105KW Facility Documented Safety Analysis

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

ch2m
P.O. Box 1600
Richland, Washington 99352

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Further Dissemination Unlimited
105KW Facility Documented Safety Analysis

B. D. Oberg
CH2M HILL Plateau Remediation Company

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September 2017

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105KW Facility
Documented Safety Analysis

Prepared by:

CH2M HILL Plateau Remediation Company
Richland, Washington

August 2017
Executive Summary

ES.1 Facility Background and Mission

The 105-K West Facility (105KW Facility) is located on the south bank of the Columbia River near the north end of the Hanford Site in southeastern Washington State. For the purposes of the safety basis, the 105KW Facility consists of the 105-K West Basin (105KW Basin) and the 105-K West Basin Annex (105KW Annex).

The original K Basins, built in the early 1950s, were two large basins for underwater storage of irradiated fuel produced by the K Reactors. The K Basins stored a large quantity of N Reactor spent nuclear fuel (SNF), which had been deteriorating for many years. A small amount of single-pass reactor fuel was also stored in the basins. The fuel from the K Basins has been removed, packaged in multi-canister overpacks, and shipped to the Canister Storage Building (CSB) for interim storage. The 105-K East Basin has been demolished. As 105KW Basin clean-out activities continue, it is anticipated that at most small quantities of fuel fragments may be found. The last fuel shipment was sent to CSB in 2012. The SNF Project has subsequently been encompassed by the K Basin Operations & Plateau Remediation (KBO&PR) Project.

The purpose of this Documented Safety Analysis (DSA) is to provide the basis for authorization of remaining 105KW Facility operations, 105KW Basin Pre-Operational Acceptance Testing for sludge removal operations performed utilizing the 105KW Annex, and Decontamination and Decommissioning (D&D) activities. The scope of this report includes operating and support structures and equipment required for the Sludge Treatment Project Engineered Container Retrieval and Transfer System (ECRTS) operations, storing the sludge and fuel fragments, and limited scope D&D activities.

The information contained in this DSA is based on the As-Built design information as of April 2017, as documented in the Construction Completion Documents attached to letter CHPRC-1701904. The quantity of material at risk is accurate for the facility at the end of Fiscal Year 2016. The radionuclide composition is decay-corrected to August 1, 2018.

DOE-STD-3009-94\(^1\) has been used as the 10 CFR 830\(^2\) “safe harbor methodology” for the development of this DSA. All appropriate topics from DOE-STD-3009-94 are addressed, including descriptions of site and facility design, hazard and accident analyses, safety-class and safety-significant equipment, derivation of TSRs, prevention of inadvertent criticality, and other areas of facility design and operational programs.

---


ES.2 Facility Overview

The 100K Area is located on the south bank of the Columbia River near Kilometer 616 (Mile 383). The two original reactors were graphite-moderated, plutonium-producing reactors using once-through cooling. Each reactor was provided with a large water system that provided the once-through coolant. The system included a pump house, filtration plant, clearwell, and combined outfall. Each reactor was provided with a large basin for underwater storage of irradiated fuel.

The 105-K West Reactor (105KW Reactor) was shut down in February 1970. The stored fuel, except for a few loose pieces, was shipped to the 200 East Area for processing. The storage basin was then idle, but was kept filled with water. The area water system was shut down, except for a small portion that was periodically activated to provide a reservoir of water for sanitary and fire protection systems, process water for other activities, and make-up water for the fuel storage basin.

The 105KW Basin was modified to store N Reactor fuel and was placed in service in February 1981. The basic design requirements were as follows:

- Store irradiated N Reactor fuel for 20 years
- Limit radioactive releases to the environment to within established limits
- Protect personnel from undue physical and radiological hazards during normal or abnormal operation of the facility and related equipment

The currently operating 100K facilities consist of the 105KW Basin, 105KW Annex, and related facilities located in the 100K Area. The Sludge Treatment Project is responsible for the general area within the fence surrounding the 100K Area and the physical facilities/buildings.

Other facilities/buildings at the 100K Area under the responsibility of the KBO&PR Project include deactivation, decommissioning, decontamination, and demolition (D4) activities. Ongoing D4 activities at the 100K Area are planned and conducted so that they do not have an adverse effect on the safety of the 105KW Facility.

ES.3 Facility Hazard Categorization

The 105KW Basin is a Hazard Category (HC)-2 facility. The hazard categorization is documented in Section 3.3.2.2. For the purposes of facility hazard categorization, the 105KW Basin and the 105KW Annex are considered a single facility (i.e., the hazard categorization does not rely upon segmentation of facility hazards). The 105KW Basin is an HC-2 facility based on the total radionuclide inventory of all six engineered containers. The hazard categorization also provides an evaluation for a single Sludge Transport and Storage Container (STSC), based on the worst-case STSC safety basis sludge inventory. These calculations show that the radionuclide inventory for a single STSC exceeds HC-2 threshold quantities.
ES.4 Safety Analysis Overview

The scope of the hazard analysis includes all 105KW Basin operations for storing sludge and fuel fragments in the 105KW Basin, 105KW Basin Pre-Operational Acceptance Testing for sludge removal operations performed utilizing the 105KW Annex, actual sludge removal operations, and some D4 activities. Appropriate hazard analysis processes are used to systematically and thoroughly review the 105KW Basin/105KW Annex equipment design and operations activities to identify hazard sources, hazardous conditions, potential accident scenarios and their initiators, and preliminary assessments of event consequences. Hazards are identified by form and location, and represent a complete spectrum of events that could occur throughout the facility.

The hazards analysis considers accidental criticality and releases of radioactive and hazardous material under normal and accident conditions and qualitatively assigns consequences. Higher consequence events are selected from the hazard analysis for accident analysis.

In the accident analysis, the unmitigated onsite and offsite radiological dose and toxicological consequences for the releases are calculated. The unmitigated consequences are compared with the evaluation guidelines to establish the need for safety-class or safety-significant structures, systems, and components to either prevent or mitigate the consequences. These accidents are presented in detail in Section 3.4. Each DBA analyzed represents a bounding case for a category of hazards and accidents. Accident consequences were quantitatively calculated for the collocated worker and offsite public, and qualitatively estimated for the facility worker.

Table ES-1 lists the DBAs and unmitigated consequences associated with the 105KW Facility operation.

<table>
<thead>
<tr>
<th>Section/Accident—Description Summary</th>
<th>Unmitigated Consequences (rem) (CEDE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Facility Worker</td>
</tr>
<tr>
<td>3.4.2.1 Operational Accident—ECRTS Spray Releases - The bounding spray release occurs during sludge retrieval and transfer of Settler Tank sludge from Engineered Container SCS-CON-230 to an STSC.</td>
<td>70-90</td>
</tr>
<tr>
<td>3.4.2.2 Operational Accident—STSC Hydrogen Explosion - A stoichiometric mixture of hydrogen and air is ignited in the STSC headspace.</td>
<td>&lt; 15</td>
</tr>
<tr>
<td>3.4.2.3 Operational Accident—Process Enclosure Explosion - A stoichiometric mixture of hydrogen and air is ignited in the TLSB.</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>3.4.2.4 Operational Accident—STSC Over-Pressurization Release - An over-pressurized STSC component or weld fails. Sludge entrained by the flowing gas is carried out of the STSC at the failure location.</td>
<td>&lt; 30</td>
</tr>
</tbody>
</table>
Table ES-1. Design Basis Accident/Event Summary

<table>
<thead>
<tr>
<th>Section/Accident—Description Summary</th>
<th>Unmitigated Consequences (rem) (CEDE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Facility Worker(^a)</td>
</tr>
<tr>
<td>3.4.2.5 Operational Accident–105KW Annex Fire - A fire has the potential to result in a breach of primary containment, causing a spray release of slurry, or to fail the Process/Exhaust Ventilation System resulting in an accumulation of flammable concentrations of hydrogen and the associated potential for a hydrogen explosion.</td>
<td>Spray Release</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.6 Natural Phenomenon–Seismic Event</td>
<td>Spray Release - The seismic spray release is assumed to involve the entire mass of SCS-CON-230 Settler Tank sludge above the level of the container egg crate sections, plus one egg crate section (i.e., the section containing the XAGO).</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.7 Natural Phenomenon–High Winds</td>
<td>Spray Release - The high wind spray release uses atmospheric dispersions associated with higher wind speeds.</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.8 Natural Phenomenon–Snow and Ashfall - Snow or Ashfall could cause structural damage to the 105KW Annex that would result in a breach of primary containment, causing a spray release of slurry. It could also lead to a hydrogen explosion in an STSC.</td>
<td>Spray Release</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.9 Natural Phenomenon–Lightning Strike - A lightning strike could result in a fire, spray release, or hydrogen explosion.</td>
<td>Spray Release</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.10 Natural Phenomenon–Low Temperatures - The bounding accident associated with low temperatures is the operational spray release.</td>
<td>Spray Release</td>
</tr>
<tr>
<td>3.4.2.11 External Events–Vehicle Impact - A vehicle impact could result in a fire, spray release, or hydrogen explosion</td>
<td>Spray Release</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
<tr>
<td>3.4.2.12 External Events–Range Fire - The bounding accidents associated with range fires are the operational spray release and the hydrogen explosion.</td>
<td>Spray Release</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Explosion</td>
</tr>
</tbody>
</table>
Table ES-1. Design Basis Accident/Event Summary

<table>
<thead>
<tr>
<th>Section/Accident—Description Summary</th>
<th>Unmitigated Consequences (rem) (CEDE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Facility Worker&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>3.4.2.13 Criticality - A criticality accident is judged to not be credible&lt;sup&gt;b&lt;/sup&gt;</td>
<td>None calculated.</td>
</tr>
</tbody>
</table>

Notes:

a. Facility worker consequences are qualitatively estimated.

CEDE committed effective dose equivalent
ECRTS Engineered Container Retrieval and Transfer System
STSC Sludge Transport and Storage Container
TLSB Transfer Line Service Box
XAGO XAGO retrieval tool

Based on the consequences presented in Table E-1, no safety class controls are required. Safety-significant controls are required for spray releases during sludge retrieval and transfer for facility worker protection. Although the radiological and toxicological consequences of a hydrogen explosion and STSC/Sludge Transport System (STS) Cask over-pressurization are below guidelines, safety-significant controls are required due to the potential for facility worker serious injury or death.

Administrative controls necessary to ensure safety are documented in PRC-STP-00992<sup>3</sup>. Administrative controls are implemented through operating procedures that refer to the TSRs as appropriate.

The safety-significant engineered features relied on in the facility safety basis are described and tabulated in Section 4.4 and include the following:

- “Above-Water Slurry Transfer Lines” (Section 4.4.1)
- “Slurry Transfer Line Rupture Disk” (Section 4.4.2)
- “Double-Valve Isolation” (Section 4.4.3)
- “Seismic Shutdown Switches” (Section 4.4.4)
- “Safety Shutdown Interlock I-1” (Section 4.4.5)
- “Auxiliary Ventilation System” (Section 4.4.6)
- “Oxygen Analyzer” (Section 4.4.7)
- “Sludge Transport and Storage Container and Transport Vent Assemblies” (Section 4.4.8)
- “Sludge Transport System Cask Pressure Boundary, STS Cask Vent Tool, and STS Pressurization Check Tool” (Section 4.4.9)

• “Sludge Transport System Cask Pressure Indicator” (Section 4.4.10)
• “Sludge Transport System Cask Leak Tester” (Section 4.4.11)
• “Sludge Quantity Instrumentation” (Section 4.4.12)
• “105KW Annex and Other Structures and Components” (Section 4.4.13)
• “SCS-CON-230 Divider Plate” (Section 4.4.14)
• “Hoist Chain Stops” (Section 4.4.15)

ES.5 Organizations
CH2M HILL Plateau Remediation Company is responsible to the U.S. Department of Energy (DOE) for planning, integration, and management of the 100K Area activities, including programs, projects, and operations. Organizational responsibilities related to 100K Area operations are summarized in Chapter 17.0 as they relate to the 105KW Facility.

ES.6 Safety Analysis Conclusions
This DSA documents that the 105KW Facility can be operated safely with respect to workers, the public, and the environment. Formal documented hazard analyses, accident analyses, and control decisions have been performed. Safety structures, systems, and components (SSCs) and specific administrative controls (SACs), selected and classified in accordance with DOE-STD-1189-2008\(^4\) guidance, provide a comprehensive suite of preventive and mitigative controls. The controls are comprehensive in that safety SSCs and SACs have been selected for each identified hazardous condition with the potential to exceed guidelines and thus address all identified initiators and accident sequences.

ES.7 DSA Organization
The 105KW Facility DSA is based on the format and content guidance of DOE-STD-3009-94. The DSA is compliant with 10 CFR 830\(^5\).

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# Terms

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<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>105KE Reactor</td>
<td>105-K East Reactor</td>
</tr>
<tr>
<td>105KW Annex</td>
<td>105-K West Basin Annex</td>
</tr>
<tr>
<td>105KW Basin</td>
<td>105-K West Basin</td>
</tr>
<tr>
<td>105KW Facility</td>
<td>105-K West Facility (consisting of the 105KW Basin and 105KW Annex)</td>
</tr>
<tr>
<td>105KW Reactor</td>
<td>105-K West Reactor</td>
</tr>
<tr>
<td>200E</td>
<td>200 East</td>
</tr>
<tr>
<td>AC</td>
<td>administrative control</td>
</tr>
<tr>
<td>AED</td>
<td>aerodynamic equivalent diameter</td>
</tr>
<tr>
<td>AEGL</td>
<td>Acute Exposure Guideline Level</td>
</tr>
<tr>
<td>ALARA</td>
<td>as low as reasonably achievable</td>
</tr>
<tr>
<td>AOV</td>
<td>air-operated valve</td>
</tr>
<tr>
<td>ARF</td>
<td>airborne release fraction</td>
</tr>
<tr>
<td>ARR</td>
<td>airborne release rate</td>
</tr>
<tr>
<td>ASME®</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>BDBA</td>
<td>beyond design basis accident</td>
</tr>
<tr>
<td>BPA</td>
<td>Bonneville Power Administration</td>
</tr>
<tr>
<td>BPVC</td>
<td>Boiler and Pressure Vessel Code</td>
</tr>
<tr>
<td>BR</td>
<td>breathing rate</td>
</tr>
<tr>
<td>BRC</td>
<td>Basin Recirculation Cooling and Cleanup</td>
</tr>
<tr>
<td>CAM</td>
<td>continuous air monitor</td>
</tr>
<tr>
<td>CAT</td>
<td>Construction Acceptance Testing</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</td>
</tr>
<tr>
<td>CHPRC</td>
<td>CH2M HILL Plateau Remediation Company</td>
</tr>
<tr>
<td>CRD</td>
<td>Contractor Requirements Document</td>
</tr>
<tr>
<td>CSER</td>
<td>Criticality Safety Evaluation Report</td>
</tr>
<tr>
<td>CVDF</td>
<td>Cold Vacuum Drying Facility</td>
</tr>
<tr>
<td>D&amp;D</td>
<td>Decontamination and Decommissioning</td>
</tr>
<tr>
<td>DBA</td>
<td>design basis accident</td>
</tr>
<tr>
<td>DBE</td>
<td>design basis earthquake</td>
</tr>
<tr>
<td>DCF</td>
<td>dose conversion factor</td>
</tr>
<tr>
<td>DEP</td>
<td>dummy elevator pit</td>
</tr>
<tr>
<td>DF</td>
<td>Design Feature</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
</tr>
</tbody>
</table>

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6 ASME is a registered trademark of the American Society of Mechanical Engineers, New York, New York.
DOT U.S. Department of Transportation
DR damage ratio
DSA Documented Safety Analysis
ECRTS Engineered Container Retrieval and Transfer System
EOC Equipment Operations Center
EPDM ethylene propylene diene monomer
ERPG emergency response planning guideline
FAT Factory Acceptance Testing
FHA Fire Hazards Analysis
FM Factory Mutual (FM) Global
FMEA failure modes and effects analysis
FPSR Floor and Pit Sludge Retrieval
FRS Fuel Retrieval System
FTS Fuel Transfer System
HAZOP Hazard and Operability Analysis
HC hazard category
HEPA high-efficiency particulate air
HFD Hanford Fire Department
HFE human factors engineering
HIH hose-in-hose
HVAC heating, ventilation, and air conditioning
I&C Instrumentation and Control
IBC International Building Code®
IDLH Immediately Dangerous to Life and Health
IPOD integrated process optimization demonstration
ITS important to safety
IWTS Integrated Water Treatment System
IXM Ion Exchange Module
KE 105-K East
KOP knockout pot
KPAT 105KW Basin/Annex Pre-Operational Acceptance Testing
LCO limiting condition for operation
LFL lower flammability limit

7 FM is a registered trademark of FM Global, Johnston, Rhode Island.
8 International Building Code and IBC are registered trademarks of the International Code Council, Inc., Whittier, California.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC</td>
<td>limiting oxygen concentration</td>
</tr>
<tr>
<td>LPF</td>
<td>leak path factor</td>
</tr>
<tr>
<td>MAR</td>
<td>material at risk</td>
</tr>
<tr>
<td>MASF</td>
<td>Maintenance and Storage Facility</td>
</tr>
<tr>
<td>MCO</td>
<td>multi-canister overpack</td>
</tr>
<tr>
<td>MOI</td>
<td>maximally-exposed offsite individual</td>
</tr>
<tr>
<td>MPAT</td>
<td>Maintenance and Storage Facility Pre-Operational Testing</td>
</tr>
<tr>
<td>MPFL</td>
<td>Maximum Possible Fire Loss</td>
</tr>
<tr>
<td>N/A</td>
<td>not applicable</td>
</tr>
<tr>
<td>NEMA®</td>
<td>National Electrical Manufacturer’s Association</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>NLOP</td>
<td>north loadout pit</td>
</tr>
<tr>
<td>NPH</td>
<td>natural phenomena hazard</td>
</tr>
<tr>
<td>NR</td>
<td>not reported</td>
</tr>
<tr>
<td>NRC</td>
<td>U.S. Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>NTEP</td>
<td>National Type Evaluation Program</td>
</tr>
<tr>
<td>OAT</td>
<td>Operational Acceptance Testing</td>
</tr>
<tr>
<td>ORR</td>
<td>Operational Readiness Review</td>
</tr>
<tr>
<td>PAC</td>
<td>Protection Action Criteria</td>
</tr>
<tr>
<td>PAM</td>
<td>polyacrylamide</td>
</tr>
<tr>
<td>PAT</td>
<td>Pre-Operational Acceptance Testing</td>
</tr>
<tr>
<td>PC</td>
<td>performance category</td>
</tr>
<tr>
<td>PCM</td>
<td>primary clean machine</td>
</tr>
<tr>
<td>PLC</td>
<td>programmable logic controller</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
</tr>
<tr>
<td>QAP</td>
<td>Quality Assurance Program</td>
</tr>
<tr>
<td>RCRA</td>
<td><em>Resource Conservation and Recovery Act of 1976</em></td>
</tr>
<tr>
<td>RF</td>
<td>respirable fraction</td>
</tr>
<tr>
<td>RFAR</td>
<td>radio fire alarm reporter</td>
</tr>
<tr>
<td>RL</td>
<td>U.S. Department of Energy, Richland Operations Office</td>
</tr>
<tr>
<td>SAC</td>
<td>specific administrative control</td>
</tr>
<tr>
<td>SARAH</td>
<td>Safety Analysis and Risk Assessment Handbook</td>
</tr>
<tr>
<td>SC-3/SC-1</td>
<td>Safety-Class 3 over Safety-Class 1</td>
</tr>
<tr>
<td>SCS</td>
<td>Sludge Containerization System</td>
</tr>
</tbody>
</table>

