE/MM/MS	Safe
			.25 D	2.50E-08	4	IE/MM/MS/D	Exceeds limit

Seismic, MCO basket and decapper spill together CSER-D7.TRE 2-04-98

Event Tree P4-1

Seismic event causes a canister and the primary cleaning machine (PCM) to spill fuel in same area.

Note: The probability of spilling a canister and the north table fuel because of a seismic event is the same as this event.

Sequence 4

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

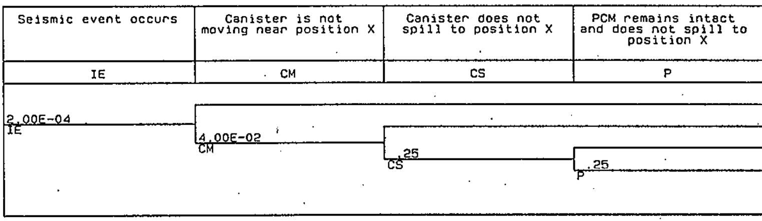
b) The probability that during a seismic event a canister will be in transport on the central monorail (27) near enough to position X is rounded to 4 E-2. This value is based on assumptions of 48 canister moves per day, 10 minutes per move, and 10% of the time the move is near position X. These assumptions combine as follows to equal 3.3 E-2:

48 moves/day * day/24 hr * hr/60 min * 10 min * 0.1 = 3.3 E-2.

c) The probability that the canister of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the canister telescoping stiff back grapple.

d) The probability that the PCM containing 1 canister of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the PCM.

If a 0.2 g seismic event occurs and a canister and the PCM spill one canister each to a common location (position X), criticality limits may be exceeded.



Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
1.92E-04	1	IE	Safe
6.00E-06	2	IE/CM	Safe
1.50E-06	3	IE/CM/CS	Safe
5.00E-07	4	IE/CM/CS/P	Exceeds limit

Seismic, Canister and PCM spill together CSERP4-1.TRE 2-04-98

Event Tree P4-3 — Seismic event causes Stuck fuel and PCM to spill fuel in same area

Sequence 4

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

b) The probability that the stuck fuel station has fuel in it is based on the bounding ratio of stuck fuel canisters to total canisters in K East Basin rounded off to 3 E-2 (110 stuck fuel canisters/3672 canisters in K East Basin per SNF-FRS-RPT-007, 90 percent Draft, Attachment B).

c) The probability that the stuck fuel station containing 1 canister of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the stuck fuel station.

d) The probability that the PCM containing 1 canister of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the PCM.

If a 0.2 g seismic event occurs and the stuck fuel station and the PCM spill 1 canister each to a common location (position X), criticality limits may be exceeded.

Seismic event occurs	Stuck fuel station has no fuel in it	Stuck fuel station remains intact and does not spill to position X	PCM remains intact and does not spill to position X	Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
IE	SF	SS	P				
2.00E-04 IE				1.94E-04	1	IE	Safe
	3.00E-02 SF			4.50E-06	2	IE/SF	Safe
		.25 SS		1.12E-06	3	IE/SF/SS	Safe
			.25 P	3.75E-07	4	IE/SF/SS/P	Exceeds limit

Seismic, Stuck fuel and PCM spill together CSERP4-3.TRE 2-04-98

Event Tree P5 — Seismic event causes a transported canister to spill into an open PCM

Sequence 3

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

b) The probability that a canister is moving down the central monorail (27) over the PCM is rounded to 4 E-2. This value is based on assumptions of 48 canister moves per day, 10 minutes per move, and 10% of the time the move is near the PCM. These assumptions combine as follows to equal 3.3 E-2:

48 moves/day * day/24 hr * hr/60 min * 10 min * 0.1 = 3.3 E-2.

c) The probability that the PCM is open is based on the assumption that the PCM is open, contains fuel, and a stiffback is available 5 minutes per canister out of every 24 hours for a value of 0.04 ({5 min/can * 12 can}/{24 hrs * 60 min/hr}).

If a 0.2 g seismic event occurs and a canister spills into an open PCM, criticality limits may be exceeded.

Seismic event occurs	Canister is not moving over open PCM and does not spill into open PCM	PCM is not open and does not fall to the floor	Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
IE	C	P				
2.00E-04 IE	4.00E-02 C	4.00E-02 P				
			1.92E-04	1	IE	Safe
			7.68E-06	2	IE/C	Safe
			3.20E-07	3	IE/C/P	Exceeds limit

Seismic, Canister spills into open PCM, spills CSER-P5.TRE 2-04-98

Event Tree NT5 — Seismic event causes an MCO basket moving over the north table to swing and spill on the table

Note: For other process table north end accidents, the probability of the table failing is assumed to be 1.0, because no credit is taken for the table.

Sequence 3

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

b) The probability that an MCO basket is moving near the north table is rounded to 2E-3. This value is based on assumptions of 1 MCO basket move per day (2 MCO scrap baskets every 2 days on monorail 26), 20 minutes per move, and 10% of the time the move is near the north table. These assumptions combine as follows to equal 1.4 E-3:

1 move/day * day/24 hr * hr/60 min * 20 min * 0.1 = 1.4 E-3.

c) The probability that the MCO basket containing fuel would spill to the center of the north table if it was on monorail #26 given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the MCO basket location.

The probability that the MCO basket containing fuel would spill to the North Table given a 0.2 g seismic event is 1.0.

If a 0.2 g seismic event occurs and an MCO basket spills to the center of the north table, then criticality limits may be exceeded.

Seismic event occurs	MCO basket is not moving over North Table and does not fal l on the North Table	MCO basket does not swing to center of North Table and spill	Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
IE	MM	MS				
2.00E-04 IE			2.00E-04	1	IE	Safe
	2.00E-03 MM		3.00E-07	2	IE/MM	Safe
		.25 MS	1.00E-07	3	IE/MM/MS	Exceeds limit

Seismic, MCO basket spills to North Table CSER-NT5.TRE 2-04-98

Event Tree NT6-1 Seismic event causes an MCO basket moving near the north table to drop to the floor, then the table contents spill from the table to the floor in same area

Sequence 5

a) A seismic event frequency of 2E-4/year (as related to a 0.2 g horizontal acceleration) was used as the initiating event frequency.

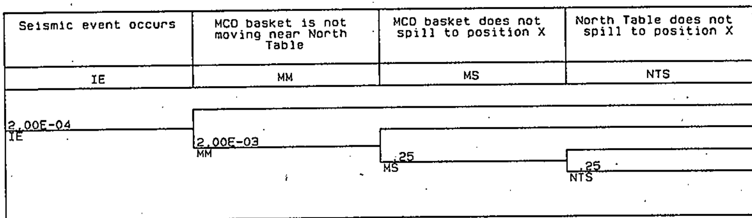
b) The probability that an MCO basket is moving near the north table is rounded to 2E-3. This value is based on assumptions of 1 MCO basket move per day (2 MCO scrap baskets every 2 days on monorail 26), 20 minutes per move, and 10% of the time the move is near the north table. These assumptions combine as follows to equal 1.4 E-3:

1 move/day * day/24 hr * hr/60 min * 20 min * 0.1 = 1.4 E-3.

c) The probability that the MCO basket containing fuel would spill to a specified location (position X) if it was near the north table given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the MCO basket location.

d) The probability that the north table containing a normal load of fuel would spill to a specific location designated as "position X" given a 0.2 g seismic event is 0.25. This value represents the probability of fuel spilling to one of four quadrants around the north table.

If a 0.2 g seismic event occurs and an MCO basket and the north table spill fuel to a common location (position X), criticality limits may be exceeded.

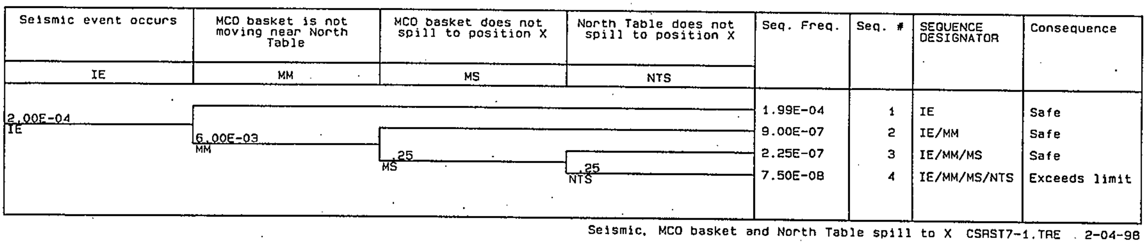


Seq. Freq.	Seq. #	SEQUENCE DESIGNATOR	Consequence
2.00E-04	1	IE	Safe
3.00E-07	2	IE/MM	Safe
7.50E-08	3	IE/MM/MS	Safe
2.50E-08	4	IE/MM/MS/NTS	Exceeds limit

Seismic, MCO basket and North Table spill to X CSANT6-1.TRE 2-04-98

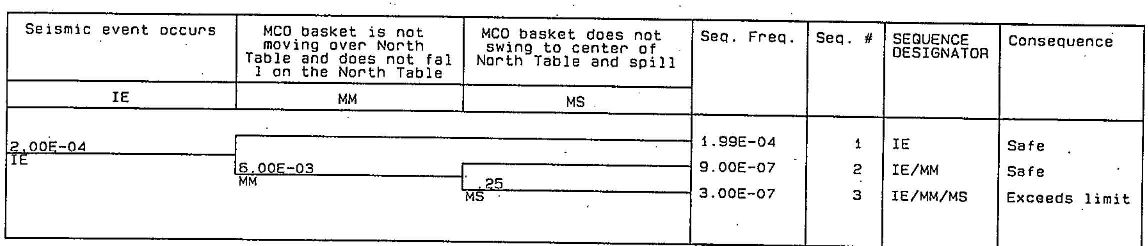
Event Tree ST7-1

For the logic equivalent of Event Tree ST7-1, refer to NT6-1 but multiply by 4 to account for 4 times the MCO basket moves.



Event Tree ST7-2

For the logic equivalent of Event Tree ST7-2, refer to NT5 but multiply by 4 to account for 4 times the MCO basket moves.



Seismic, MCO basket spills to North Table CSERST72.TRE 2-04-98

REFERENCE

FDNW, 1998, *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*, HNF-SD-SNF-CSER-010, Rev. 0, prepared by Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

7.0 RADIATION PROTECTION

The existing K Basin Radiation Protection Program described in Chapter 7 of the K Basins safety analysis report is applicable to fuel retrieval system (FRS) equipment installation and installation acceptance testing. Potential revisions to the existing program as a result of FRS operations will be evaluated as part of the K Basins safety analysis report upgrade activities. No changes have been identified that will result in a revision to the existing K Basins Radioactive Protection Program at this time.

As part of the engineering evaluation of the FRS equipment design, an as-low-as-reasonably-achievable (ALARA) assessment (BNFL 1997) was performed to review the adequacy of the FRS design features used to protect personnel from radiological exposure. The assessment considered exposure to workers from operation and maintenance activities associated with the FRS equipment. Based on the results of the estimated exposures, the design was evaluated to see if design or operating improvements could be made to reduce worker dose.

Fuel is handled underwater for all FRS operation activities. Only the FRS tools and equipment that penetrates the basin water, such as stiffbacks and manipulator masts, will expose contamination (from the basin water) to the air. The design features that minimize worker dose were identified as maintaining a minimum water cover over all FRS equipment and fuel-handling activities, use of remote-controlled manipulators to minimize operator time in basin, providing a positive exhaust path for canister gases, and incorporating design requirements that will minimize dose during maintenance of FRS equipment. These include the use of quick disconnects and design features that facilitate decontamination efforts. The administrative control features that minimize dose include rotation of in-basin workers and application of standard ALARA principles to minimize time in the basin, move to a low dose area when work tasks do not require the worker to be in higher dose areas, and an approach to maintenance that minimizes repair of low-cost replaceable components.

A cost/benefit evaluation of automating the majority of operator tasks for the K East Basin concluded that further automation was not warranted. The evaluation concludes that the FRS equipment does not contribute significantly to the overall dose rate profile for the basin and that the FRS design with the recommended administrative controls will provide individual ALARA dose uptakes for the FRS operations. There are no changes to this section of the K Basins safety analysis report associated with the FRS subproject.

In addition to the ALARA assessment, the dose effects of the chronic release of canister gases (krypton and hydrogen) was evaluated. The evaluation concluded that without some type of positive ventilation, it may be possible to build up krypton below the basin grating resulting in additional dose to workers in the basin. Consequently, the canister decapping exhaust system was designed to provide a positive means to minimize the buildup of canister gases.

REFERENCE

BNFL, 1997, *Fuel Retrieval System ALARA Assessment,* SNF-FRS-RPT-12, Rev 1, British Nuclear Fuels Limited, Inc., Richland, Washington.

8.0 HAZARDOUS MATERIAL PROTECTION

The existing Hazardous Material Protection Program is described in Chapter 8 of the current K Basins safety analysis report (DESH 1998) and will be applied to fuel retrieval system (FRS) installation and installation testing. Potential changes to the Hazardous Material Protection Program will be addressed in the upgraded K Basins safety analysis report activities to be performed at a later date. No potential changes have been identified as part of the on-going FRS activities.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3B, prepared by DE&SH Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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9.0 RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

Fuel retrieval system (FRS) installation and installation acceptance testing will adhere to the requirements of the existing K Basins Radioactive and Hazardous Waste Management Program as described in Chapter 9.0 of the existing K Basins safety analysis report (DESH 1998). Potential changes to the program required for FRS operation will be addressed in the updated and upgraded K Basins safety analysis report activities planned for the future. No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3B, prepared by DE&SH Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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10.0 INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

This section summarizes the installation testing to be performed on the fuel retrieval system (FRS) equipment. Initial system testing, in-service surveillance, and maintenance will be described in the upgraded K Basins safety analysis report. The FRS Subproject will not use actual spent fuel for installation acceptance testing or for in-service surveillance and maintenance procedures or activities required for installation and installation acceptance testing. Because no fuel is involved and only limited functional testing is performed, no hazards of concern are associated with the performance of this testing. A job hazards analysis and a USQ screening will be prepared for each installation and test package before performing work.

The scope of installation testing is expected to include testing similar to, but not limited to the following:

- Manipulators:
  - Full functional test of manipulators
  - Functional test wrist cameras and lights
  - Pressure and functional test bridge hydraulics
  - Meggering and functional test bridge electrical
  - Check bridge free movement.
- Manipulator support structure, load-test wire rope assemblies
- Electrical, verify terminations
- Bump motors for rotation
- Piping systems
  - Flush and pressure tests
  - Verify system fluid levels.
- Canister gas venting
  - Verify fan rotation
  - Leak and pressure test pipe/duct.
- Equipment operations center
  - Verify control panel and alarms
  - Functional test cameras, intercom, and lights.

- In-pool equipment

  - Leak test hydraulic connections
  - Functional test tipper station
  - Functional test decapper and stuck fuel equipment
  - Functional test primary clean machine
  - Functional test disassembly station.

11.0 OPERATIONAL SAFETY

Fuel retrieval system (FRS) installation and installation acceptance testing will be performed in accordance with the applicable provisions of the existing K Basin conduct of operation and fire protection program. Changes to the program required for FRS operation will be addressed in the updated and upgraded K Basins safety analysis report. No changes have been identified to date.

The K Basins draft fire hazard analysis has been updated to include the FRS. The results of the fire hazards analysis update (DESH 1998) conclude that the maximum fire loss accident was not affected by FRS and no changes to the fire protection system were required.

REFERENCE

DESH, 1998, *Fire Hazards Analysis for the K Basins Facilities at the 100 K Area*, HNF-SD-SNF-FHA-001, Rev. 1, Draft, DE&S Hanford, Incorporated, Richland, Washington.

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12.0 PROCEDURES AND TRAINING

All fuel retrieval system (FRS) installation and installation testing activities will be performed in accordance with approved, written procedures. Procedures will be developed and maintained in accordance with the program described in the existing K Basins safety analysis report (DESH 1998). Personnel performing FRS installation and installation testing activities will be trained and qualified for the tasks they are performing. Revisions to the procedure and training program necessary to support operation of the FRS will be described in the updated and upgraded K Basins safety analysis report.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3B, prepared by DE&SH Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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13.0 HUMAN FACTORS

No fuel retrieval system (FRS) safety-class structures, systems, and components (SSCs) require the application of human factors requirements because all safety-class SSCs are passive devices. However, human factors were considered in the design of FRS equipment to ensure that human–machine interfaces do not pose operational or ergonomic problems. Human factors or ergonomics were factored into the design of the equipment operations center, manipulator, and other equipment controls, and powered drives were applied to the hoists.

To ensure that human factors had been suitably considered the FRS design and procurement specifications were evaluated. This evaluation is documented in Report No. 964001-001, *Evaluation of Fuel Retrieval System Design for Human Factors Engineering Features* (ARES 1996). The following recommendations were made for improvements to the procurement specifications. The recommendations for the FRS equipment were implemented.

- Provide information on hydraulic fluid containment or confinement on manipulator removal, and require hydraulic pump skid to be capable of containing the entire hydraulic fluid reservoir.
- Require use of nonmaintaining switches for FRS hoist.
- Require chain stops to prevent jamming or loss of the chain.
- Include the type of receptacle plug in use in the basin and that the hoist pendant control have nonmaintaining switches.
- Include MIL-STD-1472D in the requirements and add environment (temperature and humidity) criteria.
- Add requirements for vibration dampers on the pump and gearbox and add operability requirements for control of the cleaning machine while the operator is wearing gloves.
- Include requirements for surface finishes of cabinets, furniture, etc., in the equipment operations center.
- Use off-the-shelf items for the fuel inspection equipment (cameras, lighting, and related controls in equipment operations center).

One recommendation was made regarding the specification of contamination levels, material of construction, and ventilation requirements for temporary containment or a glove box for manipulator maintenance. This recommendation has not been implemented because final definition of these tools is not complete.