9 NEMA is a registered trademark of the National Electrical Manufacturers Association, Rosslyn, Virginia.
SDC: seismic design category
SIH: standard industrial hazards
SIS: Safety Instrumented Systems
SKW: Skimmer Water Cleanup
SLOP: south loadout pit
SMP: Safety Management Program
SNF: Spent Nuclear Fuel
SOF: sum of fraction
SOM: Shift Operating Manager
SOV: solenoid-operated valve
SR: surveillance requirement
SSC: structure, system, and component
SSM: Segregated Settler Material
STP: Sludge Treatment Project
STS: Sludge Transport System
STSC: Sludge Transport and Storage Container
TED: total effective dose
TEEL: temporary emergency exposure limit
TLSB: Transfer Line Service Box
TNT: trinitrotoluene
TRU: transuranic
TSR: Technical Safety Requirement
TWA: time-weighted average

UHMWPE: ultra-high molecular-weight polyethylene
UL®: Underwriters Laboratories, Inc.
USGS: U.S. Geological Survey
USQ: Unreviewed Safety Question

VFD: variable frequency drive
vol%: volume percent

XAGO: XAGO retrieval tool
\( \chi/Q' \): atmospheric dispersion factor

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UL is a registered trademark of Underwriters Laboratories, Inc., Northbrook, Illinois.
Chapter 1.0

Site Characteristics
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1.0 Site Characteristics

The 105-K West Basin (105KW Basin) and the 105-K West Basin Annex (105KW Annex) are located in the 100K Area of the U.S. Department of Energy’s (DOE’s) Hanford Site. The 105KW Basin is an existing Hazard Category (HC)-2 nuclear facility, and the 105KW Annex is an HC-2 major modification to the 105KW Basin. For the purposes of the safety basis, the 105KW Basin and the 105KW Annex are known collectively as the 105K West Facility (105KW Facility). The 105KW Basin provides underwater storage for sludge remaining from the storage and processing of spent nuclear fuel (SNF) that was generated by the Hanford Site’s plutonium production reactors. The Sludge Treatment Project’s (STP’s) Engineered Container Retrieval and Transfer System (ECRTS) consists of the 105KW Annex and structures, systems, and components (SSCs) installed in both the 105KW Basin and 105KW Annex for removal of the remaining sludge. This chapter describes the characteristics of the 100K Area, and the surrounding portions of the Hanford Site.

1.1 Introduction

The geography, demography, meteorology, hydrology, geology, natural phenomena threats, and external man-made threats to the Hanford Site and 100K Area are well characterized as described in HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Programs. The specific characteristics for the 100K Area and the 105KW Facility are the focus of the text in this chapter.

1.1 Requirements

HNF-11724, Section 1.2, describes requirements associated with the Hanford Site in general. In addition to the documents and requirements identified in HNF-11724, the STP is subject to a code of record (HNF-44226, Code of Record Sludge Treatment Project Engineered Container Retrieval and Transfer System), which supersedes HNF-11724 in the case of conflict.

1.2 Site Description

The 100 Areas, on the south shore of the Columbia River, include nine retired plutonium production reactors. The areas are designated 100B/C, 100D, 100F, 100H, 100K, and 100N. The following sections address the geography, demography, and regional land and water use of the area encompassed by and surrounding the 105KW Facility in the 100K Area. See HNF-11724, Section 1.3, for a description of the Hanford Site and associated areas.

1.2.1 Geography

HNF-11724, Section 1.3.1, provides a general description of the Hanford Site geography. The location of the 100K Area on the Hanford Site is shown on Figure 1-1, and the 100K Facilities are shown on Figure 1-2.
Figure 1-1. Hanford Site Map
Figure 1-2. 100K Area
This section provides additional data that are important to the safety analyses presented in Chapter 3.0. These data are the distances to potential receptors near the point of origination of facility-specific, postulated accidents described and analyzed in Chapter 3.0. As indicated in Section 3.4.1.3, “Consequence Analysis,” two receptor locations were used to determine the consequences of accident releases to collocated workers and to the public (offsite receptors). Directions and distances to receptors used for comparison to evaluation guidelines are shown in Table 1-1.

Table 1-1. Receptor Locations for Comparison to Evaluation Guidelines

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Direction</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collocated worker</td>
<td>N/A</td>
<td>100</td>
</tr>
<tr>
<td>Site boundary</td>
<td>W</td>
<td>10,070</td>
</tr>
</tbody>
</table>

Notes:
N/A = not applicable
W = west

1.2.2 Demography

Detailed demographic information is provided for the Hanford Site in HNF-11724. As of the 2010 Census, about 580,572 people resided within 50 miles of the 100K Area (PNNL-20631, Hanford Site Regional Population - 2010 Census). The communities nearest the Hanford Site are Richland, Kennewick, Pasco, West Richland, and Benton City, all of which are located south of the site. The 50-mile radius for the 100K reference point includes the city of Yakima and several surrounding towns located west of the site. Except on the state highways and the Columbia River, only DOE-authorized workers, contractors, and visitors are permitted on the Hanford Site.

1.3 Environmental Description

The Hanford Site environmental description is provided in HNF-11724, Section 1.4. Specifics for evaluation of 100K facilities are provided in this section.

1.3.1 Meteorology

Meteorological parameters have been measured in the vicinity of the Hanford Site since 1912. The Hanford Meteorological Station became operational in December of 1944. Since 1944, additional large-scale meteorological monitoring towers have been constructed, including one in the 100N Area. The 100K Area Meteorological Station is near the northwest corner of the site.

Summaries of wind direction indicate that winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases, with a corresponding decrease in northwest flow. Monthly average wind speeds are lower in the winter, averaging 6 to 7 mph, and higher in the summer, averaging 9 to 10 mph. Wind speeds that are well above average usually are associated with southwesterly winds.
However, the summertime drainage winds are generally northwesterly and frequently reach 30 mph. These winds are most prevalent over the northern portion of the Hanford Site.

During the winter, the highest average monthly temperature was 44.5°F in February 1991, and the minimum average monthly temperature was 12.1°F in January 1950. During the summer, the record maximum monthly average temperature was 82.8°F in July 2014, and the record minimum monthly average was 63°F in June 1953. The highest temperature ever recorded at the Hanford Site was 113°F; the lowest recorded temperature was -23°F.

The annual average relative humidity is 54 percent. Humidity is highest during the winter months, averaging about 75 percent, and lowest during the summer, averaging about 35 percent. The average annual precipitation at the Hanford Site is about 6.81 in., based on 80 years of rainfall data. Most precipitation occurs during the winter, with nearly half of the annual amount occurring from November through February.

Atmospheric dispersion is a function of wind speed, duration and direction, atmospheric stability, and mixing depth. Dispersion conditions generally are good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and a deep mixing layer is present. Good dispersion conditions exist about 57 percent of the time during the summer. Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter and exist about 66 percent of the time. Occasional extended periods of poor dispersion conditions occur that are associated with stagnant air in stationary high-pressure systems (PNRL-4622, Climatological Summary for the Hanford Area). These occur primarily during the winter.

1.3.2 Hydrology

The Hanford Site is located within the Columbia River drainage basin, with the 100K Area situated along the river. The Columbia River is the principal hydrologic surface feature in the area, and the fourth largest river in the contiguous United States in terms of total flow.

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by releases from three upstream storage dams: Grand Coulee in the United States and Mica and Keenleyside in Canada. Flows in the Hanford Reach and adjacent to the 100K Area are directly affected by releases from Priest Rapids Dam, which is located approximately 12 river miles upstream of the 100K Area.

Priest Rapids is a run-of-the-river dam, which means that it normally operates with a full or nearly full reservoir and provides minimal flow control. The average flow of the Columbia River near the Priest Rapids Dam is about 116,500 ft³/s. During 1996 and 1997, and again in the spring of 2011 and 2012, exceptionally high spring runoff resulted from larger than normal snowpacks. The peak daily average flow rate during the spring of 1997 was approximately 415,000 ft³/s. The minimum flow downstream of Priest Rapids Dam is regulated by law, primarily to protect salmon spawning sites. Minimum allowable discharges above the Hanford Site are calculated to be sufficient to not impact the functioning of raw water intake structures that supply much of Hanford’s process and potable water.

Groundwater beneath the Hanford Site is found in both an upper unconfined aquifer system and deeper basalt-confined aquifers. The unconfined aquifer beneath the Hanford Site ranges from about 230 ft above mean sea level near the Columbia River, to about 476 ft above mean sea level.
along the site’s western boundary. The maximum saturated thickness of the aquifer is about 230 ft. The hydrology of the 100K Area is affected by its location adjacent to the Columbia River. The water table depth under the 100K Area was reported as about 406 ft above mean sea level in the spring of 2006 (PNNL-6415, Hanford Site National Environmental Policy Act [NEPA] Characterization).

Groundwater is monitored across the Hanford Site by a sizable network of monitoring wells. Movement of the groundwater is generally from west to east toward the Columbia River. However, during high river stage, the flow direction may reverse immediately adjacent to the river. The total rate of groundwater discharge from the aquifer to the Columbia River is in the range of 40 ft$^3$/s to 90 ft$^3$/s (DOE/RL-2010-11, Hanford Site Groundwater Monitoring and Performance Report for 2009).

A groundwater pump-and-treat project also operates at the 100K Area, to treat groundwater affected by contaminant releases from facilities and waste sites within the 100K Area. The primary contaminant of interest is hexavalent chromium, which was released to ground from the reactor cooling water treatment facilities and retention basins over several decades of operation. A tritium plume also is present under the 105KW Basin area. Seven active groundwater sampling wells are located in the immediate area of the 105KW Basin.

1.3.3 Geology

The Hanford Site is located within the Pasco Basin, which lies between the Saddle Mountains to the north and Rattlesnake Mountain to the south. The Pasco Basin is part of the Columbia Basin, a larger intermontane area located between the Cascade Range to the west and the Rocky Mountains to the east.

The Columbia River Basalt Group forms the main bedrock of the Pasco Basin and the Hanford Site. Over most of the site, the Ringold Formation overlies the Columbia River Basalt Group. This formation is a result of the evolutionary course changes of the Columbia River, driven primarily by the growth of the series of small ridges that make up the Yakima Fold Belt. Above the Ringold Formation is the Cold Creek Unit, which consists of wind-derived sediments and fine-grained stream deposits, and the Hanford formation, which consists primarily of sand- and gravel-dominated sediments deposited by a series of cataclysmic floods. The 100 Areas are located on the Wahluke syncline, an asymmetric and relatively flat-bottomed structure north of the Yakima Fold Belt structure called Gable Mountain.

Low-angle reverse faults generally occur at the base of the anticlinal folds. A few faults also cut across the folds, such as the Cold Creek and May Junction faults. Most of the current seismicity around the Hanford Site seems to be concentrated between the Saddle Mountains and Frenchman Hills, and between the Saddle Mountains and Gable Mountain-Gable Butte areas. The 100K Area lies in the area between the Saddle Mountains and Gable Mountain-Gable Butte. No evidence of surface faulting is present within the boundaries of the 100 Areas. However, the Hanford Site is within a Zone 2 seismic designation area, which implies a credible probability for moderate earthquake damage. Generally, the sand and gravel formations beneath the Hanford Site serve to attenuate the energy of an earthquake, offering significant protection against severe damage.
1.4 Natural Event Accident Initiators

HNF-11724, Section 1.5, provides a summary of Hanford Site natural event accident initiators. This section identifies the natural phenomena with potential for adverse impacts on the 105KW Facility SSCs. For each natural phenomenon accident initiator, information is presented on frequency of occurrence, magnitude, and the design considerations that reduce impacts. The natural phenomena presented in this section are floods, seismic events, wind, snow, rain, ashfall, lightning, and range fires. Hazards from other natural phenomena (e.g., surge and seiche flooding, tsunami flooding, and ice flooding) are considered not credible for the Hanford Site.

The industry codes and standards used for the design, fabrication, and procurement of safety-significant SSCs are provided in Chapter 4.0. The design codes used for general service equipment follow industry-accepted design codes and standards.

1.4.1 Floods

Large Columbia River floods have occurred in the past, but the likelihood of large-scale flooding recurring has been reduced by the construction of several flood control/water-storage dams upstream of the Hanford Site. The three primary scenarios for flooding on the Hanford Site are a breach of the Grand Coulee Dam, blockage of the Columbia River, or intense precipitation.

The maximum postulated flood scenario results from a hypothetical 50-percent breach of Grand Coulee Dam on the Columbia River, upstream from the Hanford Site. This scenario is calculated to result in an inundation of the Hanford Site with floodwaters to an elevation of about 486 ft above mean sea level, resulting in flooding of the 100, 300, and 400 Areas, and nearly all of the City of Richland.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River has been examined for an area bordering the east side of the river upstream of the City of Richland. The possible landslide area considered was the 250-ft high bluff locally known as White Bluffs. Areas inundated upstream of such a landslide event would include the 400 Area and portions of the 100F and 100H Areas. The floodwaters from this event are postulated to reach the north perimeter of the 100K Area.

Flood levels for the 100K Area, as listed in PRC-PRO-EN-097, Engineering Design and Evaluation (Natural Phenomena Hazard), are provided in Table 1-2; all measurements indicate elevation above mean sea level.

<table>
<thead>
<tr>
<th>Location</th>
<th>River Mile</th>
<th>PC-3 Flood (ft)</th>
<th>PC-2 Flood (ft)</th>
<th>PC-1 Flood (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100K Area</td>
<td>382</td>
<td>455</td>
<td>430</td>
<td>413</td>
</tr>
</tbody>
</table>

Notes:
P.C. Performance Category

The final design for the 105KW Annex indicates a finished floor elevation higher than 464 ft above mean sea level; the elevation of the existing access road is also higher than 464 ft above
mean sea level. Therefore, the PC-3 flood does not affect either the facility or access to the facility.

1.4.2 Seismic Events

The seismicity of the Columbia Plateau, as determined by the rate of earthquakes per area and the historical magnitude of these events, is relatively low compared with other regions of the Pacific Northwest, the Puget Sound, western Montana, and eastern Idaho.

The historical record of seismic activity in the area dates from about 1840. During this time, only 14 earthquakes occurred that may have been felt or were recorded at or near the 100K Area. Five of these earthquakes may have affected the site with an average peak ground acceleration of 0.015g to 0.025g or greater, which corresponds to an intensity of IV or greater on the Modified Mercalli scale. The most severe of these occurred in 1872, with a probable epicenter located near Lake Chelan. This event was estimated at an intensity of VIII on the Modified Mercalli scale, or a magnitude of 6.8 on the Richter scale. Another significant seismic event occurred in 1936 near Milton-Freewater, Oregon. This earthquake has been estimated to have had a Richter magnitude of 5.75 and a maximum intensity of VII on the Modified Mercalli scale, and was followed by a number of aftershocks indicating a northeast-trending fault plane.

Earthquakes often occur in spatial and temporal clusters in the central Columbia Plateau and are termed “earthquake swarms.” The region north and east of the Hanford Site is a region of concentrated earthquake swarm activity, but earthquake swarms also have occurred at several locations on the Hanford Site. The frequency of earthquakes in a swarm tends to gradually increase and decay with no one outstanding large event within the sequence. Roughly 90 percent of the earthquakes in swarms have Richter magnitudes of two or less. The spatial pattern of seismicity in the central Columbia Plateau suggests an association of shallow swarm activity with the east-west oriented Saddle Mountain anticline.

1.4.2.1 105KW Basin

The existing 105KW Basin structure was designed to the historical system in which SSCs of interest are placed in one of five performance categories that define the performance goals and the design criteria. This system of seismic hazard evaluation and design is based on the system provided by DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities.

The design basis earthquake (DBE) is an earthquake that is the most severe design basis accident of this type. The DBE produces the vibratory ground motion for which safety-class items are to remain functional. Additional DBE information is available in SDC-4.1, Standard Arch-Civil Design Criteria: Design Loads for Facilities. The DBE for Hanford nonreactor safety-class structures is defined as an event producing a maximum horizontal ground acceleration of 0.2g simultaneously with a vertical ground acceleration of 0.13g. The 105KW Basin pool structure was analyzed for the DBE. The DBE was also used for analyzing non-safety structures whose failure could impact and potentially damage the basin pool structure, fuel racks, and fuel canisters. The superstructure over the basin, the adjoining office, and Transfer Bay areas (WHC-SD-N031-SA-002, 105-KE/105-KW Irradiated Fuel Storage Basin Seismic Qualifications), the reactor building north wall (WHC-SD-NR-SA-024, 105-KE/105-KW Irradiated Fuel Storage Basins Seismic Qualifications), reactor building steel structure (WHC-SD-NR-DA-026, Structural
Qualifications for the 105KE/105KW K-Basin Roof Repair Designs), and reactor stacks (WHC-SD-NR-DA-025, 105 K Stack Seismic Qualification, Final Report, Phase III) were analyzed to Safety-Class 3 over Safety-Class 1 (SC-3/SC-1). The metal beam building structure over 105KW Basin was analyzed to SC-3/SC-1 criteria (WHC-SD-N031-SA-001, 105-KW Irradiated Fuel Storage Basin Roof Addition Seismic Qualification, Phase II of III). The superstructure over the Basin, the adjoining office area, and the metal beam building structure over the 105KW Basin had localized overstressed areas when analyzed to the above listed 0.2g DBE criteria. Subsequent to the analyses, the decision was made to remove SNF from the basins as soon as possible. As discussed in Section 3.4 of SDC-4.1, “If evaluation using site-specific natural phenomena hazards cannot show an existing facility to be in conformance with the acceptance criteria, then the methods for evaluating existing structures defined in UCRL-15910, Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, may be used. If an existing facility is close to meeting the guidelines, a slight increase in the annual risk to natural phenomena hazards may be allowed.”

One of the specified approaches in SDC-4.1 for permitting the higher annual risk is to allow “hazard exceedance probabilities of twice the recommended values” for seismic loads. This amounts to reducing the 5000-yr DBE to a 2500-yr DBE. For the currently-approved seismic hazard curves for the Hanford Site (WHC-SD-GN-DB-003, Natural Phenomena Hazards: The Hanford Site, Washington), this results in a reduction in the peak K Basins DBE horizontal acceleration from 0.2g to 0.12g and a corresponding reduction in vertical acceleration from 0.13g to 0.08g. Consequently, some structures were reevaluated with reduced DBE accelerations to demonstrate acceptance in HNF-SD-SNF-SA-004, Seismic Qualification of 105 K Basin Superstructure using 0.12g Earthquake Ground Acceleration, and WHC-SD-N031-SA-001.

1.4.2.2 105KW Annex and ECRTS SSCs

Formal design standards provided in PRC-PRO-EN-097 govern the seismic design of the 105KW Annex and ECRTS equipment. This technical standard presents guidelines to control the level of conservatism introduced in the seismic design process. The guidelines specify that probabilistic methods be applied to establish performance goals. The performance goals are expressed as the annual probability of exceedance of some level of facility damage from an earthquake.

The 105KW Annex and ECRTS equipment, as required by DOE-STD-1189-2008, Integration of Safety into the Design Process, are subject to the system of seismic design categories and limit states defined in ANSI/ANS-2.26-2004, Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design. Seismic design of the new structure and equipment, including seismic separation of the 105KW Annex from the existing KW structure, is in accordance with ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, as defined in PRC-PRO-EN-097 and the International Building Code.

1.4.3 Extreme Winds

The prevailing surface winds over much of the Hanford Site are from the northwest and occur most frequently during the winter and summer. In the 100 Areas and along the Columbia River, local winds are strongly influenced by the topography near the river. At the 100K (Station 29)
and 100N (Station 13) Areas, the prevailing wind direction is from the west. At the 100F Area (Station 24) and near the old Hanford townsite, winds often have a northwesterly or southeasterly component. Stations that are relatively close together can exhibit significant differences in wind patterns, which increases the importance of using wind data from the closest representative station for estimating local dispersion conditions. The locations of meteorological stations and corresponding wind roses are shown in Figure 1-3.

Figure 1-3. Hanford Meteorological Stations and Wind Rose Data
The maximum peak wind gust recorded at the Hanford Meteorological Station (Station 21) at 50 ft above ground level is 80 mph. The Hanford Site averages 156 days per year with peak wind gusts stronger than or equal to 25 mph, and 57 days with peak gusts stronger than or equal to 35 mph. Uniform design and evaluation guidelines based on these wind data were developed for protection against extreme wind hazards at Hanford Site facilities and are used to determine the design criteria for SSCs. Wind load design requirements for new, nonreactor, nuclear facilities, and associated safety SSCs are provided in PRC-PRO-EN-097, and shown in Table 1-3. Wind-driven missile criteria, if applicable, are based on a nominal 2-by-4-in. timber plank weighing 15 lb, with a maximum height trajectory of 30 ft and a maximum speed of 50 mph.

### Table 1-3. Wind Load and Wind-Driven Missile Design Criteria

<table>
<thead>
<tr>
<th>Wind speed (mph)</th>
<th>PC-3</th>
<th>PC-2</th>
<th>PC-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal missile</td>
<td>111</td>
<td>91</td>
<td>85</td>
</tr>
</tbody>
</table>

#### 1.4.4 Rain and Snow Loads

Average annual precipitation at the Hanford Meteorological Station is 6.8 in. During 1995, the wettest year on record, 12.3 in. of precipitation were measured; during 1976, the driest year, only 3 in. were measured. The wettest season on record was the winter of 1996 to 1997 with 5.4 in. of precipitation; the driest season was the summer of 1973, when only 0.03 in. of precipitation was measured. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Days with greater than 0.50 in. of precipitation occur, on average, less than once each year.

Average snowfall ranges from 0.1 in. during October to a maximum of 5.2 in. during December, and decreases to 0.5 in. during March. The record monthly snowfall of 23.4 in. occurred during January of 1950. The seasonal record snowfall of 56.1 in. occurred during the winter of 1992 to 1993. Snowfall accounts for about 38 percent of all precipitation from December through February.

Because the Hanford Site is located in a semiarid region, the rain loading is bounded by the snow loading. The 105KW Annex SSCs are designed to withstand a ground snow loading of 15 lb/ft², and a roof snow loading of 20 lb/ft² (PRC-PRO-EN-097). Unbalanced snow loads resulting from drifting or sliding also must be considered in the design.

#### 1.4.5 Ashfall Loads

The Hanford Site is located in a region subject to ashfall from volcanic eruptions. The three major volcanic peaks closest to the site are Mount Adams, about 100 mi to the west; Mount Rainier, about 110 mi to the west-northwest; and Mount St. Helens, about 130 mi to the west. Important historical ashfalls affecting this location were from eruptions of Glacier Peak (located about 210 mi northwest of the Hanford Site) about 12,000 years ago; Mount Mazama (Crater Lake, located about 450 mi south-southeast of the Hanford Site) about 6000 years ago; and Mount St. Helens about 8000 years ago (USGS 2011-1064, Estimate of Tephra Accumulation...
Probabilities for the U.S. Department of Energy’s Hanford Site, Washington). The most recent ashfall resulted from the May 18, 1980, eruption of Mount St. Helens. Examination of the annual probability of eruption of known active volcanoes in the Pacific Northwest combined with wind data for the area results in a conclusion of an annual probability of exceedance of 1E-04 for ashfall accumulation of approximately 3.94 in. This provides reasonable correspondence with the historical reference (WHC-SD-GN-ER-30038, Volcano Ashfall Load for the Hanford Site), which concludes an annual probability of exceedance of approximately 2E-04 for equivalent ashfall accumulation.

The 105KW Basin was evaluated for ashfall loading in accordance with SDC-4.1. The engineering design criteria used for the 105KW Annex and associated SSCs (PRC-PRO-EN-097) specify that ashfall loading is to be combined with roof live loads, as that normally will produce the highest loading for the design. Design for a roof live loading of 20 lb/ft² or greater has been determined to be adequate for a combination of snow loading and ashfall loading. As with snow loading, design for unbalanced loads resulting from drifting or sliding is required.

Suspended ash also must be considered for facilities that require active safety components to operate during and following an ashfall event. The U.S. Geological Survey (USGS) monitors volcanic activity for 9 priority volcanoes in Washington and Oregon, and 57 priority volcanoes throughout the country, and publishes regular volcanic threat assessments. Regional volcano observatories operated by the USGS issue alert-level notifications and specific forecasts regarding eruptions and their potential impacts. Under the Volcano Alert Notification System, scientists at regional observatories notify emergency management officials and the media, which disseminate information to a wider distribution. Advance warning of the potential for volcanic eruption would generally be provided by increased seismicity at the volcano from days to years before the event. As cited in USGS 87-297, Volcanic Hazards with Regard to Siting Nuclear-Power Plants in the Pacific Northwest, rates of drift of clouds containing volcanic ash are usually in the range of 12 to 62 mph, but can be higher where wind speeds are higher. This would correspond to a delay of between 1.5 and 8 hours between eruption of Mount Adams or Mount Rainier and arrival of ashfall on site. The engineering design criteria used for new systems (PRC-PRO-EN-097) is 2 hours.

1.4.6 Lightning

Thunderstorms are common to the Hanford Site and can occur during most months of the year. The thunderstorm season is normally from April through September, with an average of 10 thunderstorm days per year. However, the total varies from a low of 3 in 1949, to a high of 23 in 1948. The largest number of thunderstorms occurring in a single month is 8; this high has been reached four times (in August 1953, June 1972, July 1983, and July 1998) (PNNL-15160, Hanford Site Climatological Summary 2004 with Historical Data). The principal hazard associated with the thunderstorms is wild fire caused by lightning strikes. However, a lightning strike near or to a building could result in a fire or damage to the structure, or damage to electronic and control systems inside the structure, as well. As documented in PRC-STP-CN-E-00655, Lightning Risk Assessment for the KW Annex, the lightning strike frequency for the 105KW Annex is 1.6E-3/yr. The 105KW Basin assumed a flash density of 0.10 strikes/km²/yr.
1.4.7 Range Fire

Range fires are an anticipated seasonal event; severe range fires have burned hundreds of square miles on the Hanford Site. Although lightning strikes cause the majority of range fires, some major fires on the site have been determined to be of human origin. Protective measures implemented on site include burning vagrant tumbleweeds and removing vegetation to maintain defensible space. Maintaining firebreaks along site roadways has been a periodic practice, when allowed by local clean air authorities and state regulators. Despite these precautions, range fires can burn out of control if driven by strong winds and can cross established defensible spaces.

The most severe range fire documented on the Hanford Site occurred in 1984. The fire burned approximately 200,000 acres both on and off site and threatened some Hanford Site facilities. This fire was started by a lightning strike on private land west of the site. Damage to site assets from this fire was limited to three small mobile office trailers located outside the primary exclusion areas, adjacent to well drilling sites. The most significant problem for facility Operations personnel was intrusion of smoke into occupied facilities through building intake ventilation systems, resulting in actuation of building smoke detection and fire alarm systems.

The most recent large range fire occurred in the summer of 2000. This fire originated from a vehicle accident that occurred approximately 2 miles west of the Yakima Barricade, near the northwest corner of the Hanford Site. When contained after 5 days, the fire had charred nearly 164,000 acres both on and off site. The fire extended across the southwestern half of the Hanford Site, bordered the 200 Area, and followed major roads to the 300 Area. The fire crossed State Route 240, Army Loop Road, and the State Route 240 Access Road and burned east to Route 10 and northeast to Route 4, and also crossed the Yakima River. The majority of site personnel were evacuated for 3 days, and several facilities were required to be abandoned (evacuated of all personnel with no estimate of return time). Asset loss was limited to minor structures near the Arid Lands Ecology Reserve, which were not protected by appropriate defensible space, and a disabled road grader abandoned on the fire line. The fire was documented in DOE/RL-2000-63, Type B Accident Investigation, U.S. Department of Energy Response to the 24 Command Wildland Fire on the Hanford Site – June 27 – July 1, 2000.

The major protections in place for 100K Area facilities from hazards associated with range fires are grading, maintenance, and housekeeping within the 100K Area to minimize combustible material and maintain defensible space. Perimeter fencing helps to minimize accumulations of tumbleweeds within the area.

The 100K Area is located approximately 2.5 miles west of the 100 Area Fire Station, which has a minimum staff of five Hanford Fire Department (HFD) crew members; and approximately 7 miles from the 200 Area Fire Station which is staffed with seven HFD crew members plus a Battalion Chief. The estimated response time is 5 to 10 minutes from the time an alarm is received at the 100 Area Fire Station until the first piece of fire apparatus arrives on the scene of an incident at the 100K Area.

1.4.8 Ambient Temperatures

The extreme ambient temperatures are defined by HNF-40475, Functional Design Criteria Sludge Treatment Project Phase I-ECRTS, Section 5.1.1. The maximum summer outdoor design condition is 110°F dry bulb. The minimum outdoor winter condition is -27°F dry bulb.
1.5 Man-Made External Accident Initiators

1.5.1 Aircraft Activity

The methodology and results for the conservative evaluation and assessment of the significance of aircraft crash risk to the 105KW Facility is provided in PRC-STP-00815, Aircraft Crash Evaluation for 105-KW Basin/ECRTS Modified Annex Operations. The evaluations are made using the methodology and data presented in DOE-STD-3014-2006, Accident Analysis for Aircraft Crash into Hazardous Facilities.

The facilities inventory in Section 3.3.2.2, “Hazard Categorization,” exceeds the exposure screening guidelines of DOE-STD-3014-2006, Section 4.1.d, “Radiological Exposures,” of 25 times the HC-2 threshold quantities provided in DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports. Therefore, an evaluation of aircraft impact frequency is required.

According to DOE-STD-3014-2006, only airports within 22 miles of the 105KW Facility can contribute to the aircraft crash impact frequency at the facility. There are 11 airports within 22 miles of the 105KW Facility, as shown in Table 1-4.

<table>
<thead>
<tr>
<th>AirNav.Com Designator</th>
<th>Near City</th>
<th>Runway</th>
<th>Name</th>
<th>Lat</th>
<th>Long</th>
<th>Distance from Facility (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>74WA</td>
<td>Mattawa</td>
<td>18/36</td>
<td>Mattawa Air Strip</td>
<td>46 43.57N</td>
<td>119 42 08W</td>
<td>7.51</td>
</tr>
<tr>
<td>91WA</td>
<td>Mattawa</td>
<td>7/25</td>
<td>Christenson Brothers Wahlke Slope</td>
<td>46 42 29N</td>
<td>119 48 04W</td>
<td>10.26</td>
</tr>
<tr>
<td>M94</td>
<td>Mattawa</td>
<td>10/28</td>
<td>Desert-Aire</td>
<td>46 41 14N</td>
<td>119 55 11W</td>
<td>15.25</td>
</tr>
<tr>
<td>6WA3</td>
<td>Basin City</td>
<td>16/34</td>
<td>Green Acres</td>
<td>46 37 00N</td>
<td>119 16 28W</td>
<td>15.75</td>
</tr>
<tr>
<td>8WA6</td>
<td>Royal City</td>
<td>7/25</td>
<td>Christenson Field</td>
<td>46 55 14N</td>
<td>119 35 24W</td>
<td>18.88</td>
</tr>
<tr>
<td>4WA0</td>
<td>Royal City</td>
<td>7/25</td>
<td>B &amp; G Farms</td>
<td>46 56 25N</td>
<td>119 44 15W</td>
<td>21.2</td>
</tr>
<tr>
<td>WN95</td>
<td>Vantage</td>
<td>9/27</td>
<td>Brown Boy</td>
<td>46 53 05N</td>
<td>119 53 29W</td>
<td>21.32</td>
</tr>
<tr>
<td>04WN</td>
<td>Royal City</td>
<td>11/29</td>
<td>Stillwater Creek</td>
<td>46 57 30N</td>
<td>119 38 19W</td>
<td>21.54</td>
</tr>
<tr>
<td>97WA</td>
<td>Mesa</td>
<td>4/22</td>
<td>Basin City Field</td>
<td>46 35 08N</td>
<td>119 09 14W</td>
<td>21.76</td>
</tr>
<tr>
<td>5WA1</td>
<td>Mesa</td>
<td>3/21</td>
<td>Dorman Field</td>
<td>46 31 17N</td>
<td>119 10 46W</td>
<td>21.94</td>
</tr>
<tr>
<td>7WA7</td>
<td>Prosser</td>
<td>5/23</td>
<td>Mc Whorster Ranch</td>
<td>46 19 14N</td>
<td>119 37 04W</td>
<td>22.6</td>
</tr>
</tbody>
</table>

Notes:
KW Facility - Lat 46 38 50.9N, Long -119 36 12.4W.
All are general aviation airports.

The distances and orientations of the runways for the 11 nearby airports were compared to the data provided in DOE-STD-3014-2006, Appendix B, to identify which flight sources contribute to the frequency that an aircraft will crash in a 1 mi² area near the facility. All of the airports exclusively support general aviation. The screening revealed that only landings at Mattawa and Desert-Aire have contributions to the crash frequency.
Evaluation of the frequency of crashes from over-flight operations that could impact the 105KW Facility is based on the expected number of crashes per square mile per year for non-airport operations \( [NPf(x,y)] \) as provided in DOE-STD-3014-2006. The standard provides DOE site-specific data for five categories of aircraft based on the historic record for aircraft crashes in the continental United States.

The facility area analyzed is obtained by extending the footprint of the 105KW Basin and administrative area north to encompass the 105KW Annex resulting in an area of \( 6.10E+4 \text{ ft}^2 \) (233 by 262 ft).

The frequency of aircraft crashes from over-flight operations and take-off/landing at nearby airfields are shown in Table 1-5. It is anticipated that for helicopters, the closest approach would be medical evacuation helicopters at a landing pad at the 100 Area Fire Station, which is about 2.5 mi from the 100K Area. However, for conservatism it will be assumed that there will be one helicopter flight per year.

**Table 1-5. Aircraft Impact Frequency for 105KW Facility Operations**

<table>
<thead>
<tr>
<th>Category</th>
<th>NPf(x,y)</th>
<th>Aeff</th>
<th>Annual Frequency of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Aviation</td>
<td>1.00E-4</td>
<td>8.51E-3</td>
<td>8.51E-7</td>
</tr>
<tr>
<td>Commercial Aviation: Air Carrier</td>
<td>1.00E-7</td>
<td>3.33E-2</td>
<td>3.33E-9</td>
</tr>
<tr>
<td>Commercial Aviation: Air Taxi</td>
<td>1.00E-6</td>
<td>3.02E-2</td>
<td>3.02E-8</td>
</tr>
<tr>
<td>Military Aviation: Large Aircraft</td>
<td>1.00E-7</td>
<td>2.73E-2</td>
<td>2.73E-9</td>
</tr>
<tr>
<td>Military Aviation: Small Aircraft</td>
<td>4.00E-8</td>
<td>1.33E-2</td>
<td>5.33E-10</td>
</tr>
<tr>
<td>General Aviation—Landing/Takeoffs Nearby Airports</td>
<td>1.91E-6</td>
<td>8.51E-3</td>
<td>1.63E-8</td>
</tr>
<tr>
<td>Helicopter</td>
<td>2.5E-5</td>
<td>3.16E-3</td>
<td>7.89E-8</td>
</tr>
</tbody>
</table>

Notes:
- a. Values of NPf(x,y) are provided in impacts per year per square mile.
- b. Values of Aeff are provided in square miles.

The overall frequency of aircraft impact from all sources is 9.8E-7/yr. If the total annual frequency of impact is less than 1.0E-6/yr the standard states that the safety risk is below the level of concern. This value includes a non-quantified conservatism because the reactor building provides shielding of the south side of the basin. Further, the expected operation is less than 1 year. Therefore, it is not necessary to further calculate the probability that the impact will lead to a release from the facility, or to determine the consequences of such a release.

### 1.5.2 Other Transportation Accidents

Two public roads cross the Hanford Site: State Highway 240 and State Route 24. At their closest points to the 100K Area, State Highway 240 is about 6.25 mi distant and State Route 24 is about 4.5 mi distant. Access to the remaining roads on the Hanford Site is restricted to authorized DOE and contractor personnel. Because of the nature of the 100K Area activities, the
roads immediately around the 100K Area are not heavily traveled and vehicle accidents outside the 100K Area are expected to have no adverse effects on the 105KW Annex operations.