The report concluded: "The inclusion of Human Factors Engineering (HFE) principles in the design of the Spent Nuclear Fuel Retrieval System is evident. The documentation reviewed, and the interviews with the Design Team ..., demonstrated a good working knowledge of HFE and indicated that consideration of man/machine interfaces and the tasks to be performed during the operational life of the equipment was well understood."

REFERENCES

ARES, 1996, *Evaluation of Fuel Retrieval System Design for Human Factors Engineering Features*, Report No. 964001-001, Rev. 0, ARES Corporation, Richland, Washington.

14.0 QUALITY ASSURANCE

Fuel retrieval system (FRS) installation and installation acceptance testing will be performed in compliance with the applicable portions of the existing K Basin Quality Assurance Program. Changes to the program required for FRS operation will be addressed in the updated and upgraded K Basins safety analysis report. No changes have been identified to date.

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15.0 EMERGENCY PREPAREDNESS PROGRAM

The existing K Basin emergency preparedness program applies during installation and installation acceptance testing of the fuel retrieval system (FRS). Changes to the program required for FRS operation will be addressed in the updated and upgraded K Basins safety analysis report. No changes have been identified to date.

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16.0 PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

The fuel retrieval system (FRS) design incorporates applicable decontamination and decommissioning provisions. Performing installation and installation acceptance testing does not affect and is not affected by these decontamination and decommissioning provisions.

ANSI (1975) identifies the items considered in the FRS equipment design, including provisions for cleaning of process piping; waterproof equipment; minimization of crevices, ledges, and protrusions in welded structures; lifting lugs on all assemblies; and adequate clearance for transfer of equipment. Decontamination and decommissioning considerations for purchased equipment were incorporated in the procurement specifications.

REFERENCE

ANSI, 1975, *Design Criteria for Decommissioning of Nuclear Fuel Reprocessing Plants*, ANSI Standard N300-1975, American National Standards Institute, New York, New York.

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17.0 MANAGEMENT, ORGANIZATION AND INSTITUTIONAL SAFETY PROVISIONS

Fuel retrieval system (FRS) installation and installation acceptance testing will be performed under the management, organization, and institutional safety provisions described in the existing K Basins safety analysis report (DESH 1998). Changes to the program required for FRS operation will be addressed in the updated and upgraded K Basins safety analysis report. No changes to accommodate FRS have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report,* WHC-SD-WM-SAR-062, Rev. 3B, prepared by DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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ATTACHMENT

ACCEPTANCE OF THE SAFETY ANALYSIS DOCUMENTS FOR THE FUEL RETRIEVAL SYSTEM, HNF-2032, REV. 0, AND K-WEST INTEGRATED WATER TREATMENT SYSTEM, HNF-SD-SNF-SAD-002, REV. 2

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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

98-SFD-169 AUG 3 1 1998

Mr. R. D. Hanson, Acting President
Fluor Daniel Hanford, Inc.
Richland, Washington 99352

Dear Mr. Hanson:

CONTRACT NO. DE-AC06-96RL13200 - ACCEPTANCE OF THE SAFETY ANALYSIS DOCUMENTS (SADs) FOR THE FUEL RETRIEVAL SYSTEM (FRS), HNF-2032, REVISION (REV.) 0, AND K-WEST INTEGRATED WATER TREATMENT SYSTEM (KW-IWTS), HNF-SD-SNF-SAD-002, REV.2

References: (1) FDH letter to E. D. Sellers, RL, from N. H. Williams, "Fuel Retrieval System Safety Analysis Document," (FDH-9854896), dated June 11, 1998.

(2) FDH letter to E. D. Sellers, RL, from N. H. Williams, "Integrated Water Treatment Safety System Safety Analysis Document;" (FDH-9855063), dated June 11, 1998.

This letter provides conditional approval of the FRS and IWTS safety basis documentation transmitted to the U.S. Department of Energy (DOE), Richland Operations Office (RL) in References (1) and (2). The RL evaluation of these documents is contained in Enclosure 1, "Safety Evaluation Report (SER) for the SNF Fuel Retrieval Sub Project Safety Analysis Report, HNF-2032 Rev. 0, and K-West Basin Integrated Water Treatment System Subproject Safety Assessment Document, HNF-SD-SNF-SAD-002." The SER states that the SADs and the SER comprise an acceptable safety basis for construction and pre-operational testing of the FRS and KW-IWTS systems subject to the conditions of approval are stipulated in Enclosure 1.

Design and safety assumptions contained in the SADs are expected to be controlled as stipulated in paragraph 4.f.(8). (c). 3, Attachment 1, to DOE Order 5480.23, Nuclear Safety Analysis Reports. Design changes must be screened against the SADs and this SER for their impact on the safety basis, and no design changes that would invalidate an assumption, analysis, commitment, or a conclusion in the safety basis shall be made without approval by RL.

In preparation of the SER, RL assessed reviewer comments and contractor responses. A summary of the identified issues is provided in Enclosure 1. Major issues requiring management attention are identified below:

- The Hazard and Accident Analysis Out-of-Date – The hazard and accident analysis presented do not accurately represent the current hazard baselines – The hazards identification and analysis presented in the FRS and IWTS SADs summarized the results of the HAZOP/other analysis conducted during preliminary hazards assessments. These hazards analyses do not reflect the results of system design changes as the design evolved. Additionally, the hazards analysis contains controls, design features, and commitments to emergency response actions which are generic and cannot be understood and in some case are obsolete.

- Hazard and Accident Analysis Omissions – No IWTS drop analysis or seismic analysis for safety class systems, components, or structures (SSC) were provided or referenced in the SAD as required by DOE Orders 5480.23 and 6430.1A. Additionally, the radiation hazard imposed by the proximity of the settlers to the pool surface under fuel basin water loss accident scenarios was not identified or assessed in the SAD. Safety analysis contained in the current K Basin Authorization Basis could potentially be invalidated relative to radiation exposure, basin manning, and emergency recovery actions.

- Adequacy of Base Information – There was a lack of, or omission of, base information in the areas required to be addressed by DOE Order 5480.23. These areas included: 1) human factors; 2) initial testing, in-service surveillance, and maintenance; and, 3) identification of what specific requirements from S/RID, which were applied, what specific DOE Order 6430.1A design requirements were applied, and identification and qualification of safety margins in accident analysis to account for uncertainties as required by DOE Order 5480.23, Item (4), d. (1). In general complaince to applicable codes, standards, and requirements was not adequately described in the SAD nor was it able to be confirmed by FDH.

The RL observations listed above require management attention to strengthen the process for preparing nuclear safety basis documentation. RL requests continued dialog on these observations such that any identified management actions necessary can be implemented prior to submittal of Final Safety Analysis Reports (FSARs) for the Spent Nuclear Fuels (SNF) Project.

Any commitments contained in the contractor responses to RL review comments on the SADs (Appendix C to the SER) are expected to be tracked to closure. Some comments are noted to remain open until closed in the FSAR. RL requested and received excellent contractor support on the review activities in order to meet the document approval dates in the RL review plan.

RL appreciates the teamwork and professionalism of the contractor in their support of the RL review team.

If any direction is provided by a Contracting Officer's Representative (COR) which your company believes exceeds the COR's authority, you are to immediately notify the Contracting Officer and request clarification prior to complying with the direction.

If you have any questions regarding this matter, please call me or Robert M. Hiegel, RL Spent Nuclear Fuels Project Division, on (509) 376-1062.

Sincerely,

C. A. Hansen, Assistant Manager
for Waste Management

SFD:RMH

Enclosure (as stated)

cc: C. B. Aycock, DESH
R. G. Morgan, DESH
R. W. Rasmussen, DESH
A. W. Segrest, DESH
T. J. Hull, EH-34, HQ
J. D. Thomspson, FDH
N. H. Williams, FDH

Department of Energy

Richland Operations Office

Safety Evaluation Report

For the

"SNF Fuel Retrieval System
Safety Analysis Document," HNF-2032 Rev. 0

And

"K West Basin Integrated Water Treatment System
Safety Analysis Document," HNF-SD-SNF-SAD-002,
Rev. 2

Approved by [signature] / 8/31/98
Charles A. Hansen
Assistant Manager for Waste Management
Richland Operations Office

FRS/IWTS Safety Analysis Document Review Team

Sidney J. Altschuler
DOE-RL/TPD

Guy E. Bishop, III
DOE-RL/SFD

Richard P. Denise
GSSC

Dennis C. Humphreys
DOE-RL/SOD

Michael C. Humphreys
DOE-RL/Nuclear Safety Advisor

Gregory Z. Morgan
DOE-RL/SFD

F. M. Roddy
DOE-RL/Radiation Control Advisor

Dale H. Splett
DOE-RL/SFD

Robert M. Hiegel
Review Team Leader
DOE-RL/SFD

Contents

EXECUTIVE SUMMARY

The Safety Analysis Documents (SADs) are new documents prepared to establish the safety basis for a decision to allow procurement, fabrication, installation, and pre-operational testing of these two new systems. As such, the SADs should provide the same information as expected in a preliminary safety analysis report (PSAR). The DOE review process for these SADs was in accordance with an approved Safety Analysis Review Plan and included an acceptability review, followed by a detailed technical review against the standards of DOE Order 5480.23.

The Review Team found that the SADs for both the FRS and IWTS are conditionally acceptable. It is evident that a significant effort was made to deliver a quality product. Nonetheless, the Review Team could not arrive at the same conclusions as presented in the documents in some cases. As a result, the Review Team concluded that the hazard and accident analysis did not provide sufficient documentation and basis to conclude the review acceptance criteria[1] had been fully met. This conclusion indicates that there is some risk to the project in proceeding. This is primarily due to a lack of base information either referenced or provided by the SADs.

The hazard and accident analysis is fundamental to establishing a sound safety basis. The hazard analysis provided in the SADs for both the FRS and IWTS was not maintained current with the design as the design evolved. The significance of this issue cannot be overstated, as the hazard analysis is used to pinpoint weaknesses in the design or operation of a facility that could lead to accidents.[2] Failure to assure an iterative safety analysis/design process can allow new hazards or design weaknesses to be introduced, via design changes, which are not adequately assessed. Conclusions reached by safety analysis may not be valid if the hazards analysis does not reflect the actual design.

Other significant issues identified during the review are summarized below and are discussed in more detail in the Review Results section of this report.

- Evidence was not provided to demonstrate that applicable requirements of HNF-SD-RD-001 (S/RID) have been systematically identified and applied to the FRS and IWTS designs.
- General Design Criteria specified by DOE Order 6430.1A, which apply to safety class components (including applicable codes and standards) were not identified, nor was evidence provided that they had been fully applied to the FRS or IWTS designs.
- The margins existing between design requirements and safety basis limits were not

[1] DOE-STD-1104-96, paragraph 2.2

[2] DOE-STD-3009-94, page xvi.

consistently documented as required by DOE Order 5480.23, item (4)d(1).
- Drop analysis and seismic analysis results were not provided in the IWTS SAD, nor were applicable references provided.
- A critical evaluation of the proposed design, operation, and test program to assess conformance with safety design objectives and verify projections of residual risks should be provided.
- The manipulator support structure tethers should be classified as safety class or show that drop consequences are acceptable, or request a deviation from DOE Order 6430.1A.
- Design and analysis of the knockout pot screen design must either (1) demonstrate that failure of the safety function is incredible or is bounded by the criticality analysis, or (2) provide safety-class monitoring of the safety function.
- New hazards resulting from the settler height should be addressed, including reviewing and revising, as necessary, the current TSR restrictions on Basin unmanning.

As written, the SADs do not fully meet DOE Order 5480.23 based on the preparation and review standards[3]. However, given the conditions of approval specified herein, the SADs for the FRS and IWTS provide a suitable safety basis for a programmatic decision to authorize assembly, installation, and testing of the FRS and IWTS. It must be emphasized that this does not replace the USQ screening / evaluation process that still must be completed prior to performing any of these activities at the K Basins.

[3] DOE-STD-3009-94 AND DOE-STD-1104-96

MISSION

The K Basins were constructed in the 1950s, and are beyond their design life. They store about 2100 metric tons of spent nuclear fuel, approximately 400 yards from the Columbia River. The current K Basin mission is to provide continued safe storage of the fuel currently located in the KE and KW Basins, to clean and repackage the fuel in new storage containers (multi-canister overpacks), and to load the repackaged fuel in a shipping cask for transport to the cold vacuum drying facility, where the water will be removed prior to shipment to the new interim dry storage facility in the 200 Area (Canister Storage Building). The mission includes subsequent removal of sludge and contaminated water. This mission is expected to require approximately 10 years to accomplish, with completion of K Basin activities by the year 2008. After that time, the basins will be transferred to a decommissioning and decontamination status.

The Fuel Retrieval System (FRS) and the Integrated Water Treatment System (IWTS) are major modifications to the K Basins, and are necessary to support the mission of the Spent Nuclear Fuel Project (SNFP).

REVIEW SCOPE AND METHODOLOGY

Review Scope

It is important to note that this SER does not modify the currently approved authorization basis for K Basin operations. The FRS and IWTS represent major modifications to the K Basins. The Safety Analysis Documents under review were therefore prepared to serve the same function as a PSAR, i.e. to provide the safety basis for the decision to authorize construction and pre-operational testing of these systems, not to authorize operation of these systems. The existing authorization basis for K Basin will be modified, by incorporating the FRS and IWTS SAD information, prior to operation of these systems. The USQ Process is the mechanism relied upon to assure construction and pre-operational testing activities in the basins will be conducted within the existing K Basin authorization basis.

The FRS and IWTS SADs describe the activities necessary to remove the fuel from canisters in K West Basin, clean and sort the fuel, and place the fuel and scrap into Multi-Canister Overpack (MCO) baskets. This includes the system needed to maintain water clarity and low dose rates from the water. These SADs do not address K Basin modifications required for placing the MCO baskets into the MCO for transfer from the Basins. This will be addressed in the SAD for the Cask Loadout System.

Review Plan

The review was conducted in accordance with a review plan as required by RLP 5480.23. The RL review plan implemented RLP 5480.23, following the guidance of DOE Standard 1104-96, "Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports".

Team Composition

A RL SAR Review Team was formed. Members of the Review Team were selected based on their technical qualifications, experience, and familiarity with the subject matter. The team was comprised of personnel from the RL Spent Nuclear Fuels Project Division (SFD), both the technical integration and support team and the operations team, as well as support from the General Support Services Contractor (GSSC), criticality analysis support, hoisting and rigging, and two senior technical advisors. Appendix A contains concise individual Curriculum Vitae describing the technical and professional credentials of each member of the team.

Reviews Conducted

A Tier I review was conducted by the contractor for both FRS and IWTS. Following completion of that review and submittal of the documents to RL, an acceptance review was conducted by RL, in accordance with the Review Plan. The purpose of the acceptance review was to determine 1) that all pertinent matters in the technical review criteria had been addressed sufficiently to justify the expenditure of resources on a technical review, and 2) that the contractor Tier 1 review was satisfactorily completed, e.g. management review and approval, and closure of RCR comments had been performed satisfactorily. The conclusion of the acceptance review was that these criteria had been met, and the detailed Tier 2 technical review was initiated.

RLP 5480.23 does not require a Tier 3 technical review. However, the Independent Review Panel (IRP) conducted a Tier 3 review on the FRS SAD, and submitted comments for disposition. The IRP consists of three persons of outstanding credentials and represents extensive experience in the nuclear industry from both a DOE and NRC perspective. The IRP did not request review of the IWTS SAD, and therefore no Tier 3 review was conducted for the IWTS SAD.

Application of Graded Approach

A graded approach was applied in evaluating acceptance of these documents. The graded approach for document acceptance focused on the following considerations: 1) major safety issues relative the IWTS and FRS must have been considered and adequately addressed; 2) the fact that most of the systems, components, and structures, (SSC) have already been procured and fabricated, such that the a significant part of the programmatic risk has already occurred; and 3) the overall need to preclude unnecessary delays which could adversely impact the major SNF Project objective to expeditiously remove the SNF and sludge from the K Basins. The acceptance of the documents based on the graded approach should not be construed as meaning the documents fully meet expected and necessary safety basis information. In fact, under normal circumstances, the documents would have required modifications prior to acceptance. Under the graded approach used by the Review Team, approval is based upon management acceptance of the conditions of approval and the increased project risk.

Review Comments and Closure

The RL SAD Review Team members identified 366 comments, which were consolidated and screened for safety significance. A significant effort was made by the Review Team to reduce redundant comments and provide only relevant comments. Editorial comments were deleted and only provided informally to FDH for consideration, with no response required. After screening, a total of 141 Review Team comments were transmitted to FDH for resolution. Resolutions to the Review Team comments were proposed by FDH personnel and transmitted to RL. The comment resolutions did not close all of the identified issues. Open comments will be tracked to closure. The completed RCRs are included as Appendix C to this report.

Comments received from the IRP on the FRS SAD were transmitted separately to FDH for disposition. The completed RCRs and IRP comments with contractor responses are included as Appendix C to this report. Editorial comments identified during the review are not included in Appendix C.

REVIEW RESULTS

Although the IWTS and FRS SADs provide a reasonable description and safety analysis for these proposed K Basin modifications, there was a lack of necessary base information in some areas. These omissions prevented the Review Team from being able to conclude that the described safety basis was fully adequate to support a programmatic decision for authorization of construction and pre-operational testing for the FRS and IWTS.

The Review Team found the information provided in the SADs for the FRS and IWTS does not fully meet the approval basis contained in DOE-STD-1104-96, Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports. There are five areas that a SAR review and approval should focus on according to DOE-STD-1104-96. These are:

- Base Information;
- Hazard and accident identification;
- Safety structures, systems, and components (SSCs);
- Derivation of technical safety requirements (TSRs); and
- Programmatic control

The safety basis for a decision to authorize construction and pre-operational testing focus primarily on the first three of these five areas.