Public access is allowed on the Columbia River through the Hanford Site, but river traffic is predominantly small fishing boats. Commercial traffic is limited because Priest Rapids Dam and other dams upriver do not include locks.

Accidents that might occur on State Highway 240, such as explosions or toxic chemical releases, are judged to present a negligible risk to the 105KW Facility because of the distance between the facility and the highway. At its closest approach, the distance to the highway is about 6 mi. Guidance on evaluating the hazard from chemicals stored or situated at distances greater than 5 mi from the facility is provided in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.78, *Evaluating the Habitability of a Nuclear Power Plant Control Room during a Postulated Hazardous Chemical Release.* The guide states that chemical releases at a distance greater than 5 mi need not be considered because atmospheric dispersion will dilute and disperse the incoming plume to such a degree as to provide sufficient time for the operators to take appropriate action. In addition, the probability of the plume remaining within a given sector for a long time is quite small.

Accidents that might occur on State Route 24, which is 4.5 mi from the facility at its closest approach, are evaluated using the NRC Regulatory Guide 1.78 methodology. This methodology does not require analysis for truck shipments below a minimum frequency of ten shipments per year. Because traffic on Route 24 is outside DOE’s control, the frequency is assumed to exceed 10 shipments per year.

Regulatory Guide 1.78 provides a minimum weight of hazardous chemicals per shipment below which no assessment is required. The quantity is based on the Immediately Dangerous to Life and Health (IDLH) limit for the chemical, local meteorological conditions, and leak tightness of the facility with ventilation isolated. At a distance of 4 to 5 mi and an assumed air exchange rate of 1.2 air changes per hour (defined as inefficient leakage control and not requiring automatic isolation capability), the weight limit is 110,000 lb. This assumes a toxicity limit of 50 mg/m$^3$ and stable meteorological conditions (Pasquill Stability Class F). A Pasquill Stability Class of F is defined by surface wind speeds of less than 7 mph, and nighttime cloud cover of less than 50 percent; this very stable atmospheric condition results in minimal plume dispersion, and a high concentration of any contaminant of concern. Although atmospheric stability classes are not tracked for the 100K Area, examination of wind speed data for the 100K Area (Station 29) shows that the wind speed is greater than 7 mph approximately 64 percent of the time (PNNL-15160).

The published methodology addresses 30 chemicals commonly offered for over-the-road transportation. Chlorine, with an IDLH limit of 30 mg/m$^3$, is selected as a representative worst-case potential chemical shipment. In accordance with the guidance provided, the weight limit is reduced by the ratio of 30/50 to 66,000 lb. This exceeds the 40,000 lb capacity of a commercial chlorine tank truck. Based on this conservative screening, shipments of hazardous chemicals on State Route 24 do not represent a risk to personnel in the 100K Area or the 105KW Annex, provided that appropriate emergency warning and response procedures are implemented, as described in NRC Regulatory Guide 1.78.
The Hanford Site railroad system is currently inactive. Any proposed railroad operations activities including hazardous chemicals transport via rail onto the Hanford Site, with 0.5 mi proximate to any nuclear facilities, would need to be reviewed by that facility using the Unreviewed Safety Question (USQ) process. Additionally, for the riverland main line route (low line) at 100K Area, the Decontamination and Decommissioning (D&D) Project has removed track just inside the 100K fence, which would eliminate any possibility of an unauthorized train entry into the basin area.

A screening method for the risk of damage caused by an explosion on a nearby transportation route is provided by NRC Regulatory Guide 1.91, Evaluation of Explosions Postulated to Occur on Transportation Routes near Nuclear Power Plants. The method is based on the premise that, for structures of concern, no significant damage would be expected for a peak positive incident overpressure of less than 1 psig. The 105KW Basin structure is transite-panel on steel-frame construction; the 105KW Annex is predominantly metal panel on steel-frame construction, although the lower 20 ft of the Sludge Loading Bay is steel-frame and reinforced concrete.

Explosion overpressure correlation with observed resulting structural damage, presented in Table 1-6, is tabulated in NFPA 921, Guide for Fire Explosion and Investigations. The information provided in the guide is based on military testing, work performed at the national laboratories, and the results of formal investigations of industrial and transportation accidents.

These data show that the construction of the 105KW Annex would be expected to survive an incident overpressure in excess of 1 psig. The lower threshold of significant damage for the transite-panel construction of the 105KW Basin superstructure is 1 psig.

<table>
<thead>
<tr>
<th>Overpressure (psi)</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 – 2.0</td>
<td>Shattering of corrugated asbestos (transite) siding</td>
</tr>
<tr>
<td>1.3</td>
<td>Distortion of steel frame for metal-panel construction</td>
</tr>
<tr>
<td>3</td>
<td>Distortion of steel frame and separation from foundation</td>
</tr>
<tr>
<td>4.0</td>
<td>Rupture of cladding for light industrial buildings</td>
</tr>
<tr>
<td>4.8</td>
<td>Failure of reinforced concrete structures</td>
</tr>
</tbody>
</table>

The NRC Regulatory Guide 1.91 defines a safe distance in terms of weight of trinitrotoluene (TNT) or TNT-equivalent weight as:

\[ R \geq 45W^{1/3} \]  \hspace{1cm} (Eq. 1-1)

where:

\[ R = \text{the distance in feet} \]

\[ W = \text{the TNT-equivalent weight of explosive material in pounds}. \]
The guide also lists the maximum probable explosive cargo for a single tractor-trailer as 50,000 lb, and the maximum explosive cargo for a single rail car as 132,000 lb. The safe distances for these quantities of TNT are 1680 ft for the tractor-trailer, and 2320 ft for the single rail car.

At the points of closest approach to the 100K Area, State Highway 240 is about 6.25 mi distant and State Route 24 is about 4.5 mi distant. The nearest railroad not controlled by DOE Richland Operations Office (RL) is located approximately 25 mi south of the 100K Area. At these distances, explosives transports do not pose a threat to the 105KW Annex, or the 105KW Basin superstructure.

1.6 Nearby Facilities

No military bases, missile sites, or other military facilities adjoin or are located near the 100K Area. The Yakima Firing Center is located about 6 mi west of the Hanford Site. The U.S. Army administers this 327,000-acre facility, which is used for troop maneuvers and heavy weapons training and includes a live-fire impact area. Because the live-fire impact area is located near the center of the facility, and live-fire exercises are administratively controlled, no threat to safety exists outside the firing center boundaries.

No commercial manufacturing plants, chemical plants, chemical storage facilities, airports, or other commercial industrial facilities adjoin or are near the 100K Area. The 100K Area is situated between, and at a distance of about 2.5 mi from the 100B and 100N Areas. Both of these areas were major operating facilities at one time, but are now shut down. Most of the functions carried out in these areas are now associated with ongoing waste management and environmental remediation and restoration activities.

1.6.1 100K Area Facilities

The new Annex building is located in the 100K Area and is considered a major modification of the 105KW Basin, which is the only operating HC-2 non-reactor nuclear facility in the 100K Area. Other nuclear facilities are below HC-3. Building 142-K (formerly the Cold Vacuum Drying Facility [CVDF]) is transitioned to operation as a maintenance facility. Activities for the 105-K West Reactor (105KW Reactor) currently are surveillance and maintenance with limited pre-demolition activities. The 105-K East Reactor (105KE Reactor) is less than HC-3. Waste-staging facilities are established and operated as necessary to facilitate debris and soil removal when D&D activities are conducted. Soil and groundwater remediation is discussed further below.

1.6.1.1 142-K Building

The 142-K Building (formerly the CVDF) is a steel-frame, precast concrete building within the 100K fenced area. The building has two attached pre-engineered metal wings that house the process water system and the administrative area. The process area contains five bays. Two bays were previously outfitted for processing, but are no longer in use. The remaining three spare bays were never used for process operations. The CVDF nuclear mission is complete, the process is permanently shut down, the safety basis has been terminated, and the facility has transitioned to operate as a less than HC-3 maintenance facility.
1.6.1.2 105-K Reactor Facilities

The 105KW Reactor is located directly south of the 105KW Basin. The 105KE Reactor is located in the northeastern corner of the 100K Area. Each reactor building currently contains a graphite-moderated stack, a cast-iron thermal shield, a high-density aggregate concrete biological shield, a front-face work area, and front- and rear-face elevators. The portion of the building structure that protects the reactor core is reinforced concrete; and other portions of the building are transite-panel on steel-frame construction. Additional structures physically attached to the reactor building include the inner and outer horizontal control rod rooms, the control rod hoist (commonly referred to as the rod rack), supply and exhaust fan rooms, an exhaust ventilation tunnel, cooling water tunnels, the control room, and office and administrative support areas. These structures were partially removed for the 105KE Reactor, in preparation for a planned reactor core removal project that has since been indefinitely postponed. Current plans for both reactor buildings are to cocoon for interim safe storage.

1.6.1.3 Soil and Groundwater Remediation

The 100-KW pump-and-treat system at the 100K Area is operated for groundwater remediation. This system extracts groundwater from the aquifer under the 100K Area via extraction wells, and transports this water to the process building (6004KW). At the 6004KW Building, an ion-exchange process is used to remove hexavalent chromium and other contaminants from the extracted groundwater. The processed water is then returned to the 100K Area aquifer by means of an injection well. The process uses sulfuric acid at a 93 percent concentration, which is present in the building in quantities of up to 120 gal. Extraction, injection, and monitoring wells are operated throughout the 100K Area, some of which are near the 105KW Facility.

1.6.1.4 Future Demolition and Remediation Activities

Soil remediation and demolition of obsolete structures are ongoing in the vicinity of the 105KW Facility. KBC-36585, 100K Area Project Facility Hazard Categorization, Section 3.1, describes planned remediation activities.

The potential for interaction of remediation or demolition activities with 105KW Facility operations is managed through the USQ process (PRC-PRO-NS-062, Unreviewed Safety Question Process).

1.7 Validity of Existing Environmental Analysis

No significant discrepancies have been identified between the site characteristic assumptions made in this chapter and those made in DOE/EIS-0245F, Addendum (Final Environmental Impact Statement), Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington.
Chapter 2.0

Facility Description
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2.0 Facility Description

2.1 Introduction
This chapter provides the facility description for the 105-K West Facility (105KW Facility) which encompasses the 105-K West Basin (105KW Basin) and the 105-K West Basin Annex (105KW Annex), including ECRTS. The information supports assumptions used in the hazard and accident analyses. The ECRTS final design is documented in PRC-STP-00751, Critical Decision 2/3 Report for the Sludge Treatment Project Engineered Container Retrieval and Transfer System.

The level of detail provided in this chapter is based on the significance of the preventive and mitigative features identified, the degree of complexity, and the application of a graded approach. The descriptions provide sufficient details of the facility, equipment, and processes to achieve a general understanding of the facility without extensive consultation of the cited references. Chapter 4.0 provides more detailed information on safety SSCs.

2.2 Requirements
The historical requirements that form the basis for the 105KW Basin design are found in HW-24800-103, Completion Report Project CA-521.

The requirements for the design and modifications for ECRTS to protect the health and safety of facility workers, collocated workers, and the public are specified in DE-AC06-08RL14788, CH2M HILL Plateau Remediation Company Plateau Remediation Contract, the contract between CH2M HILL Plateau Remediation Company (CHPRC) and DOE, Richland Operations Office, including but not limited to the following:

- 10 CFR 830, “Nuclear Safety Management”
- 10 CFR 835, “Occupational Radiation Protection”
- 10 CFR 851, “Worker Safety and Health Program”
- 29 CFR 1910, “Occupational Safety and Health Standards”
- Contractor Requirements Document (CRD) O 413.3B, Program and Project Management for the Acquisition of Capital Assets
- CRD O 414.1D, Quality Assurance
- CRD O 420.1C, Facility Safety
- CRD O 420.1C, Supplemented Revision 0, Facility Safety
- CRD O 460.1C, Packaging and Transportation Safety
- CRD M 450.4-1, Integrated Safety Management System Manual
- DOE-STD-1189-2008, Integration of Safety into the Design Process
These contractual requirements are supplemented by HNF-44226, *Code of Record for the Sludge Treatment Project Engineered Container Retrieval and Transfer System*. The requirement to document a code of record for facilities or modifications to facilities is found in DOE O 413.3B, DOE O 420.1B, *Facility Safety*, and Supplemented CRD O 420.1B.

### 2.3 Facility Overview

The 105KW Facility is located on the south bank of the Columbia River near the north end of the Hanford Site in the 100K Area.

The original facility was the 105-K West Reactor (105KW Reactor), built in the early 1950s. The reactor was provided with a large basin for underwater storage of irradiated fuel. The 105KW Reactor was shut down in February 1970. The stored fuel, except for a few loose pieces, was shipped to the 200 East (200E) Area for processing. The storage basin was then idle, but was kept filled with water.

The 105KW Basin was modified to store N Reactor fuel and was placed in service in February 1981. The basic design requirements were as follows:

- Store irradiated N Reactor fuel for 20 years
- Limit radioactive releases to the environment to within established limits
- Protect personnel from undue physical and radiological hazards during normal or abnormal operation of the facility and related equipment

The K Basins initially stored a large quantity of N Reactor spent fuel and a smaller amount of single pass reactor spent fuel. Because this stored spent fuel had been deteriorating for many years, and because the K Basins were approaching the end of—or had exceeded—their useful lives, the Spent Nuclear Fuel (SNF) Project was established to move the spent fuel to a safer storage location. The SNF Project removed the spent fuel from the 105KW Basin, dried it at the CVDF, and placed it in interim storage at the Canister Storage Building on the Hanford Site. The SNF Project has since been replaced by the STP.

The 105KW Basin was modified by the addition of fuel- and cask-handling equipment and associated equipment to support fuel cleaning, packaging, and transport activities. This equipment is no longer needed, but remains in the basin.

All activities associated with removal of fuel and/or knockout pot (KOP) material and multi-canister overpack (MCO) processing have been completed as of 2012 and the associated equipment is no longer required. The idle equipment may be removed or abandoned in place.

Current operational activities include safe storage and movement of fuel fragments, sludge, and debris; as well as the removal of debris from the 105KW Basin. The 105KW Facility layout is shown in Figure 2-1.
Figure 2-1. 105KW Facility Layout
The ECRTS is installed in the 105KW Basin and in the newly constructed 105KW Annex to transfer approximately 27 m³ of sludge into Sludge Transport and Storage Containers (STSCs) and to prepare the STSCs for shipment to T Plant for interim storage. Shipments from the 105KW Annex to T Plant will be performed in accordance with a DOE-approved One Time Request for Shipment in accordance with DOE/RL-2001-36, *Hanford Sitewide Transportation Safety Document.*

Sludge will be retrieved from the engineered containers in multiple batches and pumped through a hose-in-hose (HIH) transfer line to an STSC located in the 105KW Annex. The design life for ECRTS and required facility upgrades is 5 years with the exception of the STSCs, which have a 30-year design life. The expected mission duration is 1 year.

There are three sludge types: 105-K East (KE) Basin (18.4 m³), 105-K West (KW) Basin (5.2 m³) and Settler Tank (3.5 m³). In addition, there is approximately 25 L of Segregated Settler Material (SSM) that has been added to SCS-CON-220 with an approximate uniform distribution. Each sludge type has a specific limitation on the quantity that can be placed into an STSC based on thermal, gas generation, and sludge-expansion characteristics. It is estimated that 18 to 25 STSCs will be required.

Only one STSC is brought into the 105KW Annex at a time. One STSC arrives prepositioned in a trailer-mounted Sludge Transport System (STS) Cask and remains in the cask during sludge retrieval and transfer.

The basic ECRTS Process consists of the operations outlined below.

- **STSC Receipt and Preparation:** The STS Trailer arrives at the 105KW Annex, the STS Cask Lid is removed, and STSC process and ventilation connections are made. Tare weight and level measurements are made to initiate STSC sludge inventory calculations.
- **Sludge Retrieval:** Sludge is retrieved from an engineered container by use of a retrieval tool that fluidizes the sludge and transfers it to a booster pump. The sludge is retrieved as a slurry at a nominal 5 volume percent (vol%) solids.
- **Sludge Transfer:** Using the booster pump, slurry is pumped out of the 105KW Basin through an aboveground HIH transfer line to the STSC. Flocculant may be added during slurry transfer to aid in settling of solids.
- **Transfer Line Flush:** The transfer line is flushed with water to remove solids to the extent possible.
- **Settling, Decant, and Filtration:** The slurry is allowed to settle, after which the supernate is decanted and filtered through the ECRTS Sand Filter. Flocculant may be added to the supernate to aid in settling of solids in the STSC and clarifying the supernate before decanting. The filtered supernate is returned to the 105KW Basin.
- **ECRTS Sand Filter Backwash:** After the last decant of supernate for a given STSC, the solids collected on the ECRTS Sand Filter are backwashed to the STSC.
- **STSC Process Disconnect:** The slurry and decant lines are cleaned, drained, final weight and level measurements are made, and the STSC sludge inventory is calculated. Slurry and decant lines and the 4-in. STSC vent line are disconnected from the STSC.
- Nitrogen Inerting and Pressurization: The STSC is inerted with nitrogen. The STS Cask Lid is then replaced and the STS Cask is inerted and pressurized with nitrogen, and the cask is prepared for transportation.

The ECRTS design includes an overfill recovery capability, in the event that too much sludge is inadvertently transferred into an STSC.

### 2.4 Facility Structure

The 105KW Basin and 105KW Annex are shown in Figure 2-2, which also shows the safety basis boundary and other facilities within it. Not all mobile offices are shown or listed. The only buildings that pose a significant hazard to receptors are the 105KW Basin and 105KW Annex and processes therein, due to remaining sludge. Hazards associated with other buildings primarily include only standard industrial hazards. These other buildings are not included in the scope of this Documented Safety Analysis because they are less than HC-3 nuclear facilities or non-nuclear facilities (KBC-36585, 100K Area Project Facility Hazard Categorization).

![Figure 2-2. 105KW Facility Safety Basis Boundary](image-url)
2.4.1 105KW Reactor Building

The 105KW Reactor Building is a reinforced-concrete structure, with a 130 by 130 ft base and a height of about 75 ft, located adjacent to the fuel storage basin. The reactor building’s concrete walls range in thickness from 3 to 5 ft. A steel superstructure sits on top of the concrete reactor building, extending the center portion of the building up another 54 ft, as shown in Figure 2-3. The reactor building houses the deactivated 40,000,000 lb reactor, which includes the graphite stack and shielding. The fuel storage basin foundation is separated from the reactor building foundation. This portion of the 105KW Reactor Building is less than HC-3 (KBC-39764, Final Hazard Categorization for Surveillance, Maintenance, and Various D4 Activities for the 105-KW Reactor) and is administratively separate from the basin, but is included to support the description of the interfaces with the fuel storage basin.