Common Results and Conclusions

Base Information

The Review Team could not conclusively determine that the FRS and IWTS were designed to be built, operated, and shut down in accordance with applicable codes, standards, and requirements specified by the K Basin S/RIDs based on the information provided or referenced in the IWTS and FRS SADs. This was primarily due to a lack of base information, which is expected to be provided in accordance with DOE Orders and Standards for the preparation and review of safety analysis documents. For example, evidence was not readily available that a systematic review had been conducted to identify and document the applicable DOE codes, standards, and requirements that should be applied to the FRS and IWTS. DOE-STD-3009-94 clearly indicates in the content guidance that chapter sections should list the codes, standards, regulations and DOE Orders, which are required for establishing the safety basis. According to DOE-STD-3009-94, the intent of this is to provide only the requirements that are specific for each chapter and pertinent to the safety analysis and not a comprehensive listing of all industrial standards, or codes or criteria. This information was not provided as intended by the standard as the SADs only referenced S/RIDs and the design specification. These references did not specifically identify the pertinent codes, standards, regulations and DOE Orders, which are required for establishing the safety basis as intended by DOE-STD-3009-94. This type of information must be included in order to provide a safety basis which is fully adequate to support a decision by DOE to authorize procurement, construction or installation of SSCs.

Hazards and Accident Analysis

The Hazards Analysis does not fully reflect actual final design, and the SAD does not clearly bin hazards to ensure that all the hazards are correctly evaluated and analyzed in the accident analysis. Although the actual risk is unknown, it is judged to be relatively low and major modifications to the FRS and IWTS are not anticipated. Completion of an update to the hazards evaluation and analysis should be accomplished expeditiously to minimize project risk.

The criticality analysis was determined to be adequate. The analytical approach taken contains substantial conservatism, however. The potential for reducing the level of conservatism, and thereby eliminating the need for safety class equipment and associated operational controls, will be given further consideration during review of the final safety analysis submittal prior to system operation.

Safety structures, systems, and components (SSCs)

General Design Criteria specified by DOE Order 6430.1A which apply to safety class components (including applicable codes and standards) were not identified, nor was evidence provided that they had been fully applied to the FRS or IWTS designs. Order 6430.1A requires analyses which are documented and auditable; this documentation has not been provided.

Contractor criteria for safety class items could not be confirmed to be in compliance with DOE requirements. Specifically, Tables provided in the IWTS and FRS SADs reference HNF-PRO-704 for safety classifications. This procedure may not comply with DOE Order 6430.1A requirements in that 1) equipment which prevents accidents with off site potential is allowed to be safety significant rather than safety class, 2) toxic material releases do not result in safety class designation, and 3) environmental degradation is not considered for designation of safety class or safety significant equipment. The use of this procedure in producing the SADs is not accepted as a resolution of the classification issues. Issues with the procedure will be resolved outside the scope of this SER.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

Information provided in Chapter 10 of the SADs on initial testing, in-service surveillance, and maintenance did not meet the required content of DOE Order 5480.23, paragraph 4f(3).(d)15. Chapter 4 of each SAD does contain some information regarding planned testing of the safety functions, however the information provided is incomplete. The final modification to the K Basins SAR incorporating this safety analysis information must fully address the testing of safety functions.

The information provided on human factors design does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. The discussion provided leaves the reader with a concern that there may be a lack of understanding relative to the timing, scope, and importance of Human Factors in facility safety. Clearly, this effort must be incorporated into the system design process and is required by DOE Order 6430.1A, section 1300-12. Compliance with this requirement has not been demonstrated and must be met. Delaying this effort to the K Basin SAR is not consistent with DOE 6430.1A requirements.

The SADs do not address the potential reduction in visibility in the basins, as the FRS stirs up sub-micron material, which the IWTS may be unable to adequately treat. This reduction in visibility may require operators to stay in the basins longer, to perform their jobs. Meanwhile, the material is radioactive and will be closer to the surface of the basin water, so the dose rate will rise. Longer exposures at higher dose rates may be a significant operator dose concern. The understanding of the Review Team's is that the decision has been made to proceed with design of additional filtration capability, which should alleviate this concern.

Common Conclusions

Special Conditions Of Approval

COM-1 The plan for testing of safety functions shall ensure an appropriate initial testing, in-service surveillance, and maintenance program, and shall be provided to RL for review early enough for RL input to be effective in ensuring proper design of those safety functions.

COM-2 A human factors review effort shall be performed, documented, and the results incorporated into the system design for both FRS and IWTS as required by DOE Order 6430.1A, section 1300-12. Any deviations from 1300-12 shall be justified and approved as required by 6430.1A.

SER Requirements For K Basin SAR

- A final (updated) HAZOP analysis shall be provided for the K Basin SAR. Any administrative controls or mitigating features identified in that revision must be recognized as authorization basis commitments, and be recognized, described, and controlled as such. It would be prudent to perform an early evaluation of design changes not considered in the original HAZOP to minimize project risk..

- The K Basins SAR shall document the margins between design requirements and the safety basis limits.

- The HNF-SR-RD-001 and DOE Order 6430.1A requirements, codes, and standards applicable to FRS/IWTS shall be identified in the K Basins SAR as required by DOE Order 5480.23 and the implementing standards.

- Crane and hoist controls for FRS / IWTS shall be provided in the K Basin SAR as directed in RL letter 98-SFD-026.

- Means to track and assure compliance with the multitude of operational commitments shall be provided.

Fuel Retrieval System Results

Base Information

One reviewer noted that system complexity may result in substantial down time due to equipment failures and malfunctions. The FRS functional requirements do not specify the use of manual methods and tools as an alternative to automated system operation. This comment has been provided to the RL project manager for consideration and will be handled outside this review scope.

Hazards and Accident Analysis

The analysis for manipulators throwing fuel clear of the water appears to have an error, in that the manipulators can lift fuel higher than assumed. Dose rates from lifted fuel may exceed those reported in the SAD.

Safety structures, systems, and components (SSCs):

The manipulator tether support system is intended to prevent the manipulator trolley support frame from falling and damaging safety related equipment, a safety related table (for criticality prevention) and the basin floor. The SAD acknowledges that under the current requirements, this equipment is required to be safety class. However, the basin floor is not only a safety class component, it is the primary confinement barrier. This confinement barrier must remain fully functional following any credible DBA as required by DOE Order 6430.1A, 1300-1.4.2. The tethers should be classified as safety class or show that drop consequences are acceptable, or request a deviation from DOE Order 6430.1A.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

No additional issues.

FRS Conclusions

Special Conditions Of Approval

FRS-1 The estimated weights of FRS equipment approaching the Table 3-10 limits contained in the K Basin SAR shall be confirmed and used for the installation USQ review.

FRS-2 Installation of the manipulator support structure tethers is withheld pending 1) contractor confirmation that the tethers will be classified as safety class, or (2) RL review of analysis justifying the safety significant designation by demonstrating that the upgrade to safety class would not entail significant reduction of risk. If (2) is chosen, a deviation request to DOE Order 6430.1A is required, or manipulator support structure drop consequences must be shown to be acceptable.

FRS-3 Approval of installation of the fuel manipulators is withheld pending 1) RL review of analysis which demonstrates that the consequences of the manipulator fuel handling accident remain acceptable, or 2) contractor confirmation to RL that safety significant interlocks for the fuel manipulators will be installed

SER Requirements For K Basin SAR

- FRS manipulator rail stops and interlocks shall be listed as defense in depth items.

Integrated Water Treatment System Results

Base Information

No additional issues.

Hazards and Accident Analysis

Appendix 3A HAZOP Analysis appears to be an initial analysis that has not been updated to the final IWTS design. Although the final IWTS design has been described and analyzed in the SAD, equipment descriptions and functions in the HAZOPS that are not consistent with chapter 2 and 3 need to be deleted or revised. Additional information may also be required. A final (updated) HAZOP analysis is required for the K Basin SAR.

The hazards analysis also needs to be updated to consider the increased hazard resulting from the proximity of the settlers to the pool surface, i.e. uncovery of a substantial source of radiation at a higher pool elevation, hence shorter time duration, than currently considered. This situation applies during fuel basin water loss accident scenarios, and has the potential to impact current authorization basis assumptions and conclusions relative to radiation exposure, basin manning, and emergency recovery actions. The SAD indicates that sludge settler tank uncovery and fire due to basin drain down is beyond extremely unlikely and beyond design basis because it would take at least five days to uncover the top two settlers at the maximum allowable post seismic leak rate. The classification as BDBA should be reconsidered, or additional information provided which justifies the classification. The reconsideration and justification should take into account the already-analyzed basin corner cracking and leakage as a result of the basin DBE, the effects of drain valve leakage, and the accepted reliable response times for emergency actions to remediate basin leakage.

Safety structures, systems, and components (SSCs):

The SAD states that the Knockout Pot screens are designed to meet safety-class specifications. Section 4.3.2.3 states that the screens must be strong enough to withstand the forces from pressure buildup resulting from filter plugging. Section 4.3.2.4 states that the Knockout Pot screens are required to have mesh dimensions verified before construction acceptance. The revised K Basin SAR should also identify the testing performed to confirm the structural adequacy of the screen to resist pressure buildup loads, and the testing which confirmed that the mesh structure maintained its safety function (specified spacing et. al.) during operation. Additionally, the design must (1) demonstrate that failure of the safety function is incredible, or (2) demonstrate that the consequences of credible failure modes are bounded by the criticality analysis; or (3) provide safety-class monitoring of the safety function.

The Radiation Monitoring System limits the consequences of spray leaks through control of the source term available for release. These instruments do not identify the occurrence of a spray leak event, however. Re-evaluation of spray leaks and required safety related equipment for detection of such leaks shall be provided by October 16, 1998.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

No additional issues.

IWTS Conclusions

Special Conditions Of Approval

IWTS-1. Approval of installation of the following IWTS components is withheld pending the conditions delineated below:

a. Knockout Pots
   (1) RL review of seismic analysis showing that the knockout pots will perform their safety class function (criticality geometry) during and following the DBE.

(2) RL review of analysis demonstrating that either a) failure of the knockout pot screen safety function is not credible, or b) the consequences of credible failure modes are bounded by the criticality analysis, or c) the safety basis and safety classification for equipment required for failure monitoring.

b. Settlers - RL review of analysis which evaluates the impact of the hazards resulting from the settler height on the existing authorization basis. This analysis shall include, but not necessarily be limited to, the following:
   (1) Evaluation of the impact of the drain valve USQ and JCO on the settlers, as well as the impact of the settlers on the USQ and JCO.
   (2) Impact on the adequacy of current TSR restrictions on basin manning.
   (3) Appropriate drop analysis and/or installation controls for settler equipment.
   (4) Seismic analysis showing that the settlers will perform their safety class function (criticality geometry) during and following the DBE.

c. Annular Filters – RL review of seismic analysis showing that the annular filters will perform their safety class function (criticality geometry) during and following the DBE.

d. Radiation Monitoring System – Completion of design and RL review of a submittal of design related safety analysis information.

IWTS-2 The safety significant function of the Radiation Monitoring System for the IWTS shall not rely on the computer control system, unless that system is designed and certified to be safety significant.

IWTS-3 Re-evaluation of spray leaks and required safety related equipment for detection of such leaks shall be provided to DOE by October 16, 1998, and the results incorporated in the K Basins SAR.

SER Requirements For K Basin SAR

No Additional Issues.

APPENDIX A
CURRICULA VITAE

PURPOSE

This Attachment contains the technical and professional credentials of the Review Team as they relate to the review.

THE TEAM MEMBERS

Sidney J. Altschuler

B.Ch.E. Chemical Engineering, The Cooper Union for the Advancement of Science and Art
M.S. Nuclear Engineering, University of California - Berkeley
Eng.Sc.D. Nuclear Engineering, Columbia University
Registered Professional Engineer

Dr. Altschuler has 21 years experience in the nuclear criticality safety. He has authored twelve papers in this field, eight of which were published in Nuclear Technology.

As a Research Physicist at the Rocky Flats Division of Dow Chemical (1970-75), he used the Monte Carlo codes KENO and O5R and was co-developer of the Surface Density vs. Unit Shape Factor Method. In 1979 he joined Rockwell Hanford Operations Criticality Engineering and Analysis Group as a Staff Engineer. He was Criticality Safety Representative for the Z Plant complex from 1981-85. His duties which continued as a Principal Engineer for Westinghouse Hanford included writing and reviewing analyses (CSERs, CPSs, and postings) and providing technical support for Hanford facilities which stored, handled, packaged, and processed fissile material, including PUREX, Plutonium Finishing Plant, Plutonium Recycle Facility, K and N Basins, WRAP, SP-100, HWVP, and the Process Facility Modification.

In 1995, Dr. Altschuler joined the Quality, Safety and Health Division of RL where he is responsible for oversight of the contractors' nuclear criticality safety programs.

Grant D. Baston

B.S. Physics, University of Wyoming
MBA, University of Hartford
Senior Reactor Operator License, 1968, 1972, 1974

Mr. Baston has more than 35 years experience in the design of fast breeder reactors, the startup and operation of commercial BWRs and PWRs, and the operation of defense production reactors. Mr. Baston's commercial experience includes plant startup test engineer, plant operation management, quality program management, materials management, Chairing Nuclear Review Board activities, and directing emergency response teams. Mr. Baston's defense production experience includes reactor physics engineer and operations management at the Hanford KE Reactor. Mr. Baston is currently working on the Spent Nuclear Fuel Project as a contractor to RL.

Guy E. Bishop, III

B.S. Aeronautical Engineering, Virginia Polytechnic Institute

Mr. Bishop has 21 years of nuclear experience. This includes completion of naval nuclear power school training and qualification in several naval installations as engineering officer of the watch, reactor engineer at a medium size commercial boiling water reactor, and operations shift supervisor at a large commercial boiling water reactor.

Mr. Bishop has extensive experience in core analysis, operations, safety analysis, and engineering in commercial nuclear power plants, and has held a senior reactor operator license. He has extensive experience within DOE in safety analysis, having served as chairman for line reviews of several other safety analysis reports. He has extensive knowledge regarding safety analysis techniques, requirements, industry standards, and worker protection issues and is familiar with all areas of safety analysis reports.

Richard P. Denise

B.S. Nuclear Engineering, North Carolina State University
Registered Professional Engineer
Patentee on Nuclear Reactors
Retired Senior Executive, U.S. Government
Certified Instructor in DOE Conduct of Operations

Mr. Denise has more than 40 years experience in the design, construction, operation, management, and regulation of complex nuclear facilities including commercial nuclear power reactors, defense production reactors, fuel fabrication facilities, chemical processing facilities for nuclear fuel, and fuel storage facilities. He has extensive senior executive experience in the management of production facilities for DOE, and in the regulation of commercial facilities for the NRC.

Mr. Denise's experience includes an assignment of five years at the K Basins in support of the RL spent nuclear fuel program. During this assignment at K Basins, a detailed knowledge and understanding of the K Basins design, operations, safety basis, fuel handling, and characteristics of the fuel was acquired. This detailed special expertise on K Basins, augmented by the other extensive technical capabilities, was utilized as a member of the Independent Technical Assessment Team.

Robert M. Hiegel

B. S. Mechanical Engineering, University of Washington

Mr. Hiegel has over 30 years total engineering experience in the nuclear industry for the Department of Energy and the Department of the Navy . His nuclear experience at DOE has included managing the design, construction and testing of nuclear facilities, and nuclear safety overview of reactor and nuclear facility operations. He is currently responsible for managing a team of engineers overviewing the development of the safety analysis for the Spent Nuclear Fuel Project. He has had experience in both chairing and participating in major operational readiness reviews, safety analysis reviews, safety audits and appraisals. He was the Project Manager for a Major System Acquisition, the Hanford Environmental Project and was the Deputy Project Manager for the Shippingport Station Decommissioning Project. Robert s experience also includes over 13 years experience in the nuclear program at Pearl Harbor Naval Shipyard and Puget Sound Naval Shipyard where he performed radiological engineering and project management assignments for maintenance and modifications to nuclear reactor systems and components on nuclear submarines.

Dennis C. Humphreys

Mr. Humphreys has over 26 years experience in the maintenance, operation, testing, defueling, refueling, and overhaul of naval nuclear power plants. This included 16 years as a certified Nuclear Shift Test Engineer in the Nuclear Engineering Department, at Mare Island Naval Shipyard. He also has 1 -years experience in management and oversight of the Hanford Site.

Mr. Humphreys has been with the Department of Energy for approximately 2.5 years. He has been a member of at least 7 full and partial Conduct of Ops and Maintenance Assessments, including the team leader for the Maintenance Team for the Characterization Project Assessment. He also was a member of the DOE Team involved with the assessment of the BHI Readiness Evaluation Team at 100N for the removal of high energy components from the basin. Mr. Humphreys has completed EM-25 Operations Assessment Training. His duties and responsibilities include the application of engineering theories and principles in the evaluation and approval of reports and other technically related subjects and documents at Hanford. While working with DOE he successfully passed the Engineering in Training (EIT) Exam for the State of Washington. Mr. Humphreys is a member of the Site Operations Division's Operations and Maintenance Management Team for Richland Operations Office. Two of his areas of responsibility include Hoisting and Rigging and configuration management.

Mr. Humphreys has been the RL Hoisting and Rigging Program Manager for the past 2.5 years. He has been trained in rigging and handling procedures and is a SME for the Site Hoisting and Rigging Manual. His sixteen years at Mare Island Naval Shipyard included familiarization with Crane and Rigging Safety and Operations. He is in charge of and a voting member of the Site Hoisting and Rigging Safety Committee.

Michael C. Humphreys

B.S. Chemical Engineering, Washington State University
M.S. Nuclear Engineering, University of Washington

Mr. Humphreys has over 17 years experience in fuels and reactor engineering, reactor systems testing, operational readiness, and operation support of Boiling Water Reactors. As an employee of a commercial nuclear utility he served as a fuels engineer, reactor engineer, Shift Technical Advisor, lead reactor engineer, and simulator engineer. He has 5 years experience as an independent consultant to commercial industry utilities and to the Department of Energy in the areas of safety analysis, fuel design, simulator nuclear physics and thermal hydraulics design, plant design basis training development, BWR incore refueling, and plant procedure support. He is the owner and developer of the COSMOS refueling software package, currently being used to prepare incore shuffle sequences by approximately 15 U.S. and European Boiling Water Reactors. Mr. Humphreys has been with the Department of Energy for approximately 1 1/2 years. During that time, he has served as the RL site representative for development and implementation of the DOE/RL Integrated Safety Management System (ISMS). Responsibilities include coordination with the DOE Safety Management Implementation Team and oversight of the Fluor Daniel Hanford ISMS implementation effort, including preparation for and conduct of the K Basins Phase I Verification. Other duties include review of safety analysis reports, establishing nuclear safety policy and resolution of nuclear safety concerns.

Gregory. Z. Morgan

B.S. Mechanical Engineering, University of New Mexico

Mr. Morgan has over 15 years experience in engineering, design, analysis, testing and operational readiness of nuclear reactors and nuclear facilities. As an employee of a nuclear utility he was a senior scheduling engineer, saving a week on the critical path for a refueling outage. As a Department of Energy employee he has analyzed the safety of six nuclear reactors, new and old tritium facilities, nuclear waste tanks, and a spent fuel facility. He has led an operational readiness review, and managed teams which finalized safety analysis reports and restarted a troubled nuclear reactor.

Francis M. Roddy

B. S. Physics , Villanova University, 1965
M. S. Physics, University of Illinois, 1971
US Navy Nuclear Power School, US Navy Nuclear Prototype A1W @ INEEL
Registered Professional Nuclear Engineer (2 states)
Certified Health Physicist

Mr. Roddy has more than 33 years of experience in the design, construction,, operation, management, repair, and regulation of nuclear facilities including US Navy nuclear propulsion plants, commercial nuclear power reactors, spent fuel storage facilities, radwaste storage facilities, radwaste burial sites, and DOE facilities. He has been associated with the K Basins for 1.5 years while serving as the Senior Technical Advisor for Radiological Controls for AMW. He has written Safety Analyses Reports for 12 commercial nuclear power plants and has reviewed safety analyses documents for 15 DOE facilities. He has performed on ORR teams for 8 DOE facilities.

Dale H. Splett

Bachelor of Science, Electrical Engineering, Seattle University, 1990

Mr. Splett was a Naval nuclear operator from 1972 to 1978, and has a total of over 20 years experience in repair and engineering in Naval nuclear power plants. He joined DOE in 1994. He has worked in K Basins Spent Nuclear Fuel since then. His responsibilities include project management and operations.

APPENDIX B
DOCUMENTS REVIEWED

1. *Spent Nuclear Fuel Project K Basins Technical Safety Requirements*, WHC-SD-SNF-TSR-001, Revision 0B Submittal, dated

2. *Safety Requirements (TSR's)- 100-KE and 100-KW Fuel Storage Basins*, WHC-SD-SNF-TSR-001, Revision 0

3. DOE Standard "Review and Approval of Non Reactor Nuclear Facility Safety Analysis Reports", DOE-STD-1104-96

4. "Preparation Guide for US DOE NonReactor Nuclear Facility Safety Analysis Reports", DOE-STD-3009-94

5. *Technical Safety Requirements*, DOE Order 5480.22, dated February 25, 1992

6. *Nuclear Safety Analysis Reports*, DOE Order 5480.23, dated April 10, 1992

7. *Justification For Continued Operations - 105 K East and K West Basins - Limited Activities To Preclude Damage To Basin Drain Valves, Plan and Schedule Of Proposed Recovery Actions*, FDH-9762048 R11, Dated March 10, 1998 (and Revs 2, 5, 7, 8 and 10).

8. *Summary of Phase 1 Task Completion 105 K Basin Floor Drain Valves*, HNF-2222, dated February 9, 1998