2.4.2 105KW Basin Structure

The 105KW Basin is located north of the reactor building as shown in Figure 2-2. The fuel storage basin is a large pool that was used to store and handle SNF. The main basin includes three bays separated by two cantilevered vertical concrete walls. Several pits are attached to the main basin, including the dummy elevator pit (DEP), weasel pit, technical view pit, north loadout pit (NLOP), south loadout pit (SLOP), and the reactor fuel discharge chute. The NLOP is hydraulically isolated from the remainder of the basin by isolation bulkheads. The isolation bulkheads have capped penetrations that can be opened to facilitate transfers of sludge and water through the bulkheads, when required. A center island is located between the main basin and the discharge chute. Discharge chute isolation barriers are installed between the basin walls and the center island to separate the basin from the discharge chute. As part of deactivation and decommissioning activities, the discharge chute has been grouted. The Transfer Bay with a large crane is located to the west of the basin to support maintenance activities. The fuel storage basin also includes attached offices and support areas. The basic arrangement of the KW fuel storage basin is illustrated in Figure 2-1.

The KW fuel storage basin is a below-ground, reinforced-concrete rectangular pool approximately 125 by 67 ft. The walls of the basin are 20 ft 9 in. high, with a nominal operating water depth of 15 ft 10 in. to 16 ft 10 in. at the 105KW Basin. The basin walls have an epoxy coating to reduce contamination levels in the basin concrete. The 105KW Basin walls are tapered from a 27-in. base to an 18-in. top, with the exception of the west wall, which is 27 in. thick from bottom to top. The basin floor is a 2-ft-thick (nominal) reinforced-concrete mat. The basin walls were formed on the basin mat. Reinforcing steel connects the basin mat to the walls. The areas in which the basin sits were excavated to approximately 38 ft and backfilled with sandy gravel according to WHC-SD-EN-SP-090, Borehole Data Package for the 100-K Area Groundwater Wells for CY 1994. An asphaltic membrane is located below the basin to capture water that leaks from the basin. The asphaltic membrane is connected to an under-basin drain system that collects water leakage.
Figure 2-3. North-South Cross Section of the 105KW Reactor Building and 105KW Basin
Exposure to neutron and gamma radiation can reduce concrete strength. Studies have shown that for ordinary Portland cement, beginning signs of deterioration can be observed at a dose of 1.3E+10 Rad. As documented in PRC-STP-CN-N-00739, Estimated Gamma/Neutron Dose to the KW Basin Concrete Wall, the total neutron and gamma dose from 35 years of KW Reactor and N Reactor fuel storage is estimated to be 1.25E+9 Rad to the basin concrete walls, 2.50E+9 Rad to the basin divider walls (i.e., the walls between the center, east, and west bays), and 6.9E+8 Rad to the basin floor. These values are less than 1.0E+10 Rad, it is concluded that the basin concrete has not been weakened due to radiation exposure.

The basin foundation is isolated from the reactor building foundation on the south wall of the basin at an unreinforced construction joint in the discharge chute region. The construction joint is sealed with a rubber seal formed into the concrete. Grouting the discharge chute isolates the main basin from the discharge chute and minimizes leakage through the construction joint so that it does not adversely affect compliance with the leakage rate requirement of less than or equal to 25 gal/min through the discharge chute barrier seal after a seismic event.

The basin contains several drain valves. Each bay contains a 12-in. cast-iron drain valve located near the north basin wall. There are five 4-in. cast-iron drain valves: one each located in the NLOP, SLOP, weasel pit, technical view pit, and discharge chute. The 4-in. drain valve in the discharge chute has been covered by grout. The drain valves are located in drain sumps in the basin floor that are filled with concrete grout. The drain valve bonnets are exposed above the grout in the sumps. The grout was intended to seal the drain valve openings, but the exposed bonnets could still be damaged by dropped loads.

The basin contains two water overflow subsystems. The first consists of overflow weirs located adjacent to and above the skimmer weir inlets in the main basin. These basin overflow weirs were routed to a 36-in. steel drain line. The weirs have since been plugged. The second subsystem consists of numerous slotted drain pipes located in the service pits, loadout pits, and underneath the discharge chute. These drain pipes attach to the grouted drain valves and lead to the east chamber of a buried collection box outside the basin. The 100-K-73 collection box has two chambers designed to trap sediment and debris. The overflow systems have been deactivated to prevent discharge of basin water to the environment. Nominal overflow elevation is 18 ft 4 in. above the main basin floor.

During drain line integrity testing, the 105KW Basin drain line was found to have a leak. The leak’s exact location is not known; however, leak testing has confirmed that the leak is at an elevation above the main 12-in. drain header. The main drain header system has been filled with grout. This effectively isolates each drain valve header section such that only damage to the drain valve with the failed piping would cause a leak path to the ground. The 105KW Basin 12-in. drain line is plugged with approximately 4 yd$^3$ of grout.

The structural boundary is defined by the water retention boundary, including the basin, pits, drain valves, and barrier doors. The drain line plugs reduce the environmental impact in the event of drain valve leakage.

Fuel storage racks were installed in the basin to provide a means to track fuel canister locations; however, most of the fuel racks have been removed or repositioned. The few remaining fuel canisters rest on the floor inside the rack spaces or directly on the floor itself. A variety of equipment (described later in this chapter) has been installed on the basin floor and in some of
the pits in the 105KW Basin to support fuel and scrap removal activities, and to support the water treatment equipment and the KW Sludge Containerization System (SCS) containers. Figure 2-1 shows the general arrangement of 105KW Basin.

An operating deck of steel grating is suspended over the basin. The operating deck is at ground elevation (465 ft above sea level). The floor of the main basin is 20 ft 9 in. below the operating deck. The floor of the NLOP and SLOP is 25 ft 9 in. below the operating deck. The floor grating over the basin is limited to a uniform loading of 60 lb/ft². Grating manufacturers give allowable distributed loads and concentrated loads for a group of 10 or more bearing bars, but generally do not allow point loads on 1 or 2 bars. For wheel loads that would be applied to only one or two bars, load-spreading sheets of plywood or plates are necessary for safe load application according to WHC-SD-GN-ER-10006, K Basins: Floor Loads and Calculations. The analysis assumed 2000 lb for a concentrated load on a 2.5- by 2.5-ft area on the fuel storage basin grating, based on basin use. Additionally, heavy-duty steel grating is installed in specific areas of the basin to accommodate higher loads (e.g., use of temporary shielding). This heavy duty grating has been analyzed in A21A-C-005, Design Analysis of KE Hand Railing and Grating, and is limited to a uniform loading of 203 lb/ft². The Transfer Bay area floor is limited to a uniform loading of 2000 lb/ft² (WHC-SD-GN-ER-10006). The office area is limited to a uniform loading of 100 lb/ft², and the tool room is limited to a uniform loading of 125 lb/ft².

2.4.3 105KW Basin Superstructure

The basin is covered by a one-story steel superstructure. The exterior walls are steel-framed with corrugated asbestos cement (transite) panels. The superstructure consists of roof trusses and purlins that transfer loads to structural support columns. The columns are attached to the concrete basin with anchor bolts. The roof structure supports the floor grating, flexible transfer crane, and a series of monorails over the basin. Electric hoists are mounted on the monorails for transporting loads.

The 105KW Basin has a structural cantilevered roof with metal-seamed panels located above and extending 10 ft north of the original basin roof. The 105KW Basin office and Transfer Bay areas have a sprayed polyurethane foam roofing system. The roof is designed for a maximum downward loading of 39.2 lb/ft² (HNF-SD-SNF-SA-004, Seismic Qualification of 105 K Basin Superstructure Using 0.12g Earthquake Ground Acceleration). The loading includes extreme load combinations (i.e., dead load, snow load, ash, and 0.12g seismic load) in accordance with SDC-4.1, Standard Arch-Civil Design Criteria: Design Loads for Facilities. The safe allowable design live load for the KW fuel storage basin roof is 20 lb/ft².

The KW Fuel Transfer System (FTS) Annex is approximately 25 ft wide, 41 ft long, and 24 ft tall, and extends north from the northeast corner of the 105KW Basin. A flexible coupling connects the FTS Annex to the 105KW Basin structure. The FTS Annex is a framed steel structure on a concrete foundation with metal siding. The north wall of the FTS Annex is a 3-hour fire-rated wall consistent with the International Building Code (IBC), Section 602, and NFPA 80A, Recommended Practice for Protection of Buildings from Exterior Fire Exposures. The wall is 8-in.-thick concrete, with a parapet extending a minimum of 30 in. above the existing roof as described in PRC-STP-CN-C-00395, FTS Annex Modifications - Fire Wall Installation Design. The wall is designed to meet Seismic Design Category-3 requirements. The FTS Annex
still contains a shielded transfer cask and cask transfer overpack, which are not currently in use and may be abandoned in place or removed.

Figure 2-1 shows the location of the engineered containers and ECRTS process equipment within the 105KW Basin. The process equipment is described in Section 2.5, “Process Description.”

2.4.4 105KW Annex

The 105KW Annex is located approximately 40 ft north of the north wall of the FTS Annex.

As discussed in HNF-SD-SNF-FHA-001, *Fire Hazards Analysis for the 105-KW Facility* (FHA), the construction of the 105KW Annex is classified as Type IIB in accordance with the IBC, as defined in Section 601. By definition, this type of construction includes building elements constructed of noncombustible materials.

The 105KW Annex consists of the Sludge Loading Bay, the Mechanical Equipment Room, the HEPA Filter Room, the Interior Stair, and the Personnel Change Room, as shown in Figure 2-4 and Figure 2-5.

2.4.4.1 Sludge Loading Bay

The Sludge Loading Bay is a steel-frame and reinforced-concrete structure approximately 53 ft long, 29.5 ft wide, and 39 ft high. The bay is equipped with a 14 ft wide, 16 ft high roll-up door on the east end, which provides access for the STS Trailer. A Mezzanine floor located approximately 20 ft above the ground floor provides a base for transfer equipment, and allows access to the top of the STS Cask and STSC via a keyhole opening located over the STS Trailer. The steel-frame structure above the Mezzanine level has an insulated roof and metal-panel siding on top of reinforced, load-bearing, concrete shear walls.

The major process equipment for loading sludge into the STSC will be located in the Sludge Loading Bay within three process enclosures: the Transfer Line Service Box (TLSB), the Decant Pump Box, and the Sand Filter Skid. The TLSB and Decant Pump Box, located on the Mezzanine level, provide secondary confinement and shielding for pumps, valves, and transfer piping. The Sand Filter Skid, located on the ground level in the southeast corner of the Sludge Loading Bay, provides secondary confinement and shielding for the ECRTS Sand Filter. Other major equipment located in the Sludge Loading Bay includes a 5-ton bridge crane and a truck scale for weighing the STS Trailer and its contents. A truck stop is provided to limit the access of a tractor into the Sludge Loading Bay for fire protection, and the access ramp outside the Sludge Loading Bay roll-up door is sloped to prevent a tractor fuel tank leak from flowing into the bay. Equipment layouts for the floor and Mezzanine levels of the Sludge Loading Bay are shown in Figure 2-4 and Figure 2-5, respectively.
Figure 2-4. 105KW Annex—Ground Floor Layout
Figure 2-5. 105KW Annex–Mezzanine Level Layout
2.4.4.2 Mechanical Equipment Room

The Mechanical Equipment Room, located at the southwest corner of the facility, is approximately 26 by 23 ft, and 15 ft high. The exterior walls are metal-panel siding on steel-frame. The east wall, which divides the Mechanical Equipment Room from the HEPA Filter Room, is gypsum wallboard on metal stud framing. A portion of the north wall is shared with the Sludge Loading Bay, and is reinforced concrete.

The Mechanical Equipment Room houses heating, ventilation, and air conditioning (HVAC) equipment and compressed air/instrument air system components. Major HVAC equipment includes the building primary air handling unit, electric hot water boiler, and hydronic system pumps and expansion tank. Major compressed air system equipment includes an air compressor, a 200-gal wet air receiver tank, two 500-gal dry air receiving tanks, and an air dryer unit. The Mechanical Equipment Room also houses 480 VAC power panels, lighting panels, control panels, the facility fire alarm control panel, fire riser, and miscellaneous ductwork and piping. Two 3-ton split system air conditioning units provide supplemental cooling within the room.

2.4.4.3 High-Efficiency Particulate Air Filter Room

The HEPA Filter Room is located immediately east of the Mechanical Equipment Room. This room is approximately 26 by 22 ft, and 15 ft high. The south and east walls are metal-panel siding on steel-frame. The north wall is shared with the Sludge Loading Bay, and is reinforced concrete. The walls separating the HEPA Filter Room from adjoining rooms are 2-hour fire rated in accordance with the requirements of DOE-STD-1066-99, Fire Protection Design Criteria.

The HEPA Filter Room houses normal and standby filter trains and fans, which provide exhaust filtration for process equipment and the majority of the building (except the Mechanical Equipment Room and the Personnel Change Room). A small hydronic fan coil unit provides supplemental cooling within the room. The Horizontal Shielded Hose Chase, approximately 3 ft high and 4 ft wide and located along the east wall of the HEPA Filter Room, provides a shielded enclosure for the transfer lines.

2.4.4.4 Interior Stair and Personnel Change Room

The Interior Stair, located immediately east of the HEPA Filter Room, provides access to the Mezzanine level of the Sludge Loading Bay. Exterior walls of the Interior Stair are metal-panel siding on steel-frame. The north wall is shared with the Sludge Loading Bay, and is reinforced concrete.

The Personnel Change Room is located in the southeast corner of the Interior Stair. This room is approximately 13 by 17 ft, and 12 ft high. The exterior (south and east) walls are metal-panel siding on steel frame. The north and west walls, which are shared with the Interior Stair, are gypsum wallboard on metal stud framing. The Personnel Change Room ceiling is also gypsum wallboard.

The Personnel Change Room contains remote readouts for area radiation monitors and continuous air monitors located in the Sludge Loading Bay, and a personnel contamination monitor used by personnel upon exiting the bay. A telecommunications board is also located in the room.
2.4.4.5 In-Basin/Horizontal Shielded Hose Chase

The hose-in-hose transfer line and decant lines exit the 105KW Basin pool via an ingress/egress assembly (see Figure 2-6, and transition into an In-Basin Shielded Hose Chase. Between the 105KW Basin superstructure and the 105KW Annex, the hoses transition from the In-Basin Shielded Hose Chase to the Horizontal Shielded Hose Chase, shown in Figure 2-7, which runs along the east outside wall of the FTS Annex and 40 ft north. This shielded hose chase connects with another segment of the horizontal shielded concrete hose chase which enters the 105KW Annex just west of Column Line D, and runs along the interior east wall of the HEPA Filter Room to the Sludge Loading Bay, with the bottom of the hose chase 2.5 ft above the finished floor. The Horizontal Shielded Hose Chase provides 2 in. of steel plate and 13 in. of concrete shielding on the top and sides of the transfer line and is trace heated outside the 105KW Annex structure. The hose chase is sloped 1/8 in. per foot to provide gravity drainage back to the basin. Within the Sludge Loading Bay, the transfer hose is routed to the Mezzanine level. A spare HIH transfer line is provided through the length of the Horizontal Shielded Hose Chase, to facilitate recovery from any transfer line failure. For further description, see Section 4.4.1, “Above-Water Slurry Transfer Lines.”

2.5 Process Description

105KW Basin operations involve handling sludge and contaminated debris, with the intent of storing and eventually removing these items. These activities are defined as the “processes” for the 105KW Basin.

The ECRTS Process is designed to transfer approximately 27 m³ of sludge into STSCs and to prepare the STSCs for transport to T Plant for interim storage. The ECRTS equipment that has been recently installed in the 105KW Basin and 105KW Annex provides for the process to retrieve the sludge stored in the 105KW Basin, place it into STSCs, and ship it to T Plant for storage pending future treatment. This process which removes the last major inventory of radioactive materials from the 105KW Basin is forecast to operate for approximately 1 year.

2.5.1 Process History

The 105KE and 105KW Basins were constructed in the early 1950s to support reactor operations. After irradiation, fuel was pushed from the reactors into the discharge chutes, then sorted, canned, and queued under water in the basins. This allowed for decay of radionuclides with short half-lives before the fuel was reprocessed for plutonium and uranium recovery. The basins originally had a 20-year design life, and were deactivated when the reactors were shut down. They were placed in long-term standby in February 1970 and January 1971, respectively.

During the 1970s the N Reactor continued to operate with a dual-purpose mission to produce fuels-grade plutonium and electricity. When spent fuel storage at N Reactor was filled to capacity, the KE and KW Basins were reactivated in 1975 and 1981, respectively, to provide supplemental storage for irradiated N Reactor fuel. All stored fuel has since been removed from the basins for reprocessing or storage. Only residual amounts of fuel remain in the form of a small number of fuel fragments.
Figure 2-6. Ingress/Egress Assembly
During the fuel storage mission, fuel element corrosion occurred and the resulting corrosion products escaped from fuel storage canisters. The basin superstructure design also allowed sand, dirt, and organic material (weeds, bugs, etc.) to be deposited in the basin. Normal and off-normal basin operations contributed additional material such as spent ion-exchange resins and other detritus such as spalled concrete, paint chips, Grafoil\textsuperscript{11}, and Sand Filter material; polychlorinated biphenyl-contaminated material; and hydroxides of iron, aluminum, and uranium. This accumulated material settled on the basin floor, was periodically vacuumed or pumped from one location to another, and eventually accumulated in engineered pits and containers. As defined in HNF-SD-SNF-TI-015, \textit{Spent Nuclear Fuel Project Technical Databook, Volume 2, Sludge}, sludge is any material that will pass through a 6350-µm (1/4-in.) screen; larger material was separated and managed as spent fuel, scrap, or debris. Over time, the sludge became identified by its original deposition location: floor sludge, pit sludge, or canister sludge. An additional category of sludge, Settler Tank sludge, was created during the process of fuel washing, via the accumulation of material in a series of Settler Tanks. In 2006 and 2007, the

\textsuperscript{11} Grafoil is a trademark of Graftech, Inc., Lakewood, Ohio.
remaining retrievable sludge from the KE Basin was transferred to the 105KW Basin in preparation for the demolition of the KE Basin.

All of the above sludge has been retrieved and transferred to the sludge containerization system described in Section 2.5.2.1.