APPENDIX C
COMPLETED REVIEW COMMENT RECORD FORMS

DOE RCRs FOR KW-IWTS SAD

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Comment Key: Comments are evaluated as falling into the following omission categories, taken from DOE Std 1104-96: (1)- failure to address hazardous material or energy releases w significant consequences to the public, worker, or environment that will otherwise be left w/o coverage; (2)- technical errors that invalidate major conclusions relevant to the safety basis; (3)- failure to cover topical material required by DOE orders (eg, 6430.1A, 5480.23) or guidance on SAR's. All comments (unless identified as not requiring a response) adversely impact the adequacy of the facility safety basis/documentation.		Comment/Disposition Status (Column 16.) Key: O/SER - COMMENT NOT ACCEPTED, ISSUE ADDRESSED IN SER OA - COMMENT NOT ACCEPTED, ACTION REQUIRED CA - COMMENT ACCEPTED, ACTION REQUIRED C - COMMENT ACCEPTED, NO FURTHER ACTION REQUIRED	AUG 28 1998
	Executive Summary:			
1	Tables ES-4 and 5: 4 items remain in draft form. These should be converted to final as soon as practicable.	Y	The reference to draft documents was made to assure that the latest design information was reviewed for SAD development. The SAD is a commitment document rather than an implementation document. Implementation was identified where available, even in draft form, due to the maturity of the design.	CA
	Chapter 2, "Facility Description":			
	General Comments:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
2	The Contractor has not systematically 1) Identified which 6430.1A design requirements apply to which safety class components, and 2) documented how these requirements were applied to a safety class system or component, and 3) demonstrated / documented the existing margin between design requirements and Authorization Basis limitations. For example, corrosion allowances (6430.1A, Section 0262) to be used for the various safety class equipment to be placed in the basins are not specified. What is the corrosion allowance assumed for the knockout pots? The assumption may be that, for the stainless steel equipment and short duration of expected operation, negligible corrosion will occur. Where is application of this requirement documented? No reference appears to identify the actual design values for the wall thickness or vessel diameter, to allow the review to confirm the margin between the allowable design dimensions and the SAD limits for vessel diameter and wall thickness. (3) Additionally, chapter 4.0 , 4.3.1.4, p. 4-2, does not identify these dimensions as items which will be verified upon receipt, prior to acceptance, although the design authority for ITWS did indicate that will occur. (3) (3)	Y	The safety functions and performance functions listed in Table 4-1 and code requirements in Section 4.3 are applicable to the IWTS safety class components. As noted SC components are passive and made of stainless steel. Their safety function is assured by the verification of dimensions, prototypical testing (screens), preoperational testing (pressure tests). Acceptability of corrosion is provided by information in the current K basin SAR Section 2.6.3, <u>Water Chemistry</u>, 2nd paragraph. Section 4 specifies the dimensions for safety function compliance, and they will be verified prior to equipment installation or upon receipt.	O/ SER
3	What is the temperature effect of operating the submersible pumps in the basin? The electrical energy dissipated by the pump motor winding resistance will all go into the basin water as heat. During the factory acceptance test the temperature rise in the tank of water with one submersible pump was significant. During IWTS basin operations essentially three heaters will be installed in the basin water. Have the effects on the current K basin temperature limits been analyzed?	Y	Evaluation of the thermal effects of submersible pumps in the basin was made. Additional chiller capacity was not required for added basin heat load from submerged pumps. Fuel removal continually reduces heat load. Start up during summer, would extend time required to lower pool temperature, but doesn't affect ability to maintain temperature.	C
* 4	<u>Section 2:</u> The system description does not adequately describe the computer system which controls the IWTS. Normal operations of the IWTS are computer controlled. This includes automatic shutdown of the system in response to abnormal or out of spec conditions. This is a significant characteristic of this system with potential system wide ramifications. For example, during the factory acceptance test complete system shutdown occurred while the operator was merely navigating through the computer display screens. (It is expected that this particular software problem will be resolved prior to basin operations.) The system description describes in detail the mechanical aspect of the IWTS, but except for scattered references to the various control functions and alarms it does not address the computer system, which is the direct operation interface with the IWTS. Section 2 should contain a description of the IWTS computer control interface. (3)	Y	The control system described is not a safety class or safety significant system that needs to be addressed in detail in the SAR or SAD. The hazard analysis addressed failure consequences which would bound the consequences of control system failures. This position assumes that the safety significant radiation monitor safety functions are not part of the computer control system.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 5	Section 2: Relative to the application of identified codes and standards, this chapter, or other chapters in this document do not adequately demonstrate commitments to identified standards and requirements which are applicable to IWTS equipment. Primary focus is on safety class SSCs. Clear statements should be provided to demonstrate and confirm that the IWTS SSCs comply with all applicable codes and standards. This would include items such as seismic and safety class requirements contained in DOE Order 6430.1A for safety class SSCs.	Y	SC and safety significant SSCs identified in Section 4 are in compliance with 6430.1A.	O/ SER
6	Section 2: The annular filter tanks, which had previously not met the double contingency criterion, now meet the criterion. The inner region is best left empty with its drain open so that any inleakage of fissile material will be automatically removed from the system. Describe how the IWTS will be operated to assure fissile material will be removed from the inner region.	Y	The inner tank has an open pipe drain. This feature will be identified in the K Basin FSAR.	CA
* 7	Section 2.2: This section states that the facility standards and criteria that apply to the IWTS are found in HNF-SD-RD-001, and that the specific standards and requirements that apply to the IWTS equipment are found in HNF-S-0564. Provide evidence to validate this statement, e.g., the results of a systematic review which identified that all applicable standards and requirements for IWTS SSCs from HNF-SD-RD-001 are contained in HNF-S-0564.	Y	All of the applicable standards and requirements for IWTS SSCs from HNF-SD-RD-001 are not contained in HNF-S-0564 (other than by reference), however the appropriate standards and requirements and application of these standards and requirements were evaluated by qualified multi-disciplinary personnel during the several design reviews. There were no open standards or requirements issues identified at those reviews.	O/ SER
	Specific Comments:			
8	2.2, p. 2-1: The applicable codes and standards are not listed, but referenced (HNF-S-0564). These codes and standards must be incorporated into the applicable K Basin SAR revision, and not referenced.	Y	The appropriate code and standard requirements will be addressed in the K Basin FSAR.	CA
* 9	Page 2-3: Section 2.5.1.1: The weights of various in-pool components should be included and verified as part of the system description. This is critical information needed for USQ screening for determining compliance with Table 3-10 of the K Basin SAR. (3)	Y	Weights will be verified prior to lifting over the basin. USQs for installation will determine compliance with existing K Basin SAR. The K Basin FSAR will address or reference specifics of compliance.	CA
10	Page 2-4: Section 2.5.1.2.1: A description is needed to describe how the knockout pots are vented and where the vented hydrogen is directed to, to help understand how potential radiological and combustion hazards are controlled. Although some information is in Table 3A, it should be included in this section. (3)	Y	The vent is to the basin when they are in storage. No consequences are anticipated. An increase in hydrogen can result from the additional surface area due to fuel breakage from FRS operations. Consequences of plugged vent, hydrogen buildup and subsequent opening is addressed in the current SAR Section 3.4.3.5.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
11	Sections 2.5.1.2.1 and 4.3.2.1 state that the Knockout Pot screens are designed to meet safety-class specifications. Section 4.3.2.3 states that the screens must be strong enough to withstand the forces from pressure buildup resulting from filter plugging. Section 4.3.2.4 states that the Knockout Pot screens are required to have mesh dimensions verified before construction acceptance. The code or standard (such as ASME B31.1) used to specify allowable design stresses and loads for the screen should be identified.	Y	ASME B31.1 is identified as the standard for the screen in 4.3.2.2..	O/ SER
12	Section 2.5.1.2.3. The description of the annular filter vessels, and their depiction in figures 2-6 and 2-7, indicate that the outer vessel tanks are of solid construction except for inlet and outlet piping. In actuality these vessels have a series of handholes around their circumference, four each near the top and bottom of the vessel. The covers for these handholes are held in place by tightening a nut on a threaded clamp and are sealed by gaskets. The SAD does not address the probability or consequences of leakage through these handholes. Failure of a gasket, due to radiation exposure, mechanical damage, age or some other mechanism, may represent one of the most credible leak paths out of the system, and could result in drain down of a filter vessel.	Y	The filter vessels are ASME B&PV Code Section VIII code stamped vessels. The covers for the openings are integral parts of the vessel. Gasket material is environmentally qualified including radiation exposure levels. Expected gasket radiation dose for the duration of fuel removal is less than 10% of acceptable exposure. The SAD drawing will be updated to reflect actual configuration in the K Basin FSAR.	CA
13	<u>Page 2-6:</u> Section 2.5.1.7: Did not see excess water removal (or receipt from the CVD) in the hazards analysis. (3)	Y	Backflow through FRS pumps of CVD water is addressed as last item of Table 3A-1 Node 1 on page 3A-4, last item of Table 3A-2, Node 2 on page 3A-6, and last item of Table 3A-3, Node 3 on page 3A-8, next to the last item of Table 3A-5, Node 5 on page 3A-11. The K Basin FSAR will address excess water removal or provide reference to appropriate hazard analysis. Truck moves in basin for receipt of water from CVD will be controlled to existing K Basin SAR and TSR controls. Unloading hazards of the this water will be formally document in updated hazard analysis.	CA
* 14	<u>Page 2-6:</u> Section 2.5.2.1: What is the basis for the 50 # DP limit (given in 2.5.2.2)? Potential failure modes of the screen / knockout pot (bypass of screen) should be addressed. If no failures are credible, justification for such statements need to exist. If failure modes are credible, then TSR operability monitoring requirements (for sudden DP drop, or the DP limit) need to be specified, and this equipment needs to be safety class. (1)	Y	The 50# delta pressure is the maximum expected operating DP across the knockout pot screen to initiate pot replacement. It is not a safety parameter so no TSR controls are required. The screen which is a passive SC design feature must withstand discharge head of pump (125 psi).	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
15	Section 2.5.2.1 states the knockout pot and screen will capture particles larger than 500 micro-meters. Please clarify whether this is actually one quarter inch, which was believed to be referred to as the limit in earlier discussions regarding the screen limit. If 500 mm, please provide the basis for selecting this limit. (3)	Y	The 500 micron screen in the knockout pot is based on the particle size used in the criticality evaluation for the settlers and the filter vessels. Settler tank dimensions were restrictive for larger particles. The 1/4 inch is the size of the FRS screens upstream of the knockout pots which are critically safe for optimal sized particle.	C
16	Section 2.5.2.3: Provide the safety classification and basis for the vent system.	Y	The vent system is General Service and is required by the Washington Department of Ecology NOC (Notice of Construction). This design was evaluated for its hazards (no unique hazard identified) and will be formally documented for reference in the K Basin FSAR.	CA
17	Section 2.6; The IWTS has significant impacts on the confinement system. They should be described here, as committed to in the FRS SAD.	Y	The impacts to the confinement system (i.e. water) are the basin pump down potential due to the submerged pumps. This issue is addressed by the current SAR and TSR and only impacts unmanning durations.	C
18	Sections 2.7 and 4.4.1.1 state that if the radiation monitor is not operating the IWTS cannot and will not operate. This implies that prevention of IWTS operation without the radiation monitor is an engineered function of the control circuitry. However, 4.4.1.5 states that an administrative control will be considered for inclusion in the TSR for operation of the radiation monitoring system. If there is an interlock which prevents operation of IWTS without the radiation monitor operable, there should be a TSR addressing operability / surveillance requirements for this interlock. If no such interlock exists, the administrative control is probably appropriate. One or the other should apply, but not both. (2)	Y	The safety function requirements of the safety significant radiation monitor are defined. The system design is still in progress. A safety significant interlock or administrative control will be provided.	O/ SER
	Chapter 3, "Hazard and Accident Analyses":			
	General Comments:			
19	Chapter 3: Specify which hazards were eliminated from accident consideration due to being covered in general worker safety. (3)	Y	The update identified in response to item 21 will provide identification of specific ES&H program that addresses hazard, as appropriate.	CA
	Specific Comments:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
20	Page 3-2: Section 3.3.1.1: Voltage is a process parameter that was not considered in the hazards analysis. Time also is a process parameter that might need to be considered. Hazards analysis is incomplete. (1)	Y	The hazard analysis did not address electrical system explicitly. It was determined that no new hazards existed that were not already present and controlled by existing institutional safety codes and requirements. (i.e. NEC, OSHA, Hanford Hoisting and Rigging Manual, Hanford Radiation Protection Program, HAZCOM, etc).	C
21	Table 3-3, 3-4, and Appendix 3A: The purpose of the hazard and accident analysis process is to systematically identify hazards within an operation and describe the measures taken to eliminate, control, or mitigate the identified hazard. It is necessary to keep the hazard and accident analysis current as baseline information changes. Baseline information includes facility description and drawings, process and operational descriptions, hazardous material inventories, etc. Numerous comments were identified during the review indicating the hazards analysis, provided in the IWTS SAD, is not current. The Appendix 3A HAZOP Analysis appears to be an initial analysis that has not been updated to the final IWTS design. Although the final IWTS design has been described and analyzed in the SAD, equipment descriptions and functions in the HAZOPS that are not consistent with chapter 2 and 3 need to be deleted or revised. Additional info may also be required. A final (updated) HAZOP analysis, as described in HNF-PRO-704, is required for the K Basin SAR. Features required for accident prevention and features required for accident mitigation have been identified in chapter 3 in the SAD, but still need to be included in the updated HAZOP. Defense-in-depth and worker safety engineered features and administrative controls also need to be revisited in the HAZOP. Consequences and frequencies need to be re-evaluated considering information obtained during the accident analyses. There is concern that not all defense-in-depth features were adequately considered regarding safety classification. These features which include monitoring instrumentation and above water piping need to be reconsidered for significance and final classification. Justify the final classification in terms of requirements and guidelines. Examples of specific identified concerns have been provided separately for information.	Y	The evolving design has been and will be reviewed for new (unique) hazards. None have been identified to date. The hazard analysis will be updated as required for reference in the K Basin FSAR. Examples for updating include deleting old design information and addressing any design changes.	CA
22	What are the consequences of a basin pumpdown with the settlers installed? Can basin now be unmanned with pumps running? What controls are necessary? (1)	Y	This is addressed by the current K Basin TSRs, Section 3.4.3. The unmanning criteria of the TSR must be met. The unmanning criteria will be reviewed to determine if the early uncovering of the settler tanks impacts this criteria. The K Basin FSAR will provide the evaluation and/or criteria change.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
23	Table 3-4: The list of potential accidents does not list a case where the dose to operators increases and the loss of visibility severely affects operations due to the plume of sludge in the water. This potential accident should be assessed for inclusion in the list of potential accidents, if it was not, and evaluated accordingly.	Y	This is an operability concern and water quality issue. A single event would not significantly impact radioactive material content of the basin.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 24	Page 3-21: Table 3-10: The SPRAY analyses are central to establishing the adequacy of the worker protection features of the entire system. Additional information is required to demonstrate the adequacy of the analysis and the overall methodology. What is the optimum hole size, and is "optimum" determined as the fraction of release which is respirable, or is "optimum" that release which gives the highest respirable inventory and dose? What verification/validation has been performed for the SPRAY program? How do the results change if the release and exposures are for shorter times? (2)	Y	1) Optimum hole size is the size that gives the greatest respirable release rate and, therefore, the greatest receptor dose. This hole size does not give the necessarily give the greatest fraction of the release as respirable. 2) The SPRAY computer code quality assurance documentation may be found in "A Model for Predicting Respirable Releases from Pressurized Leaks," WHC-SD-GN-SWD-20007 (Hey and Leach 1994). The models used in the SPRAY code are based upon empirical correlations available from published literature. The SPRAY code was written to assist in determining optimum values for releases and for quickly and consistently calculating release rates. Independent validation was performed for the correlations used in the SPRAY model by taking data from other published sources and comparing it with the model predictions. Hand calculational checks were performed for several SPRAY code outputs to ensure that code outputs are correct. The code runs under DOS and should be compatible with any IBM-compatible personal computer running DOS Version 3.0 or later. 3) Shorter release times reduce the amount of respirable release in a way that is directly proportional to the total release time. However, the air transport factors increase for a shorter total release time because there is less wind dispersion. The air transport factors increase in a way that is proportional to the ratio of the logarithm of the two release durations. The total amount of respirable release is multiplied by the air transport factors to calculate the total dose. In general, the receptor dose will be greater for greater release times. The current methodology (HNF-SD-SNF-TO-059, Rev. 1) for calculating the air transport factor as a function of release duration will not produce a monotonically increasing total dose as a function of release and exposure. Artifacts of the model will, for some release durations between 0 and 24 hours, sometimes give an estimated dose that is slightly larger for lesser release times. This is due primarily to the fact that different breathing rates are applied after 16 hours and a constant air transport factor is applied for releases of duration less than one hour or between on and two hours.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 25	Section 3.4.3: page 3-38: The first paragraph indicates that this accident is beyond extremely unlikely and beyond design basis because it would take at least five days to uncover the top two settlers at the maximum allowable post seismic leak rate. The classification as BDBA should be reconsidered, or additional information provided which justifies the classification. The reconsideration and justification should take into account the already-analyzed basin corner cracking and leakage as a result of the basin DBE, the effects of drain valve leakage, and the accepted reliable response times for emergency actions to remediate basin leakage. The current analyses for these effects indicates that uncovering the top settlers would occur sooner than five days, and stopping leakage at the corners with structural damage may be difficult. The first sentence of the section indicates that this accident is a DBA rather than a BDBA. The word "beyond" should be inserted. The first sentence of the third paragraph uses the word "detonation", which should be changed to "deflagration" to be consistent with the rest of the text and Table 3-17. Page ES-viii, Table ES-2, may require revision based on resolution of comments on Section 3.4.3 questioning the validity of the accident classification as BDBA. (2)	Y	The corner leakage per Document HNF-SD-SNF-DA-012, Closure of Seismic Review Issues and Other Structural Safety Concerns for the 105 KE and 105 KW Spent Fuel Basins, is not a significant amount relative to the 50 gpm limit now in the SAR and cracking is only postulated to approximately 13 ft above the basin floor. The excessive drain valve leakage could impact the analysis but currently the plan is to preclude drain valve leakage through mitigation, determination of incredibility or engineer fixes. The location of the settlers in weasel pit does provide attenuation by weasel pit walls of radiation field if they do become uncovered, such that access concerns for mitigation efforts are minimized. Contained material could not be aerodynamically entrained.	O/ SER
	HAZOP Analysis, Appendix 3A:			
	General Comments:			
26	Table 3A-16: Should add to Table 3A-16, Node 17, consideration of an overheating/fire in the electric heaters.	Y	The vent system was evaluated for hazards, including the heater. No hazards were judged to be significant. The hazard analysis of this system will be formally documented for reference in the K Basin FSAR. 3A-16, Node 17, is the results for an earlier system design. Typically such designs have limited heater capacity to prevent overheating.	CA
27	Table 3B-5, Acute Maximum 99.5 Percent Sector Atmospheric Dispersion Factors: Provide the basis to believe that heavy PuO2 particles will make it not only 100 meters but 7.5 miles in a dead calm (99.5% meteorology) especially within the first 30 minutes.	Y	We are using accepted accident release criteria, no credit is given for fallout.	C
	Chapter 4, "Safety SSC's":			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 28	Page 4-2: Section 4.3.1.3: The racks in the basins are safety class per the K Basin SAR. Modification of the racks is not described in the SAD, nor is it clear that there is any authorization documentation for rack modifications. The rack modification and analysis of the modification relative to the racks continuing to perform their safety function must be provided to DOE. It is also requested that the safety classification of the modified racks be clearly delineated including the basis and controls, if the racks are not maintained as safety class. (3)	Y	The rack modification involves cutting the center bar to allow room for the knockout pots. The knockout pots have built in spacers and are not dependent on the racks to maintain separation for criticality reasons. Therefore for the knockout pots the racks are not required to provide their indexing safety function. For existing canisters the cutting of the center bar would not impact the safety indexing function because no additional canisters would fit than is allowed with the center bar not cut. The adequacy of the modified racks is documented in HNF-SD-SNF-SARR-006, Evaluation of Safety Issues Associated with Damage or Removal of K Basin Storage Racks.	OA
* 29	Page 4-2: Section 4.3.1.4: The drop analysis for the pots was not referenced nor was it completed at the time the SAD was issued to DOE. This analysis should demonstrate compliance with safety class functional requirements. It is requested that FDH confirm the analysis is completed and issued, and that it demonstrates functional requirements are met. DOE requests that they be provided a copy of this analysis. (1)	Y	The intent of the SAD is to provide criteria not implementation details of the criteria. Because of the maturity of the design implementation details were provided or referenced when available. Drop analysis will be provided for DOE review where required by existing authorization basis and/or prior to installation of equipment. The upgraded K Basin SAR for fuel removal operations will provide details of compliance for safety class and safety significant SSCs.	CA
* 30	Page 4-5: Section 4.3.5: This section provides no functional requirements to withstand potential impacts of drops onto the annular filter vessels. Basin crane limitations for loads over the filter vessels are not described nor are there handling administrative controls identified. The safety class functions must be maintained under accident scenarios. Provide the basis why a load drop on the annular vessels is not a credible accident, and, if the accident is credible, provide reference to any drop analysis performed to show the annuler vessel safety function is maintained. (1)	Y	The location of the filter vessel enclosure is beyond the reach of the Transfer Area Crane trolley. Removal of access port during operation will be with mobile crane and will be subject to evaluation at that time. It should be noted that normal maintenance access would only occur after vessels have been backwashed to provide tolerable radiation levels. Criticality concerns and release consequences are much reduced or non-existent after vessels have been backwashed. The upgraded K Basin SAR for fuel removal operations will address as required.	CA
* 31	Section 4.4.1.2: DOE-STD-3009-94 guidance indicates that safety significant systems, structures, or components is to be described in this chapter. Section 4.1 of the SAD further states that Chapter 4 provides details of the safety significant SSCs. Only one safety significant SSC was identified in this chapter and the system description design details are not provided. It is reported that design details are not yet determined. Design details of this system should be provided for review, as this system is currently incomplete.	Y	The SAD is a criteria document not an implementation document as noted in response to item 29. The K Basin FSAR will provide implementation details.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 32	Table 4-2: Section 4.4: This section states that certain SSCs will be designed to meet safety significant requirements for purposes of mitigation and defense-in-depth. It further presents safety significant equipment designations for K West IWTS in Table 4-2. Only one item is identified in the Table. According to DOE-STD-3009-94, page 8, SSCs which provide defense-in-depth are designated as safety significant. There are a number of SSCs that could be classified as safety significant, but have not been identified as such in Table 4-2, e.g., shielding, primary containment (pipes, IXM, etc.), computer controled interface between the radiation monitoring system and the IWTS, filter vessel temperature monitors, spray shielding, filter vent system, etc. It is requested that a careful review of these and other SSCs be made using DOE-STD-3009-94 criteria to assure the SSCs are properly classified as safety significant, and that Table 4-2 and Section 4.4 are modified to reflect any changes. (2)	Y	The hazard analysis performed for the SAD SSCs and the results are in compliance with the above definition of safety significant from STD-3009-94. For the examples cited there was no identified hazard that could result in fatalities or serious injuries, or excessive exposure.	O/ SER
33	Page 4A-3: Table 4A-1: This table shall be revised as required to be in compliance with DOE Order 6430.1A and DOE-STD-3009-94. Any affected SSC classification shall be identified and documented. (3)	Y	No changes are anticipated but table will be updated for any new safety significant items.	CA
	Chapter 5, "TSR's":			
	Chapter 6, "Prevention of Inadvertent Criticality":			
* 34	Page 6-5: Section 6.1.4: The summary of controls identifies that analysis has been performed for fuel spilled from canisters into the array of knockout pots, and identifies both administrative prohibitions and mechanical stops as controls to prevent canister movement over knockout pots. Provide the basis for not making the mechanical stops safety class or safety significant as defense-in-depth. (2)	Y	Mechanical stops will be used and are safety class with a safety function to have sufficient strength to stop movement of canisters past them. The upgraded K Basin SAR and Criticality Prevention Specifications for fuel removal operations will provide the implementation details as required.	CA
35	Section 6.1.4: second paragraph: States that IWTS IXMs have been shown to be critically safe even if inlet plutonium concentration is increased by two orders of magnitude over that discussed in Erickson (1994). The statement implies that it is not in Erickson 1994 itself. The statement should reference the document that substantiates this claim. Confirm this was based on Erickson (1998) and clarify in the K Basin SAR.	Y	Evaluation is in Erickson 1994. Statement was only made to identify conservatism. This will be clarified in the upgraded K Basin SAR for fuel removal operations.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
36	Page 6A-13: Section 6A2.4.1: This section identifies that the CVD process will ensure double contingency against a backwash introducing particles larger than 550 um into the filter vessels. This requirement is identified in section 6.1.3. Provide evidence that it is covered in the CVD SAR. (3)	Y	This issue is an interface item that is being formalized with CVD. Various solutions to the issue are viable.	CA
	Chapter 10, "Initial Testing, In-Service Testing, Maintenance":			
* 37	Chapter 10: General Comment: The information provided in Chapter 10 does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. Specific concerns include a lack of specific information on requirements, initial testing, in-service surveillance, or maintenance. Requirements such as those identified in HNF-S-0564, section 5.3 should also be considered for inclusion into this chapter.	Y	Details of initial testing, inservice inspection and maintenance is premature at this time. Commitment to existing programs addressing these items is appropriate based on Program Commitment guidance section of 3009-94. The upgraded K Basin SAR for fuel removal operations will provide more specific information for safety class and safety significant SSCs. The safety function of passive components are verified by code required inspections, factory acceptance testing, and receipt inspections. No inservice inspections or maintenance requirements for these items have been identified to date. Safety significant filter vessel radiation monitor will be lab or K Basin tested with check sources and periodically calibrated.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 38	<u>Chapter 10: General Comment:</u> The content of Chapter 10 of the Integrated Water Treatment System Safety Analysis Document is wholly deficient in meeting the scope and content requirements of DOE Order 5480.23 and DOE-STD-3009-94, and does not support a conclusion that the requirements of DOE Order 6430.1A, 1300 (testing of safety functions), have been or will be met. The submitted information simply states that there will be an appropriate initial testing, in-service surveillance, and maintenance program, and defers the provision of information until the upgraded K Basins SAR. Since this plan makes the information available to RL at the latest possible time, and is likely to make any RL input difficult to accommodate, it is not a satisfactory arrangement for making important safety information available. It is recognized that some of the testing, such as factory acceptance testing and construction testing, may have already been performed, and that other testing may still be in the planning stages. Since RL needs the utmost confidence in the equipment performance, FDH should provide that information on design and construction confirmation testing which is now available, and inform RL of the plan and schedule for preparing and providing the remaining information which is required by Chapter 10.	Y	See 37 above.	O/ SER
	Chapter 11, "Operational Safety":			
39	The operational Safety section of the K Basin SAR must include a description of the program to assure systematic identification and incorporation of the various operational commitments of the FRS SAD. A table listing all the various special operational commitments in the SAD is suggested. (3)	Y	Implementation of the specifics of Programmatic commitments (e.g. radiation protection; quality assurance, maintenance, etc.) are to be addressed external to the SAD and SAR as allowed by SAR PREPARATION CONCEPTUAL BASIS AND PROCESS, PROGRAMMATIC COMMITMENTS, of DOE STD-3009-94. Special operational commitments will be addressed or referenced in the K Basin FSAR	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Chapter 13, "Human Factors":			
* 40	Chapter 13: General Comment: The information provided in this chapter does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. The discussion provided leaves the reader with a concern that there may be a lack of understanding relative to the timing, scope, and importance of Human Factors in facility safety. Clearly, this effort must be incorporated into the system design process and is required by DOE Order 6430.1A, section 1300-12. Compliance with this requirement has not been demonstrated and must be met. Delaying this effort to the K Basin Safety Analysis Report is not consistent with DOE 6430.1A requirements. (3)	Y	The discussion in the SAD is not in conflict with the graded-approach guidance of STD-3009-94. The safety significant vessel monitor system was not addressed but is subject to human factor evaluation. However the human factor concerns for operator action to alarms do not require immediate actions (hours would be action requirements. Also operator action in response to alarm is not complex (shutdown and initiate backflush)	O/ SER
41	Chapter 13: No evidence that environmental factors were considered for impact on operators or equipment operation. Provide assessment. (3)	Y	Environmental factors have been evaluated and none have been identified for SC SSCs.	O/ SER