2.5.2 Engineered Container Retrieval and Transfer System

The ECRTS is composed of SSCs installed into the 105KW Basin and 105KW Annex (including the Annex structure) to retrieve the sludge stored in the engineered containers, hydraulically transfer it through HIH enclosed in a horizontal hose chase into the 105KW Annex and discharge the slurry (diluted sludge) into STSCs. The slurry is settled, the supernate is decanted, and the process repeated until the required amount of sludge is collected. The STSC is then inerted, enclosed in the STS Cask which is likewise inerted, and shipped to T Plant for interim storage. Figure 2-8 provides a schematic of the ECRTS process and identifies equipment discussed in the following subsections. The ECRTS SSCs and process, designed and analyzed in accordance with DOE O 420.1B and installed by the STP, are further described below.

The installed ECRTS SSCs will undergo pre-operational testing prior to completion of an Operational Readiness Review. This activity is referred to as K Basin Pre-operational Acceptance Testing. Testing may be performed using basin water or alternative water sources, but the system will not be used to retrieve sludge to an STSC.

2.5.2.1 Sludge Containerization System

In the 105KW Basin, sludge is stored in six engineered containers (Figure 2-9). Engineered Containers SCS-CON-210, -220, and -230 are located in the 105KW Basin Center Bay. Engineered Containers SCS-CON-240, -250, and -260 are located in the East Bay. The containers are rigid, freestanding structures. Each container consists of three rectangular stainless-steel sections bolted together. The inside bottom section of each container is divided into eight separated compartments (referred to as “egg crates”). The tops of the engineered containers are approximately 8.5 ft below the water surface.

The internal dimensions of the containers are approximately 7.5 ft high by 5 ft wide by 11 ft 10 in. long. The containers have slots to allow for placement of retrieval tools at the lowest point in each egg crate. Brushes on the slots minimize the release of sludge from the engineered containers to the basin water, and rollers on the slots aid in hose management (see Figure 2-9).

The settler sludge material retrieved from the Integrated Water Treatment System (IWTS) Settler Tanks into SCS-CON-230 was deposited asymmetrically and the uranium metal particles are concentrated in the north end (see PRC-STP-CN-CH-00712, Evaluation of Sludge Leakage from Divider Panel in SCS-CON-230). A safety-significant Divider Plate Assembly in the north half of SCS-CON-230 divides the mound of solids accumulated during settler retrieval. The four sections, co-incident with the egg crate design of the base section of the engineered container, limit the amount of sludge that may be withdrawn from a given egg crate segment, thus protecting assumptions relating to the amount of uranium metal contained in an STSC for hydrogen generation rate analyses.
Figure 2-8. Simplified Process Flow Diagram
Engineered Container SCS-CON-210 contains KW Basin floor and pit sludge. Engineered Container SCS-CON-220 contains KW Basin floor and pit sludge and a small volume of SSM. Engineered Container SCS-CON-230 contains sludge retrieved from the Settler Tanks and has the divider plate assembly installed in the north end. Engineered Containers SCS-CON-240, -250, and -260 contain KE Basin floor, pit, and canister sludge. Table 2-1 provides the average sludge volume per container, as reported in HNF-41051, *STP Container and Settler Sludge Process System Description and Material Balance*.

![Diagram of typical engineered container](image)

**Figure 2-9. Typical Engineered Container**

<table>
<thead>
<tr>
<th>Origin</th>
<th>KW Basin</th>
<th>Settler Tank</th>
<th>KE Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (m$^3$)</td>
<td>4.2</td>
<td>1.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Source: HNF-41051, Table 4-1.
2.5.2.2 Sludge Transport and Storage Container

The STSC is designed as an ASME Boiler and Pressure Vessel Code (ASME BPVC), Section VIII, Division 1, “Rules for Construction of Pressure Vessels,” pressure vessel. The STSC is approximately 5 ft in diameter and 10 ft tall, with semi-elliptical top and bottom heads. The STSC shell and bottom semi-elliptical head are constructed of 0.5-in.-thick stainless steel, and the top semi-elliptical head is constructed of 0.75-in.-thick stainless steel. The STSC is provided with a skirt that is perforated to enhance heat transfer from the STSC bottom. The design capacity of an STSC is approximately 4.0 m³.

STSC internal components include a fill-tube assembly to provide a more even distribution of sludge in the STSC, a floating decant assembly, a safety-significant sloped fin to prevent the formation of a vessel-spanning gas bubble within the sludge, and an Overfill Recovery Tool. The STSC design is provided with nozzles for process connections, instrumentation, and ventilation. In addition to the nozzles, two lifting lugs are located on the top of the STSC with a safe working load of 20,000 lb.

Figure 2-10 provides a cut-away view of an STSC showing the internal assemblies. Figure 2-11 is a plan view of the STSC showing the process, instrumentation, and ventilation connection nozzles and ports when configured for transportation.

2.5.2.3 STS Cask and Trailer

The STS Trailer is a four-axle single-drop flatbed with an overall length of 35 ft and a width of 10 ft, equipped with sixteen 275/70R22.5 tires. The height of the drop deck is 42.5 in., and the overall height including superstructure work platform railings is 15 ft 3 in. The trailer is fabricated of welded carbon steel, and primed and painted with appropriate coatings that resist corrosion and allow for more efficient decontamination. The superstructure is a welded framework surrounding the STS Cask, allowing access to the container during loading and handling operations. A work stand for storage and inspection of the STS Cask Lid is located at the rear section of the trailer.

The STS Cask is anchored to, and is an integral part of, the STS Trailer. The cask was designed and constructed in accordance with ASME BPVC, Section III, Division 1. The design pressure is 80 psig. The cask is a right circular cylinder constructed primarily of Type 304 stainless steel and lead. It is approximately 11 ft high and 6 ft in diameter. The cask is constructed of a 1-in.-thick stainless-steel inner shell and 1.5-in.-thick stainless-steel outer shell. The inner and outer shells are welded to a 6-in.-thick stainless-steel bottom forging. At the top, the inner and outer shells are welded to a stainless-steel upper forging. The approximately 3 in. annulus between the two shells is filled with lead for gamma radiation shielding. The STS Cask Lid, fabricated from 5-in.-thick stainless steel, is secured to the cask upper forging with twenty-four, 1.5-in.-diameter bolts. The cask has a bottom drain port in the shell, and two vent ports and a test port in the lid. The trailer and cask are shown in Figure 2-12.
Figure 2-10. Sludge Transportation and Storage Container Cut-Away View
Figure 2-11. Sludge Transportation and Storage Container Connection Nozzles

Figure 2-12. Sludge Transport System Trailer and Cask
2.5.2.4 STSC Receipt and Preparation

The first step of the engineered container retrieval and transfer process is receipt of the STS Cask and container. The STSC arrives at the 105KW Annex loaded in an STS Cask with four instruments installed: (1) a slurry transfer line leak detector, (2) a decant/backwash line leak detector, located in separate fittings installed on the appropriate STSC nozzles, (3) an STSC level gauge, and (4) a level switch. Once the trailer is properly positioned on the truck scale, the tractor is decoupled from the trailer. A truck stop/concrete platform physically limits how far the STS Trailer can be backed into the 105KW Annex. It is positioned such that the tractor fuel tanks are always located outside of the 105KW Annex. In addition, the trailer entrance ramp is sloped away from the 105KW Annex such that a fuel spill, if it occurred, would flow away from the facility. After the tractor is decoupled from the trailer, it is driven away from the facility and the 105KW Annex roll-up door is closed.

The bridge crane is used to remove the STS Cask Lid, which is placed in a designated location on the transport trailer. The top of the STSC is then covered with a plastic Rad Con drape to prevent drips or small leaks of slurry from contaminating the STSC, and a supplemental Rad Con hood is installed over the top of the STS Cask/STSC. This hood draws approximately 600 cfm and provides a confinement function for airborne radioactivity.

The slurry transfer line and decant/backwash lines are connected to the STSC using pipe-in-pipe coaxial connectors at Nozzles A and B, respectively. Ventilation system connections are then made. These include the purge inlet line (Nozzle S2), the STSC/STS purge outlet line (Nozzle F2), and the vent outlet line (Nozzle F1). The purge inlet line and purge outlet line are components of the safety-significant Auxiliary Ventilation System (see Section 2.7.1.1, “Auxiliary Ventilation System”).

Instrumentation that arrives attached to the STSC is then connected, and the STSC is filled with Ion Exchange Module (IXM) water to the working capacity of 3.5 m$^3$ as indicated by the liquid level instrumentation. At this point, the truck scale is used to weigh the trailer to establish the STSC tare weight. IXM water above the minimum decant level in the STSC is then transferred back to the 105KW Basin using the decant pump.

The connections between the STSC and the Transfer and Decant/Filter System transfer lines are River Bend Transfer Systems$^{12}$ coaxial connectors, shown in Figure 2-13. These connectors are qualified to ASME B31.3, Process Piping, as an unlisted component. The process connections feature a coaxial design where the inner process connection is housed with an integral secondary confinement pipe (pipe-in-pipe).

The River Bend Transfer Systems coaxial connectors consist of 1.5 in. primary piping and hose components housed in a secondary confinement pipe. The connector assembly mates to the HIH with a standard pipe flange to form the hose assembly. The connector is bolted to the STSC nozzle with a three-bolt flange (transfer line) and a four-bolt flange (decant line) to help operators differentiate between the two and prevent cross connections. The primary line is sealed to the STSC nozzle with a face seal. The outside of the nozzle has a gland seal that serves as a ventilation seal to decrease air inleakage and maintain a higher negative pressure on the

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$^{12}$ River Bend Transfer Systems is a registered trademark of River Bend Transfer Systems, LLC, Richland, Washington.
primary line during hose drying evolutions. This seal also wipes the outside of the primary connector as it is removed from the STSC nozzle, thus reducing the amount of contamination on the outside of the connector. Both the face seal and gland seal are an integral part of the STSC primary nozzle and therefore will be new with each STSC and used only once.

Figure 2-13. Coaxial Connector
Other features of the connector include integral leak detection at the base of the connector and flush ports integral to the STSC that allow introduction of water to flush the annuli if the HIH or pipe-in-pipe portion of the transfer line (ECRT-H-107) or decant line (ECRT-H-203) leak.

The annulus of the slurry hose and the decant hose both drain to the STSC. The secondary annulus also has drain piping and valves integral to the STSC that allow the secondary annulus to be drained into the STSC. Drainage from the HIH annulus to the leak detectors is through a 3/8-in. diameter orifice in a faceplate that also forms the coaxial spacer between the primary and secondary lines. The orifice size was determined through testing based on the need to control air inleakage from the ambient to the process enclosures (both decant and transfer boxes) when the connectors are disconnected from the STSC.

2.5.2.5 Sludge Retrieval

There are two sludge retrieval lines: one in the Center Bay and one in the East Bay (Figure 2-1). The In-Basin retrieval and transfer equipment starts with one XAGO retrieval tool (XAGO) Pump Skid that has three-way valves to allow for lining up to either the Center or East Bay retrieval line. Each bay’s retrieval and transfer equipment consists of a XAGO, an Instrument Spool, a Booster Pump Skid, and an In-Basin Flocculant Addition Skid. The Booster Pump Skid discharge hoses both connect to the rupture disk skid. The rupture disk skid has a manual isolation valve for each line. The two lines meet after the isolation valves and one hose is on the outlet that continues to the Ingress/Egress Assembly. Only one bay’s retrieval and transfer equipment is lined-up and used at a time. This configuration allows for an easy re-alignment to support layering of SCS-CON-230 sludge (Center Bay) with KE Sludge (East Bay) in a single STSC (see Section 2.5.2.6, “Sludge Layering”). The following description refers to only one line being used.

Sludge will be retrieved from the engineered containers in the 105KW Basin using a XAGO, manufactured under license from XAGO Nuclear Ltd by NuVision (see Figure 2-14). The XAGO has three principal components: a Coanda fluidizer head, high-pressure fluidizing jets, and an eductor. The Coanda head provides local fluidization of the sludge to facilitate insertion of the XAGO into the sludge bed. The fluidizing jets, mounted at the end of the XAGO, locally mobilize the sludge bed in the engineered container to facilitate efficient sludge retrieval. The eductor provides the motive force to transfer the sludge-water slurry out of the container to an in-line booster pump. Detailed drawings of the XAGO are provided in VI-15-000024, Final Revised Drawings.

The XAGO Pump Skid boosts IXM water pressure to the levels needed by the XAGO. A separate sludge mobilization tool, also supplied with water from the fluidizing pump on the XAGO Pump Skid, can be used to dislodge and move sludge to the vicinity of the XAGO. An In-Basin Flocculant Addition Skid may be used during sludge retrieval and transfer to add flocculant to the slurry to enhance sludge settling in the STSC. Flocculant would be injected at the suction-side of the in-line booster pump.

The XAGO for a given retrieval line is positioned north and south using a deployment beam on the overhead monorail system; and is positioned east and west using a trolley on the deployment beam. The XAGO is positioned vertically using a hoist on the trolley. This configuration allows placing the XAGO tool in each of the egg crates of a given container.
The location of the containers in the basin is indicated by labels on the lids of the engineered containers.

Operators position the XAGO on a chain hoist above the selected engineered container from which sludge will be retrieved. The basin water level is verified, instruments are read, hose connections verified, valve positions verified, and the appropriate switch settings and cable hook-ups are made. Switch settings and cable connections are made according to whether the transfer will be made from an engineered container using the center bay or East Bay train. After the selections are made, the appropriate booster pump is ready to start.

To retrieve sludge, Operators start the Automatic run sequence, which initiates motive water flow to the XAGO by turning on the Motive Flow Pump ECRT-P-51, and starts Booster Pump ECRT-P-101A/B. To prevent inadvertent start-up, the power to the booster pump is controlled by a key switch which is under the control of the Field Work Supervisor. The operators then insert the XAGO into the engineered container. As the operators lower the XAGO into the sludge, the booster pump transfers sludge slurry from the engineered container to the STSC. The retrieved sludge slurry concentration is monitored on AIT-710-101A/B at panel ECRT-PNL-101 by the operators controlling the XAGO tool. As needed to control slurry solids concentration, the operator can either actuate the XAGO fluidizing jets intermittently using the Fluidizing Pump to increase the concentration, or raise the XAGO tool using the Hydrolance Deployment Beam hoist to lower the concentration. The target is to maintain the sludge slurry concentration at a nominal 5 vol% solids.

Operators conduct the sludge retrieval process manually. The rate at which sludge is retrieved depends on the speed of the booster pump, and is controlled to maintain a constant 70 gal/min. The solids concentration of retrieved slurry depends on the frequency at which the fluidizing jets are operated, and the depth of the sludge bed.

Process flowsheets assume that sludge is retrieved at a nominal 5 vol% solids. The retrieved sludge-water slurry varies in volume percent solids content ranging up to as high as 15 vol%, as demonstrated in equipment testing with sludge simulants. Operators use readings from a specific gravity instrument as an aid in operating the fluidizing jets.
The STSC design capacity defines the volume of slurry that is transferred in a given batch. At 70 gal/min and an empty STSC, it takes approximately 11 minutes to reach the design capacity of 3.5 m$^3$. Differential weight is the primary process control parameter for determining the quantity of sludge transferred to the STSC. For a discussion of differential weight as a process control parameter, refer to PRC-SP-00366, White Paper – Process Control Using Differential Weight Calculation Application and Limitations. The STSC also is equipped with level indication that is interlocked to prevent overfilling, and the retrieval and transfer equipment is provided with a timed, automatic shutoff.

The quantity of sludge in an STSC is limited to the values listed in Table 2-2 based on thermal, gas generation, and sludge expansion considerations during long-term storage at T Plant. These limits, which are used to derive operational setpoints, are protected by a specific administrative control technical safety requirement. The amount of sludge in an STSC is based on measurements of the buoyant weight of the sludge. The buoyant weight limits in Table 2-2 are derived from the volume limits using safety basis sludge densities (see Section 4.5.6, “Sludge Buoyant Weight Limits”).

Figure 2-14. XAGO Retrieval Tool
Table 2-2. STSC Sludge Volume and Buoyant Weight Limits

<table>
<thead>
<tr>
<th>STSC Sludge Composition</th>
<th>Sludge Volume Limit (m³)(^a)</th>
<th>Corresponding Buoyant Weight Limit (kg)(^{b,c})</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCS-CON-230</td>
<td>0.4</td>
<td>≤720</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>1.6</td>
<td>≤960</td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>1.6</td>
<td>≤1056</td>
</tr>
<tr>
<td>SCS-CON-220</td>
<td>1.0</td>
<td>≤789</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>2.1</td>
<td>≤1260</td>
</tr>
</tbody>
</table>

Notes:
\(a\). HNF-41051, Table 2-2.
\(b\). PRC-STP-00754, Sludge Treatment Project Engineered Container Retrieval and Transfer System Setpoint Determination Document, Table 6-1.
\(c\). Derived using safety basis densities.

Sludge expansion considerations during long-term storage at T Plant include: (1) sludge expansion that raises the supernate level in the STSC to the point it blocks the vent flow at Nozzle S2, and (2) sludge expansion that causes the supernate to spill out of the STSC via open Nozzle S2. Preventing these events requires limiting the maximum fill level of supernate and sludge in an STSC to the values listed in Table 2-3 prior to shipment to T Plant. Compliance with the Table 2-3 limits ensures that the level of supernate and expanded sludge remains approximately 1.5 in. below Nozzle S2. The Table 2-3 values were derived using design basis sludge expansion factors and provide the maximum level of supernate for shielding that does not expand and block the vent. The use of design basis versus safety basis expansion factors is a balance between the actual radiological exposure to the facility worker from direct radiation dose versus theoretical sludge expansion during long-term storage.

Table 2-3. STSC Maximum Liquid Level

<table>
<thead>
<tr>
<th>STSC Sludge Composition</th>
<th>Maximum Liquid Level (supernate and sludge) (in)(^{b})</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCS-CON-230 layered with SCS-CON-240, -250, -260</td>
<td>72</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>74</td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>77</td>
</tr>
<tr>
<td>SCS-CON-220</td>
<td>73</td>
</tr>
</tbody>
</table>

Notes:
\(a\). From PRC-STP-00754, Table 6-2
\(b\). Level in inches relative to STSC interior bottom
2.5.2.6 Sludge Layering

Early in the STP, RL provided direction that Settler Tank Sludge was to be stored separately (i.e., “maintain segregation”) from other sludge types (07-KBC-0057). CHPRC formally requested removal of the requirement to maintain segregation of Settler Tank Sludge from other sludge types based on the potential to improve the safe transport and storage of sludge and the potential to reduce project cost and schedule (CHPRC-1302732). This request was conditionally approved by RL (Letter 1303505A/1313-AMRP-0285), and CHPRC was directed to perform a life-cycle cost analysis to compare cost impacts with potential savings associated with sludge blending. Although several STP documents use the term “blending,” the term, as described in PRC-STP-00884, Life Cycle Cost & Benefit Analysis for Blending Sludge Types in Sludge Transport and Storage Containers for the Sludge Treatment Project Engineered Container and Retrieval Transfer System, refers to layering of sludge types within a single STSC without intentional physical mixing or homogenization. Therefore the term “layering” is used in this Documented Safety Analysis (DSA).