DOE RCRs FOR FRS SAD

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Comment Key: Comments are evaluated as falling into the following omission categories, taken from DOE Std 1104-96: (1)- failure to address hazardous material or energy releases w significant consequences to the public, worker, or environment that will otherwise be left w/o coverage; (2)- technical errors that invalidate major conclusions relevant to the safety basis; (3)- failure to cover topical material required by DOE orders (eg, 6430.1A, 5480.23) or guidance on SAR's. All comments (unless identified as not requiring a response) adversely impact the adequacy of the facility safety basis/documentation.		Comment/Disposition Status (Column 16.) Key: O/SER - COMMENT NOT ACCEPTED, ISSUE ADDRESSED IN SER OA - COMMENT NOT ACCEPTED, ACTION REQUIRED CA - COMMENT ACCEPTED, ACTION REQUIRED C - COMMENT ACCEPTED, NO FURTHER ACTION REQUIRED	A U G 28 1998
	Executive Summary:			
1	Section E.8, Page xiii; Contrary to the SAD, USQ K-97-0265 is not "recently closed".	Y	Agree, the upgraded K Basin SAR for fuel removal operations will remove statement that USQ K-97-0265 is closed.	CA
2	Table E-1 lists the Guidelines for off site radiological consequences for accidents having frequencies from 1 E-02 to < 1 E -06 as 0.5 rem EDE. This is not consistent with the risk Evaluation guidelines of Table 3-1. When the SAD information is incorporated into the K Basins SAR, correct and consistent guideline values should be used.	Y	Agree, the upgraded K Basin SAR for fuel removal operations will provide the risk evaluation guidelines in the table and footnote the 0.5 rem which is the safety class threshold.	CA
	Chapter 2, "Facility Description":			
	General Comments:			
3	Provide the corrosion allowances used for the various equipment in the basins? (3)	Y	Corrosion is not considered an issue. Equipment in basin is predominately painted carbon steel. The fuel racks are unpainted carbon steel. Refer to Section 2.6.3 Water Chemistry 2nd paragraph of the existing SAR which provide data to indicate that corrosion is not an issue because of the short service time and low corrosion rates for carbon steel.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
4	Describe provisions for easy removal later on, or as required for maintenance (eg, the PCM)? See 6430.1A, section 1300-11.2. (3)	Y	The FRS maintenance strategy is documented in the Fuel Retrieval SubProject Maintenance Assessment, SNF-FRS-RPT-010. The strategy is largely driven by cost, personnel dose, and schedule considerations. The assessment recommended a strategy that is based upon direct replacement of modular components rather than repairing failed in basin units for all FRS systems with the exception of the manipulator systems (due to the high costs and long lead replacement times of manipulators). In support of this strategy, the following features have been incorporated into FRS design for in basin equipment: * In basin equipment prone to failure designed as modular units. * In basin components designed for remote, in place replacement using long handle tools or the manipulator. * Traditional remote handling features incorporated into design to expedite replacement times, such as use of acorn nuts designed for easy engagement and special anodized or painted finishes for ease of decontamination. * Failure prone items, to the extent practical, relocated to above water, hands on accessible locations. Servo valves, controller cards, etc. relocated to manipulator bridge are examples. * Maintenance agreements with off site vendors in progress for the manipulator system to expedite repair times and improve repair capability. Fundamental to the strategy is the procurement of equipment and systems that have an operating life of better than two years	C
* 5	Cannot determine that GFI (Ground Fault Interrupter) breakers have been used, as required by 6430.1A, section 1605-2.3. Contractor states issue is still "open". (1)	Y	GFIs will be incorporated as required by code.	C
	Specific Comments:			
6	2.2, p. 2-1. The applicable codes and standards are not listed, but referenced (WHC-S-0461). The applicable codes and standards need to be incorporated into the applicable K Basin SAR revision. (3)	Y	The precedent set by the K Basin SAR at RLs direction was to refer to the SRIDs document for identification of requirements. The SRIDs is approved by Site Manager, is treated as an authorization basis (AB) document. The intent is not to have two sets of requirements both approved as ABs creating the possibility of conflicts or inconsistencies. STD 3009-94 also states that SRIDs may be referenced. WHC-S-0461 has been cross-checked against the SRIDs by the system engineering process to assure all appropriate requirements were specified.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
7	Page 2-4: top of page: Found no mention of the "telescoping stiffbacks" discussed here as Defense in Depth feature for worker safety and may be safety-significant. However, this feature is no where mentioned as such in chapter 3. (3)	Y	The telescoping stiffback features is one of several pieces of "Equipment that prevents lifting the PCM wash basket and canisters out of the basin water" as defined in the 6th bullet on the page 3-11 list of defense in depth equipment. The telescoping stiffback. and its safety classification are also discussed in Section 3.4.2.2	OA
8	Section 2.5.1.1 states that canister hooks and stiffbacks are designed to prevent lifting canisters too close to the surface. This may be true for single canisters, but if canisters are engaged when racks are lifted, tilting of the racks can over-raise the canisters. This scenario is not analyzed in the SAD or the K Basin SAR. (1)	Y	The unmotorized hoists with unrestrained rollers will return the stiffback to a vertical lift position because of the horizontal load induced by the tilting of the rack. All lifts of canisters are under manual local control . Lifting of fuel close to surface by tilted rack would be detected by area radiation monitors before operator dose limits were exceeded. With operator presence, overload limits on hoists, and unrestrained rollers the probability of this accident extremely unlikely or incredible. The lifting of a canister is addressed in the K Basin SAR Section 3.4.2.6 -Canister Lift Overexposure. Will identify the rack scenario as another way for fuel to approach surface in FSAR in the upgraded K Basin SAR for fuel removal operations.	CA
9	Page 2-4: Section 2.5.1.2: 1st paragraph: Specify the decapping system material. carbon or stainless steel? (3)	Y	Carbon steel with exception of water wetted tools which are stainless steel.	C
* 10	Page 2-4: Section 2.5.1.2: 2nd paragraph: More detailed information is required on the vent system for canister decapping. (3) & (1) e.g. Where does the gas vent go to? Is this vent line included in the K Basins NEPA license, etc? What kind of monitor is on the vent line (for radiation or other)? See 6430.1A, sections 1589-99.0.1 and 1320-6.3.1. e.g. Where is this strainer? How would it be cleaned and what limits are on its accumulation of junk?	Y	The vent system is an ALARA feature as addressed here and in Section 7.0. DOE/RL 97-28, Radioactive Air Emissions Notice of Construction Fuel Removal for 105KW Basin does not require any abatement or monitoring for Kr. The system is routed to be vented near roof vent 10. The strainer is only a demister, junk should not be present. No additional detail is required.	C
11	Page 2-4: Section 2.5.1.2: 4th paragraph: How does the demister work w/o pads (as so stated in the Hazards Analysis)? (3)	Y	The Hazard Analysis reviewed a more complicated system, and this item is no longer part of the design. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 12	Page 2-4: The FRS system description on page 2-4. Section 2.5.1.2, and page 2-5, Section 2.5.1.3, needs to be strengthened to clearly identify the interfaces between the FRS and IWTS relative to high pressure water. If FRS includes any piping, pumps, ect., it should be identified as a potential hazard and evaluated. E.g. Describe what is the PCM made of (all parts), pressure the water jets operate at, the source of water, where the piping is (above waterline or below), how the jets are controlled, where everything is located (control station, hi press water pumps, etc), where the washed out sludge goes. and how sludge is removed.	Y	The FRS pumps which supply water to jets are located atop west basin divider wall and the water supply is from the IWTS treated water i.e. after filtration and ion exchange. Pumps and piping are designed to appropriate pressure system codes (ANSI B 31.3) as required by WAC. This provides for worker protection. Maximum pressure is 250 psi. Only pumps and their suction and discharge piping are above water. The consequences of a leak is essentially the same as for the existing recirculation or skimmer system , same radioactive source. The current K Basin SAR Section 3.4.2.11 Contaminated Building Atmosphere bounds spray leaks of the type addressed(basin water). The upgraded K Basin SAR for fuel removal operations will clarify interfaces. Personnel hazards from spray leaks will be addressed as part of the development of the hazards baseline to be prepared to cover all K Basin activities and update the existing hazards information.	CA
13	Page 2-5: Section 2.5.1.3: Describe purpose of torque limiter. Limiter appears to be a Defense-in-Depth item to prevent excessive breakage of fuel and therefore excessive contamination of the basins. radiation exposure. etc. (3)	Y	The purpose of the torque limiter is to prevent mechanical damage to the PCM gear box and is not to prevent fuel damage. Defense-in-depth is only required to be identified to prevent uncontrolled release.	C
14	Page 2-5: Section 2.5.1.3: Describe where the skid-mounted HP pump assembly and valves are located. (3)	Y	See 2nd paragraph. page 2-6. - The skid-mounted high-pressure pump assembly is positioned over the wall separating the center and west bays of the basin pool. The high-pressure pump provides the fuel flush nozzles with treated basin water from IWTS.	C
15	2.5.1.4. 2.5.2.4: Stuck Fuel Removal Equipment Description: Provide the dose consequences from sawing the fuel along with the canisters? Are special PPE needed for everyone in the basin?	Y	3.4.2.3 Fuel Assembly Burns Under Water, provides the evaluation of the worst case event. The event scenario, which is the same for decapping, primary cleaning. or removing stuck fuel, could initiate an energetic reaction of uranium hydrides, uranium. or zirconium cladding materials. Section. 3.4.3.9 Confinement of Gaseous Radiolysis Products, of the current K Basin SAR refers to Weber 1994 which a more detailed evaluation of the consequences of a burn of canister uranium fuel elements under water and concludes that the release to the site boundary is significantly less than acceptance criteria. Further there is no damage to the K Basin structure nor injury to personnel for credible events.	C
17	Page 2-6: 1st paragraph: It cannot be determined if there is any potential hazard, without defining what is meant by "treated" basin water. Please define this term and clarify if there are any differences radiologically between this term in K East and K West. (3)	Y	"Treated" basin water is water that has been filtered and deionized by the IWTS. KW will have less activity than KE.	C
18	Page 2-6: Section 2.5.1.5: 1st paragraph: Specify table material. (3)	Y	Table material is carbon steel and is to be painted.	C
19	Page 2-7: top of page: Need better explanation of purpose of the MCO baskets go/no-go gauge. (3)	Y	The go-no-go gauge is a pipe that assures the MCO baskets will fit in the MCO (non safety function) and that the fuel is confined to a safe geometry in the event of MCO basket rupture during a siesmic event or drop accident (safety function to prevent criticality) . Refer to section 4.3.2.2	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
20	Page 2-7: middle of page: • What fuel element "length requirements" are these? Could not find further mention of them anywhere. • What are these two other go/no-go gauges for? • Where are the test weights stored? Could not see them on Fig 2-11. • Is there only one lamp? Must there be a certain illumination of the work area, or will work be stopped to relamp? (3)	Y	Limit 11 from the CSER (contained in Appendix 6A of the SAD) addresses the length requirements • Assembled fuel assemblies can be no longer than longest allowed fuel. • MCO fuel or scrap basket loading/storage; see item 19 • Test weights are stored south of fuel basket loading station under monorail 27. • Yes, there is one lamp to back light the MCO basket to facilitate assembly loading which is easily re-lamped. Additional lighting is provided by the CCTV system.	OA
* 21	Page 2-8: Section 2.5.1.6: Specify how the environmental design requirements have been met to assure the effect of radiation on the hydraulic lines has been evaluated. (Radiation generally reduces rubber/plastic integrity.) (3)	Y	The following citations of the FRS procurement specifications highlight where environmental and radiation design considerations have been imposed upon the equipment vendors: * Performance Specification for the Manipulator Purchase. SNF-FRS-SPC-03 Section 5.3- Radiation, Section 3.2.5.1- Operating Environment * In-Pool Equipment Procurement Specification, SNF-FRS-SPC-007 Section 5.12- Radiation, Section 5.1.2.2- K Basin Operating Parameters (environment conditions). * Performance Specification for Closed Circuit Television, In Basin Lighting, and Equipment Operations Center. SNF-FRS-SPC-09, Section 3.2.2.1- Operating Environment, Radiation environment was not specified, since it was determined that replacement upon failure was the most economical approach.	C
* 22	Section 2.5.1.6 states that the control system is designed to prevent over lifting of the fuel. Please explain why there are no mechanical interlocks. Please explain what ensures "the manipulators are not capable of lifting fuel out of the basin water".	Y	As identified in Table 3.A.4, Item 4 page 3A-18 the physical reach capability of the manipulator is up 4.5 feet from surface of water. Control limits reach to 6 feet from surface of water. No other controls are necessary. A detailed explanation is provided in Appendix 3C pages 9 -12.	O/ SER
23	Page 2-8: Bottom of page: The manipulator control system has been classified as GS in table 3-8. It appears the system should be classified as safety significant. Justify the classification.(3)	Y	The existing area radiation monitors provide the necessary protection for workers for lifting of SNF above the water. The failure of manipulator control system is evaluated in 3.4.2.1 Appendix 3C.	C
* 24	Page 2-9: 1st paragraph: The removable mechanical rail stops should be S/S, per its definition. (1).	Y	Manipulators operate at or below grating level. Failure of the end stops does not create an unacceptable load drop, or criticality concern or a worker safety issue.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 25	Page 2-9: 1st paragraph: The manipulator collision-avoidance system would at least be a Defense-in-Depth feature. (3)	Y	In accordance with DOE-STD-3009-94 "Systems, structures and components that are major contributors to defense in depth are designated as safety significant". While the collision avoidance system may be considered as a defense in depth measure to minimize equipment damage, it would not be considered as safety significant. This feature will be added to the defense in depth list recognizing it is capable of preventing a challenge to the basin floor or FRS safety class equipment due to a drop, but will be classified as general service since the drop is acceptable.	CA
26	Page 2-9: 2nd & 3rd paragraphs: The location of rooms 3 and 20A should be described. (3)	Y	See attached figure for location of room 3 and 20A	C
27	Page 2-11: Section 2.5.1.8: 2nd paragraph: Specify the material for the basket queue. (3)	Y	Basket queues are carbon steel (painted).	C
* 28	Page 2-12: Section 2.5.2.1: 3rd paragraph: Provide basis justifying why the telescoping stiffback is not SC for the same reason the MCO stiffback is SC. (1)	Y	The maximum amount of material that can be lifted out of the water by the telescoping stiff back (assuming failure of the stiffback) is the PCM wash basket (equivalent to 1 canister). Ignition of the scrap in the wash basket will not occur based on analysis demonstrating that a canister containing scrap would not reach ignition temperatures with the scrap canister insulated by sludge layer of 10 percent or less of the debris bed height (Porten and Crowe 1994). The PCM wash basket provides for higher heat transfer than the canister in sludge. Since the similiar analysis is not available for the MCO basket, the scrap in the over-lifted MCO basket is assumed to ignite. The release from this combustion exceeds the limit. The MCO basket stiffback also functions to limit drop height, which the telescoping stiffback need not do due to the mass difference. The release from the wash basket is aerodynamic entrainment from surface and the MCO basket release is fire driven which is much higher. This is the basis for differences in classification of MCO basket grapple and telescoping stiff back. Refer to Sections 3.4.2.1 & 3.4.2.2.	C
* 29	Page 2-13: Section 2.5.2.3: Unable to determine that the PCM is designed for easy withdrawal from the Basins, consistent w 6430.1A, section 1300-11.2. This is important as the PCM is probably the most likely thing to break down during operations and need removing for repairs. (3)	Y	The PCM is installed in pieces and assembled under water. The reverse process will be used to remove the PCM following completion of operations. Procurement specifications includes criteria and design features for remote maintenance. Factory Acceptance Tests require remote maintenance demonstration.	C
30	Page 2-14: Section 2.5.2.5: Provide additional description of the "wash basket" to better understand it's function. (3)	Y	The description in 2.5.1.3 PCM Equipment Description is considered adequate for safety evaluation.	OA
31	Section 2.5.2.5: Procedural controls and inspections necessary to control mixing tramp SNF with debris shall be described in the waste management section of the SAR to ensure commitments in this section are adequately controlled.	Y	This is a "debris removal" activity from the standpoint of waste management and is beyond the scope of this SAD.	C
32	Page 2-16: Top of page: Describe basis and safety significance of the 3" limit on scrap. (3)	Y	There is no safety significance. The limit is the size based on experience that is realistically expected to be capable of being reassembled as a fuel piece.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
33	Page 2-16: Section 2.5.2.6: 1st paragraph: 3rd, 4th sentences: Clarify how we ensure that the operating lever (of the MCO stiffback grapple) engages the ball detent grapple from the operating floor, looking down on the equipment? This is a critical operation. Suggest consideration in operating procedures to lift slowly while checking with a TV camera, as this would provide immediate visual evidence of attachment. (3)	Y	The MCO stiffback grapple has an indicator associated with the operating lever to indicate position of grapple which is not shown in the figure. This is not a safety concern since lifts or drop have been analyzed and do not present a problem.	OA
34	Page 2-16: Section 2.5.2.6: 3rd paragraph: Clarify: • How the empty MCO grapple is grappled to the MCO basket, how the hoist is then connected to the MCO grapple and how the positive engagement of the two (basket to the grapple, grapple to the hoist) is ensured, • What safety precautions are needed vis a vis hoist operation to ensure proper engagement of the empty MCO basket hoist to the flexible transfer crane, and • how verification is made that the empty MCO grapple is disengaged from the unloaded basket underwater. (3)	Y	See pages 2-11 through 2-12 for a description of the empty basket grapple. The FTC interlocks to monorail 27 with the same basic functional design as all other existing basin monorail interlocks. This is an appropriate level of detail for safety analysis.	OA
35	Section 2.6. Contrary to this SAD, the IWTS SAD does not develop "detailed changes to the K Basins SAR" for the confinement system design description.	Y	The intent was to refer to the IWTS discussion of changes to the "confinement system" due to the IWTS system which provides the water for the confinement system. This will be corrected in the upgraded FSAR.	CA
* 36	Page 2-18: Section 2.9.4: 2nd bullet: Provide basis justifying why these new interlocks are not safety class, per 6430.1A, section 1300-3.2. (1)	Y	Administrative controls for criticality prevention will ensure no fuel canisters are stored in the MCO basket movement path, so a criticality caused by a failure of the interlock and non-upgraded portion of the rails becomes a double contingency event. In addition weight/height for drops of MCO baskets are within K Basin SAR Table 3-10 limits. Therefore the consequences of the accidents associated with failure of the interlocks are acceptable and they need not be safety class.	CA
37	Page 2-18: Section 2.9.4: 2nd bullet: Describe the flexible transfer crane in more detail to allow an understanding of this equipment. (3)	Y	Since complete failure of the FTC is acceptable, more specific details are not required to estyablish the safety basis.	OA
38	Figure 2-3: Figure needs to be updated to describe what happens to the unstuck fuel elements. and to address incomplete information. (3)	Y	Appropriate Figures will be included in the updated K Basins SAR.	CA
39	Figure 2-6: There is not sufficient information in the figure or discussed in Section 2.5.1 to understand: • how the "telescoping hook" section works, • What the hook's capacity is, • What the spreader bar is for, and • How all of this works. (3)	Y	An appropriate level of detail for safety analysis has been provided to allow assessment of the safety analysis.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
40	Figure 2-12: Can the debris bins be loaded with fuel and go critical? CSER had no limits on the debris bins. (Is loading the bin w fuel bits a single contingency?) The plan view seems to show gaps between the pail and the two debris canisters where debris (or pieces of fuel elements) could fall to past the bins to the basin floor. (1)	Y	The criticality aspects of the debris baskets are addressed in 6A.3.7 **Debris Handling Limits** as follows: - No limits. -Basis: Debris is defined as nonreactor-origin material, e.g., a wrench in a canister. Debris is separated from the fuel and reactor-origin material and placed in the debris bin until it is disposed of. The debris bin should not contain any fuel. The process table design includes a height difference between the debris bin and the table surface to prevent fuel pieces from inadvertently spilling into the debris bin. The table analysis demonstrated that, even if the debris bin were full of optimized scrap, it would not cause a criticality problem. Drops of the debris bin are bounded by canister drops. As-low-as-reasonably-achievable controls will be in place to protect workers handling debris.	C
41	Figure 2-14: Print is inadequate. Provide better print or additional print with clear details. Engineering print w parts listing is needed at a minimum. (3)	Y	The upgraded K Basin SAR will provide appropriate figures, it is inappropriate to provide engineering prints with detailed parts lists in the SAR.	CA
42	Figure 2-16: Print is inadequate. Provide better print with clear details. Engineering print w parts listing is needed at a minimum. (3)	Y	The upgraded K Basin SAR will provide appropriate figures, it is inappropriate to provide engineering prints with detailed parts lists in the SAR.	CA
	Chapter 3, "Hazard and Accident Analyses":			
	General Comments:			
43	How the hazards roll into the accidents is unclear. ie, Not clear that the hazards are bounded by the accidents. Part of the problem is that the hazards' risks (freq X consequence) were not calculated. Also, did not provide freq for the "what if" HA, so risks cannot be calculated for those hazards, anyway.) Provide clear connection (binning) between the hazards and the accidents. Must show that all hazards other than standard industrial hazards are picked up by the accident list. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
44	Could not see which hazards were eliminated from accident consideration due to being accepted industrial type hazards and covered in general worker safety. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
45	Environmental factors not considered for impact on operators or equipment operation. (Heat, humidity, etc). Provide assessment. (3)	Y	FRS safety class components are passive and painted structural steel. Environmental factors for the safety class equipment are negligible. Environmental factors that impact operations and equipment were considered.	OA
	Specific Comments:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
46	P. 3-2, 2nd paragraph. The SAD states that unmitigated onsite and offsite dose consequences for radiological material and toxic chemicals were calculated, as applicable. The consequences were compared with Table 3-1 to evaluate the risk level and establish the need for safety SSCs and TSRs. Since Table 3-1 shows the REGs, not the threshold for safety class of 500 mR for all event probability classes, this statement gives the impression that the requirements of 6430.1A (which by reference to the 5400 series establishes the threshold for safety class determination at 500 mr, independent of event probability) are not being met. In fact HNF-PRO-704 correctly applies this requirement in step 2.4.2.A.4, and this procedure was correctly followed, based on 3.4.2.1.5, which correctly identified the MCO basket stiffback grapple and the empty basket grapple as required to be safety class. Table 4A-1 should be revised to be consistent with Table 3-1.	Y	The safety class or safety significant classification was determined based on HNF-PRO-704 criteria. The acceptability of the accident analysis was then based on comparison to Table 3-1. Section 4.3 has the correct statements. The upgraded K Basin SAR will correct the text.	CA
47	Page 3-3: Section 3.3.1.1: 1st sentence is wrong. Hazards are things capable of causing harm to people, the facility, or the environment. Hazards cause the harm, and NOT accidents. Accidents are only triggers "releasing" the hazard from the SSC's containing them. Revise. (3)	Y	Agree, the upgraded K Basin SAR will correct.	CA
48	Page 3-5: top of page: The form used for the hazards analysis is not provided in Appendix 3A as stated. (3)	Y	The statement should say the "completed forms".	CA
49	Page 3-7: Tables 3-5 and 3-6: Tables do not appear complete as some items in Table 3A-2 were not picked up. Verify that all entries from the hazards analysis tables are picked up here. e.g. items 21,22,23,and 24 from Table 3A-2 should be in Table 3-5, and items 2,3,and 6 from Table 3A-2 should be in Table 3-6. (1)	Y	The tables are complete. Several items from Hazops were combined in the summary table.	C