Five layering options were evaluated in PRC-STP-00884. The STP-selected layering option was to combine Settler Tank Sludge from SCS-CON-230 with KE sludge from SCS-CON-240, -250, and -260 in an STSC. As evaluated in PRC-STP-00884, this option reduces the total number of STSCs from 24 to 18, and allows for a single STSC design without an inner cylinder. As documented in HNF-41051, a maximum of 0.4 m³ of Settler Tank Sludge will be combined in an STSC with a maximum of 1.6 m³ of KE sludge. RL approved the STP-proposed layering option via their approval of PRC-STP-00718, Preliminary Documented Safety Analysis for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, Rev. 1 (letter 15-NSD-0027_RL).

Removal of the requirement to maintain segregation of Settler Tank Sludge also impacts the management of SSM. In addition to the sludge in the engineered containers, there were four, double-barreled fuel canisters containing 25.4 L of SSM. This material was generated during the pretreatment and processing of KOP material, which was performed in the 105KW Basin in 2012 as described in PRC-STP-00750, Project Transition/Closeout Report for the Sludge Treatment Project Knockout Pot Disposition Subproject. RL has directed this material to be managed as settler material (Letter 1200862 A/12-AMRC-0101). Given removal of the requirement to maintain segregation, this material was placed into SCS-CON-220 and will subsequently be retrieved into an STSC along with the SCS-CON-220 sludge. Analyses (e.g., thermal and gas generation) have been performed that demonstrate that the SSM and SCS-CON-220 sludge can be safely loaded into an STSC and transported to T Plant.

2.5.2.7 Sludge Transfer

Two skid-mounted, underwater booster pumps provide the motive force to pump slurry from the 105KW Basin selected bay to the 105KW Annex. The pumps are peristaltic pumps consisting of a hose immersed in a lubricating fluid. Rotating shoes that are external to the hose, compress the hose and push the slurry through the hose ahead of the shoe. The transfer rate is nominally 5 vol% solids at approximately 70 gal/min, at a pressure of approximately 100 psig. The retrieved sludge-water slurry is transferred from the underwater booster pumps through underwater hoses. The underwater hoses attach to the rupture disk skid, which includes isolation valves that allow for line-up of either the Center or East Bay transfer lines. Pressure relief is provided by a rupture disc located underwater on a skid.
From the rupture disk skid, the slurry is transferred via underwater hose to the Ingress/Egress Assembly shown in Figure 2-6. The Ingress/Egress Assembly contains piping for the transfer of slurry and for the return of filtered supernate to the basin (see Section 2.5.2.10, “Sand Filter Backwash”). It also provides separate piping to supply IXM water to the 105KW Annex. The IXM water piping is external to the double-contained slurry piping and decant return piping; there is no cross-connection between these lines. For slurry transfer, the assembly construction is pipe-in-pipe (i.e., a 1.5-in.-diameter inner pipe and a 16-in.-diameter outer pipe). The assembly contains leak detectors to detect leaks in either the slurry transfer line or filtered supernate (decant) line, and routes the release safely back to the basin below the water level. The slurry, filtered supernate, and IXM water lines are routed within a shielded hose chase (referred to as the In-Basin Shielded Hose Chase) that extends approximately 8 ft from the Ingress/Egress Assembly to a penetration in the north wall of the 105KW Basin, where it connects to the Horizontal Shielded Hose Chase that runs to the 105KW Annex.

The transfer line from the 105KW Basin to the 105KW Annex is made up of flexible HIH. The interior hose is 1.5-in. nominal inside diameter, with a 0.375-in. wall thickness. The secondary confinement hose is 4-in. nominal inside diameter, with a 0.45-in. wall thickness. The hose material is ethylene propylene diene monomer synthetic rubber, reinforced with a synthetic fabric mesh and a two-wire helix to prevent static charge buildup.

To minimize plugging, the 1.5-in.-diameter hose is six times the diameter of the largest sludge particles. At a flow rate of 70 gal/min, the velocity in the hose is 12.7 ft/s, which is greater than the bounding critical velocity of 12.3 ft/s as calculated in PRC-STP-00021, Preliminary Hydraulic Analysis for Direct Loading of Sludge Transport and Storage Containers, and double the terminal settling velocity of a 0.25 in. uranium metal sphere (6.3 ft/s).

A review of critical velocity was performed in PRC-STP-CN-M-00563, Slurry Transfer Hydraulic Parameter Review for the Sludge Treatment Project - Engineered Container Retrieval and Transfer System (STP-ECRTS). As defined in PRC-STP-CN-M-00563, the critical velocity is the velocity required to avoid the settling of solids in the transfer line. The bounding critical velocity of 12.3 ft/s was calculated using the Schiller and Herbich correlation. Use of the more commonly employed Wasp correlation yields a critical velocity of 9.8 ft/s. The adopted flow rate of 70 gpm provided by the Schiller and Herbich correlation exceeds the 20-30 gpm predicted by the Wasp correlation, thus providing a design margin of approximately 40 gpm. Subsequent testing, documented in PRC-STP-TR-00903, Report for the Integrated Process Optimization Demonstration for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, demonstrated that the Transfer System is capable of re-suspending settled solids were an upset condition to occur.

On the Mezzanine level of the Sludge Loading Bay, the HIH slurry transfer line connects to the TLSB. Temporary shielding (lead blankets, etc.) may be used to keep radiation exposure as low as reasonably achievable (ALARA).

The TLSB provides secondary confinement for piping, hoses, and valves normally configured for slurry transfers to the STSC, and also for the Overfill Recovery Pump and associated instrumentation and valves. The TLSB also provides confinement for venting the transfer line, and is equipped with leak detection interlocked with the In-Basin Booster Pump and Overfill Recovery Pump to shut down a transfer in the event of a loss of primary containment in the box. The TLSB is provided with IXM water to back flush lines as necessary, and to enable flushing of
the box in the event of a loss of primary containment. A second length of HIH transfer line runs
from the TLSB to the STSC.

2.5.2.8 Transfer Line Flush

Because of the volume percent solids contained in the retrieved sludge-water slurry, multiple
batches of slurry must be retrieved, settled, and decanted to fill an STSC to the maximum sludge
volumes shown in Table 2-2. Following each batch transfer of slurry into the STSC, the transfer
line is flushed with 105KW Basin water to remove excess solids. This decreases the radiological
dose rate of the unshielded process lines and prevents the transfer line from plugging by
accumulated solids.

To perform the flush, the XAGO is withdrawn from the sludge in the engineered container while
still operating to allow basin water to flush solids toward the booster pump. The basin water
flush valve is then opened and basin water is introduced into the suction side of the booster pump
to complete the line flush. A total of approximately 50 gal of basin water is added to the STSC
during a flush.

Fouling of the Transfer and Decant/Filter System hoses could increase radiation dose rates and
increase the potential spread of contamination as the hoses are disconnected from the STSC. In
order to reduce fouling, a foam swab, referred to as a pig, can be inserted into process piping,
and pushed through the system by water transfer. The pig’s diameter is approximately 2.5 in., is
5 in. long, and is made of polyurethane open-cell foam. The need for pigging is determined by
Radiation Control based on measured radiation dose rates in the KW Annex Sludge Loading Bay
and Mezzanine. Pigging will be considered if the measured dose rate in contact with a transfer
line exceeds 35 mrem/hr. The Transfer System is pigged starting at the booster pump through
the 3-in. flush line. In-Basin remote tools will be used to manually introduce pigs into the
Transfer System. The Decant/Filter System is pigged starting at the Ingress/Egress Assembly. Pigs will be introduced manually into the Decant/Filter System at a manifold at floor
level. The pigs will flow through the systems and into the STSC. Pigging will only be
performed after slurry transfers into an STSC are completed because a pig could block the
internal STSC piping. The pigs have an internal magnet to allow the magnetic pickup
instrumentation in the TLSB and Decant Pump Box to identify that a pig has passed through
the box.

2.5.2.9 Settling, Decant, and Filtration

After a transfer is completed, the slurry in the STSC is allowed to settle by gravity for a
minimum of 2 hours. The supernate in the STSC can then be decanted from the STSC via a HIH
decant transfer line similar to the slurry transfer line.

On the Mezzanine level of the Sludge Loading Bay, the decant transfer line connects to the
Decant Pump Box. Temporary shielding (lead blankets, etc.) may be used to keep radiation
exposure ALARA.

The Decant Pump Box provides an enclosure for the Decant Pump and associated
instrumentation and valves and also provides confinement during venting of the decant line. It is
equipped with leak detection interlocked with the Decant Pump to shut down a transfer in the
event of a loss of primary containment in the box. The Decant Pump Box is provided with IXM
water to back flush lines as necessary, and to enable flushing of the box in the event of a loss of
primary containment. A HIH transfer line connects from the Decant Pump Box to the TLSB to allow recirculation of decanted supernate to the STSC. A HIH transfer line connects the Decant Pump Box to the Sand Filter Skid located on the floor of the Sludge Loading Bay.

After a required settling duration of 2 hours, the Decant/Filter System is operated in recirculation mode. The required settling duration is established to protect accident analysis assumptions regarding the material-at-risk for supernate and sand filter backwash spray release accident scenarios (see Section 3.4.2.1.5). In recirculation mode, supernate is pumped at 20 gal/min from the STSC through the Decant Pump Box into the TLSB and back into the STSC. During recirculation, the supernate turbidity is measured by an inline turbidity meter located in the Decant Pump Box. If the turbidity is less than 1500 Nephelometric Turbidity Units (NTUs), the supernate is pumped from the STSC to the ECRTS Sand Filter to remove entrained solids and further reduce turbidity to below 210 NTU (90 mg/L). From the ECRTS Sand Filter, filtered supernate is transferred through a HIH transfer line back to the Ingress/Egress Assembly and into the basin.

If the supernate turbidity is greater than 1500 NTU, the 105KW Annex Flocculant Addition Skid can be used to add flocculant through an inline mixer located in the Decant Pump Box. The supernate is then allowed to settle for additional time, if required. The decant process can be shut down manually or it can shut down automatically on high filtrate turbidity, high supernate turbidity rate-of-change, decant low flow rate of change, or STSC low level.

After decanting the supernate, the liquid level in the STSC and the weight of the STS Cask/STSC on the trailer are recorded. The buoyant sludge weight in the STSC is determined to ensure that the STSC is not overfilled with sludge. Additional batches of slurry are retrieved from an engineered container and transferred into the STSC as previously described until the desired sludge volume is loaded into the STSC.

The ECRTS Sand Filter is housed inside the Sand Filter Skid located in the southeast corner of the Sludge Loading Bay on the floor level. The ECRTS Sand Filter is approximately 2 ft in diameter and 7 ft tall. The ECRTS Sand Filter media is composed of anthracite, silica, and garnet.

The process of sludge retrieval and transfer, supernate decant, filtration, and return of filtered supernate to the basin may be repeated until the desired volume of sludge is loaded into the STSC. The volume of settled sludge in an STSC is limited so that, during storage at T Plant, the sludge level remains below the open nozzles for sludge expansion occurring from gas accumulation in the sludge and uranium density changes from oxidation. Operators will use a combination of liquid level, STSC weight, and tabulated sludge densities to verify the STSC sludge volume.

2.5.2.10 Sand Filter Backwash

Following the last decant of supernate from the STSC, the solids captured by the ECRTS Sand Filter are backwashed to the STSC. The backwash uses IXM water from the basin water skimmer system. The same transfer line used to decant supernate from the STSC is then used to send the ECRTS Sand Filter backwash to the STSC. The decant pump is bypassed to enable the transfer of the ECRTS Sand Filter backwash solution and solids into the STSC. After the ECRTS Sand Filter backwash has been performed, the backwash line is flushed with approximately 1.5 line volumes of IXM water. The liquid level in the STSC and the weight of
the STS Cask/STSC on the trailer are recorded. Once the ECRTS Sand Filter backwash is completed, the mass of settled sludge in the STSC is determined to ensure that the STSC is not overfilled with sludge.

2.5.2.11 Overfill Recovery

An Overfill Recovery Tool, permanently installed in each STSC, is used in the event that sludge needs to be removed from the STSC. The capability of the Overfill Recovery Tool to remove substantial quantities of sludge from an STSC was successfully demonstrated during full-scale, Pre-Operational Acceptance Testing conducted at the Maintenance and Storage Facility (MASF).

If needed, the Overfill Recovery Tool would be connected via hoses to IXM dilution water, the Overfill Recovery Pump, and the Overfill Recovery Water Pump. The Overfill Recovery Pump is an air-operated, double-diaphragm pump located in the TLSB. The Overfill Recovery Water Pump and associated pump controller are mounted on a portable skid located on the mezzanine.

Underwater in the 105KW Basin, the slurry transfer line is disconnected from the discharge side of the appropriate booster pump and routed to the appropriate engineered container through a retrieval slot. The Overfill Recovery Tool uses IXM water to fluidize sludge in the STSC, which is diluted with IXM dilution water then pumped via the slurry transfer line to an engineered container in the 105KW Basin by the Overfill Recovery Pump, bypassing the In-Basin Booster Pump. Following the removal of excess sludge, the Overfill Recovery Pump and slurry transfer lines are flushed with IXM water to the engineered container and to the STSC. The IXM water line and the slurry pump line are then disconnected from the Overfill Recovery Tool and the nozzle caps are reinstalled. The In-Basin hose is restored to its original configuration on the booster pump.

2.5.2.12 STSC Process Disconnects

Following any final flush of the slurry transfer and decant lines, IXM water is added to the STSC to the final fill level. This provides the maximum possible water level to provide radiation shielding at the top of the STSC when operators perform the process disconnects while also limiting the water level, thus preventing sludge expansion events during long-term storage at T Plant. High point vent valves on these lines are opened, allowing the lines to drain. The coaxial connectors are lifted approximately 2 in., which releases the seal between the inner pipe component of the connector and the STSC nozzle without retracting the inner pipe component from the STSC, and the lines are allowed to dry. This allows the remaining contents of the line to drain into the STSC, minimizing the potential for contamination release. The slurry transfer line and decant line are then removed from the STSC nozzles and the nozzles and hoses are capped. The slurry transfer line, decant line, and nozzles on the STSC are surveyed and decontaminated as necessary, and the supplemental ventilation hood is removed. The lines are placed into their storage area on the Mezzanine. Instrument cables are disconnected. The 4-in.-diameter ventilation line is also disconnected from the STSC and capped, leaving only the purge inlet and purge outlet lines connected.

2.5.2.13 Nitrogen Inerting and Pressurization

To prevent hydrogen from reaching a flammable mixture in the STSC, the STSC is inerted with nitrogen. Nitrogen gas is provided from both the Auxiliary Ventilation System and the Inert Gas System. To inert the STSC, the nitrogen flow is initiated by opening the inert gas supply valve.
and then the valve on the room air inlet HEPA filter is closed. When the valve on the room air inlet HEPA filter is closed, the Auxiliary Ventilation System automatically begins a flow of nitrogen to ensure that the hydrogen concentration in the STSC stays below 25 percent of the lower flammability limit (LFL) during the inerting process. The STSC is purged with nitrogen until the oxygen concentration in the purge outlet line is less than 0.5 vol% as measured by an Oxygen Analyzer. After the STSC has been successfully inerted, the nitrogen flow is isolated, the purge inlet line is disconnected from the STSC by use of a self-sealing quick-disconnect mounted on Nozzle S2, and a NucFil® filtered vent is connected to the quick-disconnect. The nitrogen purge outlet is then disconnected at a self-sealing quick-disconnect and a NucFil filtered vent placed on the nozzle. A final radiological survey of the STSC is conducted and the lid is placed back on the STS Cask.

To prevent hydrogen generated by the sludge from reaching a flammable concentration in the STS Cask, the cask is inerted with nitrogen from the Inert Gas System. The STS Drain Port Tool, which was preinstalled in the STS Cask, is connected to the Nitrogen Purge Panel and verified prior to inerting. To inert the cask, a STS Cask Vent Tool is connected to the STS Cask Lid and the purge outlet line, and nitrogen flow is started. The STS Cask is purged with nitrogen gas until the oxygen concentration is less than 1.2 percent as measured by an Oxygen Analyzer. The cask vent plug is then reinstalled and the STS Cask Vent Tool is removed.

The STS Cask is pressurized with nitrogen to between 3 and 15 psig. Pressurizing to greater than 3 psig prevents air inleakage during transportation. Pressurizing to less than 15 psig ensures that the STS Cask will not exceed its pressure rating during transportation. To pressurize the cask, the STS Cask vent port is closed, and a pressure regulator is set to establish the required backfill pressure as indicated on a pressure indicator. The STS Cask drain port plug is reinstalled and the STS Drain Port Tool is then removed to make the STSC ready for transport.

The 105KW Annex roll-up door is opened, the tractor is then reconnected to the STS Trailer, and the shipment transported to T Plant for interim storage.

2.5.3 Other 105KW Basin Process Equipment

105KW Basin operations involve handling sludge and contaminated debris, with the intent of storing and eventually removing these items. All activities to support fuel retrieval, KOP processing and fuel/KOP material removal from the basin have been completed as of 2012 and the support equipment is no longer in use. Fuel handling equipment will remain available in the event fuel fragments are found during sludge and debris handling. A plan view of the equipment installed in the 105KW Basin is shown in Figure 2-15. The major pieces of equipment used in the basin are described in the following subsections, and are as follows:

- Monorails, hoists, and basin cranes
- Sludge handling
- Debris and fuel storage and handling tools

Typical operations activities include the following:

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13 NucFil is a registered trademark of Nuclear Filter Technology, Inc., Golden, Colorado.
• Operation of the water treatment system
• Management of fuel fragments
• Retrieval, storage, movement, and containerization of sludge
• Sorting and removal of debris
• Removal and disposal of equipment no longer in use
• Packaging, handling, and interim storage of waste

2.5.3.1 Cranes, Monorails, and Hoists

The monorails, hoists, and cranes provide a means to load, handle, and retrieve sludge, underwater equipment and debris, and IXMs, and to support maintenance activities. DOE/RL-92-36, Hanford Site Hoisting and Rigging Manual, requires inspections of cranes, hoists, chains and hooks, monorails, wire rope, wire rope slings, multi-legged slings, spreader bars, and below-the-hook lifting devices. Before use, inspections are performed on eyebolts and shackles. Hoists, cranes, and monorails will not be loaded beyond the rated load except for test purposes, as provided in DOE/RL-92-36.