50	Table 3-5 states that the table consists of 2 sheets. Either the statement is in error or one sheet of S2 and S3 items is missing.	Y	Agree.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 51	Section 3.3.2.3.2 indicates that safety significant equipment prevents uncontrolled drops of the manipulator support system. Table 3-7 indicates that the manipulator rail support structure tether system is classified as safety significant, along with a footnote which states that the tether system was classified, designed. and procured as safety significant based on the safety classification that existed at the time. and that under the current criteria, this would be a safety-class device. The manipulator tether support system is intended to prevent the manipulator trolley support frame from falling and damaging safety related equipment, a safety related table (for criticality prevention) and the basin floor. The SAD acknowledges that under the current requirements, this equipment is required to be safety class. However, the basin floor is not only a safety class component, it is the primary confinement barrier. This confinement barrier must remain fully functional following any credible DBA as required by DOE Order 6430.1A, 1300-1.4.2. The tethers should be classified as safety class. It is recognized that the tether system relies upon the K Basin building structure for support. (2)	Y	The tether system was designed and procured in accordance with the existing criteria at the time., The tether system is supported by a similar safety significant structure (building superstructure). Making the tether system safety class will not signifcantly reduce the overall risks since the weak link is likely the superstructure. The design includes significant margins and is judged to be acceptable as is. More specifically, the design and design reviews, procurement, installation and inspection would be would be no different for these items if they were designated as safety class, with the exception of some commercial grade dedication activities (likely a test of a sample assembly). FDNW applied procedures typically used for safety class construction for the procurement, material certifications, welding / inspections, records, etc. for the safety significant tether support system. All structural steel was procured as safety class. All welding was performed as safety class. All inspections performed as safety class. The cable was procured as commercial grade item, and pull tested to 125% of load equivalent to drop load (i.e., 2 x weight of support structure and live loads such as the manipulators and PCM drive system). ECN to original analysis which defined the loads is being investigated to validate pull test of cable. Some rework may be required if pull test must be repeated.	O/ SER
52	Page 3-14: Section 3.3.2.3.5: 1st paragraph: Which hazards were eliminated because of design or process changes or because another existing safety analysis bounded the hazard? These need to be listed. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
53	Page 3-14: Section 3.3.2.3.5: Revisit the listing of hazards brought forward to accident analysis after revising Tables 3-5 and 3-6 as needed (See comment # 49). Perform any additional accident selection and analysis necessary. Document results. (1)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
* 54	Page 3-15: 4th paragraph: Provide the rational describing why fuel elements were not used instead of fuel scrap for the analyses? (2)	Y	Scrap baskets have a higher potential to ignite, i.e has the largest surface to volume ratio, lower heat convection, and larger area for release calculations than fuel baskets.	C
* 55	Page 3-19: Section 3.4.2.1.5: The discussion provided in this section is confusing and would not lead to a classification of safety class for empty basket and stiffback grapples. The basis for the limit of .5 rem (5 mSv) as referenced in Table 4A-1 is also not clear. Provide clarification and basis for the .5 rem limit in Table 4A-1. Table 3-1 is the basis for safety classification on the SNF Project per DOE letter 97-SFD-172. (2)	Y	The safety classification is to prevent removal of a full basket of scrap from the water which would result in exceeding 0.5 rem off site. The empty basket grapple design prevents the possibility of remote (i.e., in-pool) engagement of a MCO basket, and prevents placement of fuel into an empty MCO basket while engaged. The MCO basket stiff back grapple is required to prevent lifting the MCO basket out of the water, and limit the lift height above the basin floor. This is addressed in section 4. The classification criteria is consistent with HNF-PRO-704 and DOE Order 6430.1A (1989).	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 56	Page 3-26: Section 3.4.2.4: There are no identified means preventing FRS equipment and operational loads from being brought over canisters of fuel. Controls must be established as TSRs to preclude this, as consequences have not been analyzed, nor is it clear that this is bounded by other accident analysis. (1)	Y	For installation the work package and USQ will assure controls are in place to prevent lifting the FRS equipment over fuel canister. Fuel will be relocated away from FRS equipment installation paths. Canisters will not be located in FRS operational load paths (in excess of canister weight loads) as required by CSER limit 6 which requires canisters be no closer than 6 feet from the load path.	C
57	Page 3-28: top of page: This tether system mentioned on this page was not mentioned/described in Chapter 2. Describe. (1)	Y	The tether is only a part of the manipulator support and is mentioned in Section 2.5.1.6, 2nd paragraph, first bullet.	OA
58	Page 3-28: 1st paragraph: State what this maximum lift height is. (3)	Y	The maximum lift height is shown on Figure 2-14.	OA
59	Page 3-29: Section 3.4.2.5.5: Page 3-31: Section 3.4.2.6.5: The summary of safety structures and components in section 3.4.2.5.5 is not complete, or is inconsistent with Table 6-3 which lists the MCO basket go/no-go gages and the process table bottom plate. Also the stiffback grapple listed in section 3.4.2.5.5 is not shown on Table 6-3. (3)	Y	The MCO basket go-no-go gauge will be added to the process table bullet in section 3.4.2.5.5 and 3.4.2.6.5, and the stiff back grapple will be added to Table 6-3 when the K Basin SAR is upgrade for fuel removal operations	CA
60	Page 3-29: Section 3.4.2.5.5: 2nd paragraph: Didn't see the limit on moving loaded MCO baskets in the CSER. This limit is not mentioned in Chapter 6. (3)	Y	Limit 12 of Section 6 addresses limits on moving loaded MCO baskets.	OA
61	Page 3-30: Section 3.4.2.6.1: State what the design basis earthquake (DBE) is. (3)	Y	Per Section 1, Site Characteristics, existing K Basin site criteria is used. This includes a seismic event of 0.2 g ZPA (0.12g ZPA for basin superstructure).	C
62	Page 3-31: Section 3.4.3: • What is the impact of the FRS on any of the B-DBA's considered in the K Basin SAR? • What is the consequence of criticality involving the FRS in the basins? (3)	Y	• No impact has been identified of any on K basin B-DBAs based on reviews of K basin DBEs during development of the SAD and based on the development of a draft Limited Activities Document for FRS, which included a matrix identifying the impacts of FRS on the existing DBE. • Consequence of criticality involving FRS in the Basin under approximately 8 foot of water (sheilding) is minimal from a physical perspective.	C
	Table 3A-2: Comments below may refer to table entries that have been sequentially numbered, from the 1st entry (canister retrieval) to the last (53).			
63	Table 3A-2: General Comment: Many of the ESFs are vague and lack specificity. It would be beneficial to provide more description of the ESFs. e.g. items 21, 30, 38, 40, 44, and 50.	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
64	Table 3A-2: Include the secondary cleaning operation's hazards in the Table. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
65	Table 3A-2, Items #4 and 12: Cameras are shown as ESFs. But, there is no further so mention, even as defense-in-depth. Should be a defense-in-depth. (3)	Y	The cameras will be used to monitor the amount of fuel on the table and as such should be considered general service defense in depth items. They will be added to the list in the upgraded FSAR.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
66	<u>Table 3A-2, Item 28:</u> Did not see the ESF in WHC-S-0461. (3)	Y	WHC-S-0461 defines the requirements for design of the FRS system. WHC-S-0461 requires that hazops be performed. Table 3A-2 reflects the results of the hazops. Subsequent to the hazops, design analysis demonstrated that these ESF were not necessary. See pages 3C-9 thru 12. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
67	<u>Table 3A-2, Item 29:</u> Did not see the ESF in WHC-S-0461. (3)	Y	These features are defined in the manipulator procurement specification specification.	C
68	<u>Table 3A-2, Item 42:</u> It should be stated that the decapping vent is routed to another building exhaust vent (as indicated in Section 2.5.1.2). Also, could find no further mention of special Kr sampling in Chapter 7 or 11. (3)	Y	To be addressed as part of the development of the hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
69	<u>Table 3A-2, Item 53:</u> What ESF "isolation" device is referred to here? What interlocks are there? (3)	Y	To be addressed as part of the development of the hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-3: Comment below refers to table entries that have been sequentially numbered.			
* 70	<u>Table 3A-3, Item 15:</u> Engineered safety features should include GFI protection for extra lighting in the basin because the basin underwater lights are 120 volt. (1)	Y	GFIs will be incorporated as required by code. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-4: Comments below refer to table entries that have been sequentially numbered.			
71	<u>Table 3A-4, Item 1:</u> "the Remarks" specifies that an action plan is needed for this scenario. Explain the meaning and status of this action plan. (3)	Y	No action plan is needed. This will be corrected as part of the development of the upgraded FSAR. A hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
72	<u>Table 3A-4, Item 4:</u> Need for control on scrap loading needs to be mentioned in chapter 6 specifically. Not sure what the remark is saying. (3)	Y	The CSER addresses this concern and no controls are necessary. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
73	<u>Table 3A-4, Item 5:</u> HNF-2229 states there is no issue, so why not simply so state here? (3)	Y	Will be corrected as part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
74	<u>Table 3A-4, Item 23:</u> Reference to item 19 vs 18 should be used under "Accident". (3)	Y	Will be corrected as part of the development of the upgraded FSAR, a hazards, baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
75	<u>Table 3A-4, Item 26:</u> Verify that safety assessment confirmed decapping station is within envelop of equipment drops evaluated for construction and operations as reflected in the remarks. (3)	Y	This is covered by HNF-2229. This will be corrected as part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
76	Table 3A-4, Item 28: Don't see the connection to Question 19. It should probably be 20. (3)	Y	Yes, it should be item 20. This will be corrected as part of the development of the upgraded FSAR. A hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-5: Comments below refer to table entries that have been sequentially numbered.			
77	Item 4: Could find no mention of combustion-safe fan spec in WHC-S-0461. Verify if this is covered in fan spec. (3)	Y	The facility modification specification for this equipment requires a spark proof fan motor.	C
	Chapter 4, "Safety Structures, Systems, and Components":			
78	Page 4-1: Section 4.3: The criteria for safety class of SSCs is not in compliance with DOE Order 6430.1A as it is limited to radiological exposure and criticality but does not include other hazardous material exposure or adverse affects to the environment. Revise the classification of SSCs to be consistent with DOE Order 6430.1A and DOE-STD-3009-94. (3)	Y	The criteria for safety classification and safety significant classification is defined by the governing procedure (HNF-PRO-704) which has been considered to be in compliance with DOE requirements based on approval of SARs. Concerns regarding the compliance of HNF-PRO-704 to DOE requirements need to be addressed to the responsible individuals in FDH. There are no hazardous materials associated with the FRS equipment or operation that would require any safety class or safety significant equipment.	OA
79	Page 4-2: Section 4.3.1.1: A more complete statement of safety functions should be made by adding the words "to prevent criticality" at the end of the first sentence. (2)	Y	The upgraded K Basin SAR will include recommended addition.	CA
* 80	Page 4-3: Table 4-1: All functional requirements specified by DOE Order 6430.1A. Section 1300-3, shall be listed or referenced in this table and/or in another section of this document to clearly identify compliance with these requirements. Compliance must be confirmed to DOE prior to equipment installation. (3)	Y	The safety functions and performance functions listed are all those applicable for the safety class components. A specific review of functional requirements in Section 1300-3 of 6430.1A were provided by cc:Mail during the later part of July.(Copy attached) structural components.	O/ SER
81	The Safety Class Equipment List given in Table 4-1 lists mechanical components only. As such, no TSRs have been proposed for these components. At a minimum, periodic inspections for cracks / other indication of potential mechanical failure / loss of safety function capability should be considered and specified.	Y	No TSRs or inservice inspections are necessary because of the benign environment for carbon steel and low stress from operating loads in the safety class structures.	C
* 82	Section 4.0: General Comment: Has the same DBE (design basis earthquake) been used for all equipment acceptance evaluations for both in-pool and out-of-pool locations? If not, provide justification. (3)	Y	The FRS in-basin safety class equipment was analyzed K Basin seismic event (0.2g ZPA). The seismic analysis of the super structure to account for the added loads from the manipulator support structure was analyzed consistent with the existing KBasin FSAR levels applied to the superstructure (0.12g ZPA). The FRS manipulator support structure tether system attachments were analyzed based on 0.2g ZPA, with acceleration amplifications appropriate for support structure location within the Basin.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 83	Page 4-9: Table 4-2: Provide the basis to justify why the manipulator rail stops and interlocks with the flexible transfer crane are not at least safety significant. (2)	Y	Administrative controls for criticality prevention will ensure no fuel canisters are stored in the MCO basket movement path, so a criticality caused by a failure of the interlock and un-upgraded portion of the rails becomes a double contingency event. In addition weight/height for drops of MCO baskets are within K Basin SAR Table 3-10 limits. Therefore the consequences of the accidents associated with failure of the interlocks are acceptable and they need not be safety class.	C
84	Page 4A-3: Table 4A-1: This table shall be revised as required to be in compliance with DOE Order 6430.1A and DOE-STD-3009-94. Any affected SSC classification shall be identified and documented. (3)	Y	The criteria for safety classification and safety significant classification is defined by the governing procedure (HNF-PRO-704) which has been considered to be in compliance with DOE requirements based on approval of SARs. Concerns regarding the compliance of HNF-PRO-704 to DOE requirements need to be addressed to the responsible individuals in FDH.	OA
	Chapter 5, "Derivation of TSR's":			
	Chapter 6, "Prevention of Inadvertent Criticality":			
85	General Comment: The contractor should re-examine the potential benefits of refining the criticality evaluation using more realistic assumptions than those used in HNF-SD-SNF-CSER-010. "Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject". The possibility of reducing operational restrictions imposed by criticality limits or eliminating the need for safety class controls on some equipment could increase operational flexibility, reduce cost, and shorten the time needed to accomplish fuel retrieval operations.	Y	The standard NRC and DOE criticality evaluation requirements and guidance have been followed. Several independent reviews by criticality experts concluded the analysis is appropriately conservative.	C
* 86	p. 6-1. No reference is given to the Nuclear Criticality Safety requirements given in section 3.4.2 of HNF-S-0461. No reference is provided as to how each of those requirements has been met. The Design Authority for FRS acknowledged this as a legitimate comment, but said that in fact a thorough systems engineering analysis has been performed to assure these and other design requirements have been satisfied. Please provide a reference which documents that analysis.	Y	HNF-S-0461 is nor referenced by the CSER or Chapter 6, however it is referenced by the SAD. The basic requirement of HNF-S-0461 is to comply with the WHC Criticality Safety Manual. The WHC manual was replaced by the HNF-PROs. The criticality analysis and design requirements reflect to the requirements of the WHC Criticality manual and the HNF-PROs. The systematic reviews mentioned by the Design Authority are discussed in the CSER and the SAD. The SAD references are appropriate.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
87	**Section 6.0: General Comment:** There is a need to strengthen this section to more clearly demonstrate compliance with applicable requirements for prevention of inadvertent criticality Examples are: • Provide reference of specific analysis in the CSER covering the last 3 process table limits (ramp, south loading area, and basket loading area). • Clarify how the 150 Kg scrap limit is to be verified. • Clarify how we are going to prevent mixing/confusing/violating the 2 separate limits between the south loading area and the table ramp. • Describe what is keeping the 34 FE's from rolling down the ramp into the loading area. • Clarify "process table MCO basket loading area" limit. Do we mean 3 baskets in the basket stand on the south end of the table, or 3 baskets period?	Y	o The specific analysis for all the limits is covered in the CSER which is referenced. o How the 150 kg limit is verified is an operational implementation detail. Basically, it is expected that the PCM will likely be inspected and cleaned out following each use, but the strict limit is defined as 150 kg. o Since only fuel assemblies and piece of assemblies will be handled in this area - the limits were based on what would fit in a single layer. This limit was originally specified as a single layer, but Operations preferred a specific number of elements. Therefore, as long as the element are not sitting on top of each other, the limit is met. o There is a lip which stops the assemblies from rolling onto the loading area, but even if all the assemblies were to roll into the loading area, this is well within analyzed fuel loading conditions and presents no problem from a criticality perspective. o The limit is that a fully loaded MCO basket may be in each of the 3 loading areas designed to hold a MCO basket. This includes one at the north end and two at the south end of the table. The other areas at the south end of the table are for test weights. This will be clarified in the upgraded FSAR.	CA
88	<u>Page 6-5:</u> top of page: Not all of the limits identified in Appendix 6A are included in Section 6.1.4 e.g. limit 14 is missing. (3)	Y	Limit 14 was unintentionally deleted from the list in Chapter 6, which was cut and pasted from Appendix 6. This will be corrected as appropriate in the FSAR (the presentation form may be different in the FSAR, but all limits will be included).	CA
89	**Section 6A:** The term K limit should include a clear statement of when K (eff.) of 0.95 as required by DB-003 is applied.	Y	The NRC equivalency is not applicable to FRS. The reference to FRS in DB-003 is fuel removal not fuel retrieval. Which limit applies where will be clear when all the sub-projects are included in the FSAR	CA
	Chapter 7, "Radiation Protection"			
90	**7.0 Radiation Protection:** The ALARA assessment, although referenced in this section, provides information which should be summarized as appropriate and included in the K Basin SAR in the Radiation Protection and/or Facility Description Chapters in accordance with 5480.23. General questions raised during the SAD review that should be answered in the ALARA assessment include: the effect of FRS equipment maintenance, decon, space requirements, containment tents, and remote maintenance facility requirements.	Y	The Fuel Retrieval System ALARA Assessment, SNF-FRS-RPT-12, does include discussions on equipment maintenance, decontamination, etc or refers to supporting studies that discuss these considerations in sections 10.0 and 13.0. Section 7.0 of the FRS SAD does provide a summary of the findings in the ALARA Assessment. More detail would not be appropriate in a safety analysis document.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
91	7.0 Krypton should not be a significant problem since the fission yield is low and the gamma yield is insignificant. Justifications for the canister decapping exhaust system are not provided and are requested.	Y	Accumulation of canister gases, including hydrogen and krypton was identified as a potential ALARA concern, as such, the exhaust system was designed and installed to minimize gas buildup in area below grating where decapping will occur.	C
92	The Specification for Design of the SNF Project Fuel Retrieval Subproject, WHC-S-0461 is twice as conservative as 10CFR835 with regard to neutron quality factor. However, this conservatism does not have any significant does consequences for the SNF Project due to the low neutron doses expected to personnel. It is not expected to affect the system cost. The requirement of 10CFR835.2 Quality Factor (I) is: "The quality factors to be used for determining does equivalent in rem are shown below: ... Neutrons, > 10 keV --- 10..." The statement in WHC-S-0461, Section 3.4.3 is: "A neutron quality factor of 20 ... should be used for design purposes." Therefore, WHC-S-0461 is twice as conservative as 10CFR835, but this conservatism should not have any significant effect on the SNF Project.	N	Agree that 10CFR835 specifies a quality factor of 10 for neutrons of unknown energy and agree that project costs not increased.	C
	Chapter 10, "Initial Testing, ... and Maintenance":			
93	5480.23, Att. 1, 3.a.(1).(a).6 states that SARs must: - Include a critical evaluation of the proposed design, operation, and test program to assess conformance with safety design objectives and verify the projections of the residual risks. - In addition, inservice inspection and maintenance for FRS needs to be specified. Chapter 10 in the current SAD focuses on the scope of installation testing, and lists examples of system functional testing, but not testing of the safety class / safety significant safety functions. The final modification to the K Basins SAR incorporating this safety analysis information must address this testing.	Y	All of the safety class equipment is passive structural equipment. There are no safety related tests, maintenance or inservice inspection requirements.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
94	Specific additional measures to enhance the reliability of the hoists and handling equipment (with intent to prevent drops) were not specified, as requested by DOE Ltr 98-SFD-026. Specifically: • control on maintenance so that corrective preventative maintenance is completed as req'd to maintain the equipment per vendor (and safety) specs; • testing of the handling equipment on prescribed intervals. • formal training & qualification of operations staff on the handling equipment (maybe incl in Chapter 12). Specify the measures requested in 98-SFD-026 in the final SAR. In addition, significant recommendations such as recommendation 3 in HNF-SD-CN-009, page D-14, need to be included in the final SAR. (3)	Y	Programmatic controls to be applied to K Basin lift control program are beyond the scope of this SAD. DESH-9852032A R1 identifies the FSAR commitlments that will be included in the K Basin FSAR regarding this area. The FRS design considered the request from DOE concerning hoists and load handling equipment design. The DESH response to this request is documented in FDH-9761261, Safety Classification of Cranes and Handling Equipment. The FRS load handling equipment was determined to be general service. Recommendation 3 is beyond the scope of the SAR, but should be included in the Design Bases Document for the Fuel Handling System (ie - the recommendation is to evaluate the effects of fatigue for some higher stressed components IF longer term usage of these devices contemplated). This has been referred to the Design Authority.	O/ SER
	Chapter 11, "Operational Safety":			
95	The operational Safety section of the K Basin SAR must include a description of the program to assure systematic identification and incorporation of the various operational commitments of the FRS SAD. A table listing all the various special operational commitments in the SAD is suggested.	Y	As addressed in response to comment 90 this is detail that is beyond the scope of the SAD or SAR. FRS activities will be governed by the K Basin Operational Safety program.	OA
	Chapter 16, "Provisions for D&D":			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 96	General Comment: Section 16 does not fully comply with the guidance and expectations contained in DOE Order 5480.23, attachment 1 for the contents of this section. It is critical that this compliance be demonstrated now, prior to equipment installation. This would also include considerations for disposal of hydraulic fluids and other hazardous materials, as applicable to the FRS. (3)	Y	The FRS design addresses the issues of maintenance (see response to #4) and D&D. Specifically in the area of D&D, the FRS has included special features to facilitate eventual decommissioning of in basin equipment: * Long length items are limited, to the extent practical, to 8' lengths or can be easily cut to 8' lengths. * Surface finishes and/coatings have been specified to facilitate decontamination. * All enclosed areas have low point drain holes to avoid hold up of liquids. * Modular design has been employed to facilitate eventual disposal. * Remote handling features have been included in the design to allow disassembly in place.	C
	REFERENCES			
97	<u>General:</u> Draft supporting documents should not be referenced in safety documents per RLIP 5480.83. Please indicate when the draft supporting documents listed in Table ES-4 and ES-5 will be finalized, and if any delays may affect the conclusions summarizes in the SAD.	Y	The analysis for FRS in the upgraded K Basin SAR will be based on approved support documentation.	CA
	Following comments on cited reference documents are provided:			
	HNF-SD-SNF-CN-009:			
98	<u>Page G-8 and G-28:</u> States that calculation results have not been incorporated into the final design. Confirm that calculation results have been incorporated into the final design. (3)	Y	The status of the design and the calculational results will be addressed during the FSAR update to confirm final results are incorporated.	CA
	HNF-2229:			
* 99	<u>Page P-1:</u> Appendix 'P': Cover sheet states that weight calculations require as built weight verification. No evidence is indicated that this has been performed. Since this is critical to drop analysis results, this verification must be performed prior to equipment installation. Provide how this will be assured or evidence that it has been performed. (3)	Y	Weights of components covered by Appendix P will be verified prior to rigging over the basin.	C
	HNF-SD-SNF-CSER-010:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
100	Page 7: Limit 8: Justify that the mass values used in the analysis bound the maximum possible mass that could be contained in a canister such that the use of "one canister" is an acceptable limit for the PCM. (3)	Y	The analysis supporting Limit 8 addressed all the bounding combinations of mass allowed in canisters based on the mass limits from the existing FSAR. See Table 4.3 of the CSER.	OA
101	Page 22: Table 2.6: General Comment: The design features listed here do not read the same (ver batim, as they should) as Table 4.1 or 6.3 or Section 3.4.2.5.5 in the SAD. eg, Primary Clean Machine states "SC bottom and supports" is not the same as (from 3.4.2.5.5) "PCM lower half". The entire lower half of the PCM would seem (to me) a much larger section of the machine than just its bottom. Also, the supports must be SC and this may/may not be the same as the lower half. It should be crystal clear to everyone precisely and exactly what must be SC.	N	Agree. this will be fixed in the FSAR.	CA

DON'T SAY IT --- *Write It!*

DATE: August 26, 1998

TO: Robert M. Hiegel

FROM: Robert G. Morgan — R Ellis for Robert Morgan

Telephone: 373-9451

cc:
R.L. Besser R3-26
G. Baston R3-82
R.G. Holt S7-41
S.H. Peck X3-75

SUBJECT: Responses to Independent Review Panel (IRP) comments on Fuel Retrieval Subproject (FRS) Safety Analysis Document (SAD), HNF-2032.

Attached, please find the responses to the comments provided by the IRP in their memo concerning the FRS SAD, dated July 14, 1998. If you have any questions, please contact Steve H. Peck at 372-3641.

INDEPENDENT REVIEW PANEL (IRP) COMMENTS
ON FUEL RETRIEVAL SUBPROJECT (FRS)
SAFETY ANALYSIS DOCUMENT (SAD), HNF-2032, Rev. 0

1. This SAD does not cover the role and use of the FRS in the process of installing loaded baskets into the Multi-Canister Overpacks (MCOs). The IRP desires an explanation of where and how that installation process and its safety evaluation will be addressed. The IRP has two specific comments or questions that arise from the lack of coverage of that installation process in the present FRS SAD.

Response: *Loading of MCO baskets and load out of the Cask/MCO is covered by the Cask Loading System (CLS) SAD.*

a) In Section 2.5.1.7, on page 2-10, the description of the grapples for both the empty and the loaded MCO baskets describe attachments which enter the central tube of the MCO basket and use a center rod to press latching balls outward into grooves on the inner diameter of the basket's central tube. It is not clear how this equipment can be used to load the basket into the MCO, since the basket's central tube must engage the central tube of the MCO. Please clarify how the MCO will be loaded and the use of FRS tools and equipment in that process.

Response: *The FRS MCO stiffback grapple is used to initially move the MCO baskets from the FRS MCO basket queue to the MCO Loading System shuttle cart, which is located in the transfer channel of the loadout pit. Loading of the MCO baskets from the cart into the MCO is accomplished with a MCO loading machine, which has a similar grapple attachment.*

The MCO central tube is attached to the MCO lid and is placed in the MCO with the MCO lid after the CMO baskets have been loaded, so there is no interference problem with the grapple.

The CLS SAD will provide more details of the loading process.

b) In Section 6.0, a requirement of maintaining k_{eff} less than or equal to 0.98 is stated as the basis for preventing inadvertent criticality. The IRP understands that the 0.98 value applies for FRS and K Basin operations. However, additional NRC Requirement 27 of HNF-SD-SNF-DB-003, Rev. 3, states: "Incorporate a criticality safety value of 0.95 for k_{eff}. (This requirement applies at the point where the spent fuel, in an MCO basket, is placed in an MCO.)" The IRP wishes to review the document in which the criticality analysis for spent fuel placement in MCO baskets is provided to satisfy additional NRC Requirement 27. Further, that document should be referenced and discussed in the FRS SAD in the context of satisfying the NRC equivalency requirement. Is that document the *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject*, HNF-SD-SNF-CSER-010, FDNW, 1998, or the *Criticality Safety Evaluation Report for Spent Nuclear Fuel Processing and Storage Facilities*, HNF-SD-SNF-CSER-005, Rev. 3, Schwinkendorf, 1997?

Response: *Application of NRC equivalent k_{eff} is covered by the CSER for the CLS system, HNF-2151. The NRC equivalency requirements apply when the spent fuel is placed in the*

MCO; this is covered in the CLS SAD. The 0.95 K_{eff} will be properly addressed in the revision of the K Basin FSAR.

2. The acceptance criteria for the completion of cleaning and inspection of the spent nuclear fuel are not provided or discussed in this SAD. The acceptance criteria for the cleanliness of SNF placed in the MCOs, including the amount of aluminum hydroxide film on some K West elements, provide the basis for the parameters selected for the safety case for cold vacuum drying and interim storage of the MCOs. Therefore, the IRP wishes to review the acceptance criteria and its associated safety analyses. The IRP has two specific comments and questions from which this overall comment derives.

Response: *The current fuel cleanliness requirements are discussed in Chapter 5 of the FRS SAD. Since there are no FRS equipment or operation accidents associated with fuel cleanliness, any fuel cleanliness, any fuel cleanliness requirements resulting from down stream facility safety requirements will be implemented as operational controls. The present safety analysis has not defined any critical cleanliness requirements that would result in the implementation of specified controls.*

See response for 2.a and 2.b for more details.

a) In Sections 2.5.2.3, on page 2-14, and 2.5.2.5, on page 2-15, no acceptance criteria for the completion of cleaning with the Primary Clean Machine (PCM), for the need to conduct inspections at the fuel element disassembler station, or for the satisfactory completion of such inspections are given. Table 5-1, on page 5-1, summarizes the fuel inspection criteria for fuel retrieval operations and refers to two documents for requirements. Those documents are: (1) *Spent Nuclear Fuel Project Product Specification*, HNF-SD-SNF-OCD-001, Rev. 2, Pajunen and Sederburg, FDH, 1998; and (2) *Fuel Retrieval System Process Validation Plan*, HNF-SD-SNF-PAP-003, Rev. 0, Shen, DESH, 1997. The IRP wishes to review those two documents and any others that contain the FRS cleaning and inspection acceptance criteria.

Response: *The acceptance criteria for fuel cleanliness are defined in HNF-SD-SNF-OCD-001, Rev. 2 as stated in Chapter 5. The FRS validation plan based on the current requirements is defined in HNF-SD-SNF-PAP-003, Rev. 0.*

HNF-SD-SNF-OCD-001 is to be revised by 10/30/98.

b) In Section 2.5.2.3, on page 2-13, the primary cleaning system appears to reflect the assumption that there will not be separate cleaning to remove the aluminum hydroxide film expected on some K West fuel elements. The only option, as stated on page 2-15, is to clean in the secondary station "using long-handled tools." The SNF Project intentions and planning regarding the FRS and aluminum hydroxide deposits should be confirmed, and the documents that contain the necessary information should be provided to the IRP. The IRP understands that such information may be included in the latest revisions of HNF-1523 and -1527, which are already being sent, per the presentations on July 8. The IRP wishes to review the revisions to HNF-1523 and -1527 that are expected based on final testing to determine the amount of aluminum hydroxide on K West fuel. We also wish to review the latest revisions of FM/97-113 and CN-017, which define the scrap and fuel surface area that will be the bases for safety analyses.

Response: *HNF-1523 and HNF-1527, which provide the basis for aluminum hydroxide, have been provided to the IRP. These documents are to be revised by 9/30/98. These documents do not define any requirements for cleaning aluminum hydroxide from the fuel and as such no additional requirements have been placed on the FRS equipment. Closure of the aluminum hydroxide issue is expected to be captured in the revisions to HNF-1523 and HNF-1527.*

3. In Section 3.0 and Appendix 3A, the hazard evaluation documented appears to be thorough and comprehensive, worthy of compliment. The IRP has the following comments.

a) In Section 3.4.2.1, on page 3-17, the scrap basket over-lift and fire is confusing. It is presented and analyzed as a design-basis accident rather than a beyond-design-basis accident, even though "it is physically impossible." The safety rationale should be clarified.

Response: *This accident is physically impossible when the MCO stiffback grapple is used. The stiffback grapple is lifted from the top of the grapple, so provided the grapple is of sufficient length (and the design isn't changed such that the MCO basket could be lifted higher due to a hoist failure) this accident is physically impossible. A different lifting mechanism design could result in overlift of the basket due to hoist failure. The contractor kept is as a design basis accident since the consequences of that event were unacceptable and it was necessary to have a safety class engineered design feature to preclude the event. This event will be clarified in the FSAR.*

b) There is unfounded precision reflected in the calculated dose consequences given in Table 3-10, on page 3-23, with results given to three significant figures. This simple plume model is applied to releases of respirable particles from a fire within the building to receptors outside the building, even at some distance. At most one might say that this is an attempt at showing that the bounding dose at 100 meters is roughly the same as the Guideline Value.

Response: *Your comment is correct, however, since the results are conservative and the guidelines are conservative, the conclusion is still appropriate, i.e., no safety class or safety significant equipment is required to mitigate this event. The defense in depth telescoping stiffback provides adequate protection.*

4. On page 2-14, in the fourth paragraph, what debris of "nonreactor-origin" is being separated here, apparently in a low-level waste stream? How is the cleaning assurance called for in the last sentence to be provided?

Response: *During the course of storage of the fuel, items have been dropped into the open canisters. This type of material and the empty canisters are the type of materials that will be handled as debris.*

The detailed methods that will be employed to check for tramp SNF in the debris have not been developed yet.

5. In Section 2.5.2.6, on page 2-16, it appears that the submerged weight of the loaded basket is being measured with the installed load cell. There is not an exact figure for the volume of the loaded material, so an exact weight is not obtained. What is the purpose of this weight measurement?

Response: *There are two reasons to weigh the fuel – to establish the amount of fuel in the MCO basket for accountability purposes and to assure the criticality mass limits are not exceeded. Exact weights are not required.*

6. The IRP wishes to review the report, *K Basin Fuel Ignition Issues,* HNF-1894, DESH, 1997, which deals with fuel ignition experience in France, as discussed in Section 3 4.2.3.1, on page 3-23.

Response: *In response to the issue contained in HNF-1894, another analysis has been performed to address fuel flashes. This document, HNF-2786, "Assessment of the Potential for Rapid Ignition of Submerged N Reactor Fuel," is in the review and approval process.*

7. In Section 4.0, safety-class systems, structures, and components (SSCs) are identified. Since the NRC's important-to-safety criteria are not applied to the FRS, per item 29 of the Additional NRC Requirements document, HNF-SD-SNF-DB-003, Rev. 3, the IRP will not comment on the SSCs selected in the FRS SAD.

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