2.5.3.1.1 105KW Basin Monorails, Flexible Transfer Crane, and Hoists

A series of parallel monorails hanging from the superstructure run north-south over the basin. Two flexible transfer crane rails, also hanging from the superstructure, extend around the basin perimeter. A flexible transfer crane is mounted on the perimeter rails. A short monorail section is suspended from the flexible transfer crane carriage and can be aligned with the fixed monorails. Hoists mounted on trolleys can traverse the fixed monorails and transfer to the monorail mounted to the flexible transfer crane. To move a load in the east-west direction, the hoist trolley is moved onto the flexible transfer crane monorail, and the flexible transfer crane is moved on the flexible transfer crane rails. Mechanical interlocks prevent loads from leaving the monorail unless the flexible transfer crane is in position to transfer the load, and they also prevent loads from coming off the flexible transfer crane monorail when the flexible crane monorail is not positioned for a fixed monorail to accept the load.
Figure 2-15. Plan View of Installed Equipment in the 105KW Basin
The monorails are rated at 2400 lb. In the 105KW Basin, portions of monorails 24, 26, 27, and 31 over the obsolete fuel retrieval equipment are rated at 4000 lb. Rail stops prevent loads from moving from the 4000-lb portion to the 2400-lb portion of the monorail. A removable rail stop is used on monorails 24, 26, 27, and 31 and may be moved to allow access to the full length of the monorail to support debris and equipment movement/handling as allowed by DOE/RL-92-36. The 4000-lb-rated monorail extension south of the flexible transfer crane is in line with monorail 27. This monorail extension has interlocks to prevent loads from moving off the extension unless a flexible transfer crane is in position to accept the load.

The monorail and flexible transfer crane interfaces and interlocks are compatible. There are two 2400-lb transfer cranes and two 4000-lb transfer cranes used in the 105KW Basin. A portion of the 105KW Basin transfer crane perimeter rail is rated at 4000 lb. Rail stops prevent the 4000-lb rated transfer cranes from accessing 2400-lb rated areas of the perimeter rails. Interlocks prevent the 4000-lb transfer cranes from placing a load onto a 2400-lb rated monorail. The 2400-lb transfer cranes are allowed access to the upgraded areas of track. The 2400-lb rated transfer crane may accept loads from the 4000-lb rated monorails as allowed by DOE/RL-92-36. The 4000-lb transfer cranes are currently out of service and may be removed or abandoned in place.

One- and two-ton electrically operated hoists hung from trolleys are used to move loads through the basin on the monorail system. Two-ton hoists were used to move loaded MCO baskets from the Fuel Retrieval System (FRS) east secondary process table to the MCO basket queue, and from the MCO basket queue to the MCO Loading System shuttle. These activities have been completed and the associated equipment may be removed or abandoned in place.

### 2.5.3.1.2 105KW Basin Transfer Bay Bridge Crane

The 105KW Basin Transfer Bay bridge crane (HOI-418) is a 32-ton-capacity, top-riding bridge crane with a motorized bridge, trolley, and hoist. The specifications for the 105KW Basin Transfer Bay bridge crane are in HNF-S-0479, Specification for Two Bridge Crane Trolley and Hoists-Project A.5/A.6. The HOI-418 trolley, bridge, and main hoist have a Class B duty classification in accordance with CMAA 70, Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes, and were constructed under ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities. Dead loads, live loads, seismic loads, and impact loads were evaluated in HNF-SD-SNF-SA-003, 105 K Transfer Area Overhead Crane and Supporting Structures Structural Evaluation.

The trolley has a 3-ton auxiliary hoist (HOI-423) located on the east side. The auxiliary hoist has a duty classification of H4 in accordance with ASME HST-4M, Performance Standard for Overhead Electric Wire Rope Hoists. The auxiliary hoist has a single swivel hook and is capable of making a true vertical lift. It is controlled with either the radio or a pendant controller. The auxiliary hoist and main hoist are not operable at the same time. A switch on the radio control panel transfers operation between the main and auxiliary hoist.

### 2.5.3.2 In-Basin Sludge Handling

The original KW Floor and Pit Sludge Retrieval (FPSR) System vacuumed KW Basin sludge from the East Bay, Center Bay, and pits, and then transferred it to the KW SCS. The FPSR System’s mission of pumping sludge from the 105KW Basin bays and pits was completed in
2010; however, the components associated with the FPSR Tri Nuclear\textsuperscript{14} pump will be maintained as an ECRTS recovery contingency in the event of an in-basin sludge spill.

Portions of the unused FPSR System may be abandoned in place or removed as debris. The system consists of end effectors, the Tri Nuclear pump and strainers, connecting hoses, and an optional debris trap and flow control valve. The main purpose of this system was to vacuum the basin floor. Floor and pit sludge was drawn into the selected vacuum head by a slurry pump. From the slurry pump, the sludge was then sent to the strainer assembly. Smaller sludge particles that passed through the strainer remained suspended in the water and were transported to the KW SCS (see Section 2.5.2.1).

Sludge pumping equipment (including portable equipment) may be used to move sludge within the confines of the fuel storage basin. This equipment was used to transfer sludge from various basin locations (e.g., the main basin and the SLOP) to a location where it could be temporarily stored; this equipment was also used to obtain sludge samples from any location in the basin.

2.5.3.3 Debris and Fuel Storage and Handling Tools

The monorail, hoist, and trolley are used for transferring empty canisters and miscellaneous debris in the basin. Long-handled tools are used to manipulate items under water. Additional equipment or tools can include shredders/choppers, shears, cutters, and a pressure water system.

Canisters and miscellaneous debris are segregated according to size to aid in handling and packaging for disposal. Debris is cut up to fit disposal containers. Debris (including empty canisters) are rinsed and packaged for disposal.

2.5.3.3.1 Fuel Storage Racks

The fuel storage racks are simple structures, resembling a series of tables when viewed in profile. They were fabricated from common carbon steel shapes. Each rack is a freestanding unit that is supported on the basin floor with four integral legs. The racks are not anchored to the basin floor or walls. Individual racks do not interlock with adjacent racks. However, the sides of the racks are designed to overlap those of the adjacent racks.

Sludge, fuel fragments, and debris may be stored in canisters and placed in the fuel storage racks stationed on the basin floor for operational convenience, or may be placed directly on the floor. The storage racks are open-bottomed so that the canisters are supported by the basin floor rather than the racks. The racks define individually numbered cubicle spaces that are sized to hold only one canister. Most of the racks in the basin have been modified or removed, as necessary, to accommodate equipment installation or sludge retrieval activities in the basin. The remaining racks may be removed or relocated as necessary to support debris relocation and future equipment installation.

The fuel storage racks were analyzed in HNF-SD-SNF-SARR-006, \textit{Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks}, to demonstrate that damage, modification, or removal of the fuel storage racks is acceptable.

\textsuperscript{14} Tri Nuclear is a registered trademark of Tri Nuclear Corp., Ballston Lake, New York.
2.5.3.3.2 Fuel Handling Tools

The canister hooks are hung from a hoist attached to the monorails or flexible transfer crane. Each canister hook has a hook on the lower end, which engages the upper trunnion of the canister. The hoist raises and lowers the canister hook to raise and lower the canister. The hooks can only travel along the slots in the grating and in the open pit areas of the basin. The design restricts the lift to approximately 2 ft 5 in. for the long straight hook and 4 ft for the short straight hook. Even when the hoist elevates the short straight hook to the highest position of hoist travel, at least 8 ft of basin water cover the canister (assuming a minimum 15-ft water depth). Telescoping stiffback and straight stiffback hooks are used for various process functions including lifting, moving, manipulating, and weighing canisters and debris. A portable scale also may be used with a straight stiffback hook for weighing canisters and other underwater-suspended loads.

Each telescoping stiffback includes a 1-ton electric chain hoist with rigid hook suspension, a chain container, chain stops, a pendant control, and a 1-ton trolley.

2.5.3.4 Miscellaneous

As 105KW Basin clean-out activities continue, it is anticipated that, at most, small quantities of fuel or fuel fragments may be found. The total quantity of fuel fragments is estimated to be less than 5 kg.

2.5.4 Basin Water Systems

Prior to the start of fuel removal operations, the 105KW Basin had approximately 1038 metric tons of spent fuel in sealed canisters that contained a corrosion inhibitor. The quantity of radioactive sludge in the bottom of the 105KW Basin was approximately 6.7 m³. Today, approximately, 0.6 m³ of sludge is estimated to remain on the basin floor and equipment, in addition to the sludge in the six SCS containers.

The basin water system consists of three distinct systems: the Basin Recirculation Cooling and Cleanup (BRC) System (commonly referred to as the primary recirculation system), the Skimmer Water Cleanup (SKW) System, and the IWTS. These systems are described in the following subsections.

2.5.4.1 Basin Water Recirculation and Cooling System

The BRC System was used for cooling the basin water during spent fuel storage. The BRC System has not been used for cooling basin water since the spent fuel was removed from the basin and may be deactivated. The cooling equipment is out of service. Based on temperature readings recorded by Operations during daily rounds, the basin water yearly average for 2014 was 60.88°F. The maximum basin water temperature of 68.5°F was recorded on October 13, 2014, and the minimum basin water temperature of 52.8°F was recorded on February 11 and 12, 2014. Figure 2-16 shows the 105KW Basin recirculation and skimmer water systems flow schematic.

Water from the basin enters the respective BRC 6-in. diameter pipe intakes at the north end of the East Bay, Center Bay, and West Bay at a nominal total flow rate of 450 gal/min. Water enters the pipes 12 ft 9 in. above the bottom of the fuel pool. The water then enters an 8 in. pipe header and flows into a recirculation cooling pump located in the Chiller Bay. A second parallel recirculation cooling pump is out-of-commission with no plans to return it to service. As the
water-cooled chiller and the air-cooled chiller are both out of service, the flow is routed through a 6-in. bypass line and discharges into an 8-in. diameter pipeline. The 8-in. diameter pipeline runs along the south end of the basin to the Transfer Bay area, where the IWTS IXMs are located. A 6-in. diameter downcomer pipe reenters the basin East Bay, Center Bay, and West Bay, providing approximately 150 gal/min of water to each bay.

A 4-in. tie-in between the skimmer pump discharge and the BRC pump suction is provided to fill the BRC pump and suction piping before a BRC pump is started.

The BRC System can provide 320 gal/min basin water flow through the IWTS annular filter vessel and IXMs to provide additional basin water ion-exchange capacity.

The piping in the BRC loops is schedule 40 carbon steel and is designed, installed, and tested to the requirements of ANSI/ASME B31.1-2007, Power Piping.

All pressure vessels are built to ASME BPVC, Section VIII, Division 1. Current IXMs are built to the 2007 revision of the ASME Code; however, new IXMs may be built to the revision that is current at the time of manufacturing. The pressure vessels include the out of service water-cooled chiller, the out of service air-cooled chiller basin water-to-refrigerant evaporator (ASME BPVC 1998), and the IXMs.
Figure 2-16. 105KW Basin Recirculation and Water Skimmer Systems Flow Schematic
2.5.4.2 Skimmer Water Cleanup System

The 105KW Basin SKW System removes radioactive and nonradioactive ionic species by processing the water through IXMs and maintains water clarity by processing the water through the SKW Sand Filter. The 105KW Basin SKW System schematic is shown in Figure 2-16.

During the normal operation of the SKW System, the basin water enters the three weirs at 120 to 150 gal/min per weir and a 17/32-in.-diameter suction loss hole at 10 gal/min. The suction loss hole is located on top of the horizontal run of the suction piping approximately 6 in. upstream from the start of the vertical run and 13 ft above the basin floor. This water flows into a 6-in. pipe and through a 6-in. ball valve and enters the skimmer pump (P-6) where the water is pressurized to 95 lb/in² gauge. The water goes through a discharge check valve and a ball valve, which reduces the pressure to between 40 and 60 lb/in² gauge. Water then flows through a butterfly valve and enters the SKW Sand Filter for particulate removal. When the water exits the SKW Sand Filter, the flow is split with a nominal flow of 160 gal/min going through an IXM. The IXM removes radioactive $^{137}$Cs and $^{90}$Sr ions. If required, a portion of the IXM water may be directed through a booster pump (e.g., to provide normal flow of IXM water to ECRTS) or through a bypass around the booster pump to the DEP. The remaining water flows to the West Bay of the basin or to the SLOP. The skimmer pump flow can be valved to bypass the IXM.

Except for the skimmer weirs, which are located in the basin at the loop inlets, the major parts of the system (e.g., the skimmer pump, the SKW Sand Filter, and the IXMs) are located in the Transfer Bay area. The basin NLOP is used to collect the backwash from the Sand Filter.

For SKW Sand Filter backwash, the flow exits into the basin NLOP. The flow rate during backwash is 300 to 450 gal/min. Before backwashing the SKW Sand Filter, the water level in the NLOP is lowered using the skimmer pump to remove approximately 1200 to 1500 gal of water to make room for the backwash water. The basin water in the NLOP may be drawn down to 15 ft 6 in. plus or minus 3 in.

The skimmer inlet weirs are adjustable water intakes for the skimmer pump. Three weirs are located on the north side of the basin, one in each bay. The weirs have been designed to supply an equal flow rate to the pump from each weir. Flow from each weir is approximately 120 gal/min. The skimmer weir intakes are screened with rectangular, 4-mesh stainless steel box-type screens that lie flat across the bottom of the weir. The screens are removable for cleaning or replacement. The screens prevent large floating debris from entering the piping system and plugging or damaging equipment downstream.

The skimmer pump, located in the northeast quadrant of the Transfer Bay area of the 105KW Basin, is a self-priming centrifugal pump. The pump is powered by a 30-hp electric motor.

The SKW Sand Filter in the 105KW Basin is composed of a housing and filter media. The housing was fabricated to the requirements of the ASME BPVC, Section VIII (1973), and is code stamped. It has a maximum allowable working pressure of 90 lb/in² gauge at 400°F. The housing is 78 in. in diameter, 84-in. high, and 0.25-in. thick. The inside is lined with 12-mil thick epoxy paint. The SKW Sand Filter is located immediately west of the skimmer pump in the Transfer Bay area.
The SKW Sand Filter vessel has a 2- by 3-in. relief valve. The inside bottom of the vessel is filled with approximately 37.5 ft³ of concrete, which supports the outlet piping. On top of the concrete is a 7.5-in.-thick layer of 1.4 mm “support sand.” On top of the support sand is a 32-in.-thick layer of 3-mm filter sand.

The filter housing is located in a rectangular 6-in.-thick concrete box to shield personnel and limit their radiation exposure to less than 5 mrem/hr. The concrete box has a removable steel lid to access the vessel manway.

Four IXMs are located in the basin, which remove soluble radionuclides from the basin water. Only one IXM at the 105KW Basin is used for the SKW System. The other three are used for the IWTS. Each module consists of six stamped, ASME BPVC, Section VIII, Division 1 (2007), pressure vessels that are 42 in. high with a volume of 4.1 ft³ each. Current IXMs are built to the 2007 Revision of the ASME Code; however, new IXMs may be built to the revision that is current at the time of manufacturing. The IXMs are fabricated from 16-in. nominal pipe size, schedule 30 (0.375-in.-thick wall) carbon steel pipe with 16-in. schedule 30 pipe caps on the ends. The maximum allowable working pressure is 150 lb/in² gauge at 200°F. No pressure relief protection is provided. The six vessels of each module are encased in a concrete structure 86 by 70 by 79.5 in. high to provide radiation shielding. Each IXM has four lifting lugs for transferring it into and out of position. Total weight of each IXM is approximately 44,000 lb wet and 42,000 lb dry. The IXMs are connected to the plant piping with hoses and quick disconnects. Each vessel contains 3.5 ft³ of ion-exchange resin, principally for removing ¹³⁷Cs and ⁹⁰Sr. The modules can remove up to 1400 Ci of ¹³⁷Cs and 233 Ci of ⁹⁰Sr. Other radioactive ions are present in the basin water and add to the overall dose; however, ¹³⁷Cs and ⁹⁰Sr are present in orders of magnitude higher concentration than other radionuclides and dominate the IXM radioactive dose. When the ion-exchange resin is depleted, the entire IXM is replaced.

The design flow rate through an IXM is 160 gal/min.

Each vessel has an outlet screen that contains the ion-exchange resin. Vent screens are connected to vent piping outside the module, which allows resin sampling and changes in resin type.

The inlet and outlet water of the IXMs require periodic sampling to estimate the quantity of radionuclides contained in the operating IXM for characterization and operational monitoring. IXMs are monitored for operating performance and to minimize the potential for greater transuranic (TRU) accumulations.

Only one pressure switch is used in the 105KW Basin SKW subsystem. The skimmer pump discharge low-pressure switch is located just downstream of the pump on a branch of piping that also contains the pressure indicator.

The SKW System in the 105KW Basin provides the flow for the IWTS annular filter vessels backwash and top sparge. The filters and IXMs are equipped with flow totalizers that measure the instantaneous flow and the total flow through the IXMs for estimating the radioactive material collected.
2.5.4.3 Integrated Water Treatment System

The IWTS filters and treats the basin water to minimize dose and maintain water clarity. It also supplies treated water directly to the basin. The IWTS equipment flow schematic for 105KW Basin is shown in Figure 2-17.

Basin water enters the IWTS through submerged pumps that provide suction to the areas where FRS operations had the potential to disperse sludge into the basin water. Other IWTS input streams include basin water from existing recirculation pumps and basin water from the existing skimmer pump for periodic backwash. The IWTS nominal flow rate is 320 gal/min with flow from the three pumps near the primary clean machine (PCM).

To meet operational needs, treated water from the IWTS is supplied to the distribution header for delivery to the following users:

- SLOP flush
- Debris processing: pump supply
- Debris processing: equipment flush
- Excess water removal

Water in the basin is managed using a closed-loop system. Most water is circulated through the treatment system and returned to the basin users. Water that exceeds the needs of the basin users is returned to the basin via the SLOP.

2.5.4.3.1 Integrated Water Treatment System Equipment Description

The 105KW Basin IWTS equipment and interfaces consist of the following:

- Pumps and intake interfaces
- Filtration units (strainers, particulate settler, and annular filter vessels)
- IXMs (same design as others in basin)
- Basin water recirculation interface
- Skimmer loop interface
- Treated water supply and demineralized water makeup
- Excess water removal

The arrangement of the IWTS equipment in the basin and Transfer Bay area is shown in Figure 2-16.
Figure 2-17. 105KW Basin Integrated Water Treatment System Equipment Flow Schematic
2.5.4.3.1.1 Integrated Water Treatment System Pumps

The IWTS pumps include the following:

- A submerged pump mounted on the obsolete FRS PCM
- A submerged pump mounted on a stand located about 10 ft southwest of the obsolete FRS PCM
- A submerged pump mounted on a stand located about 10 ft west of the obsolete FRS PCM
- A booster pump located in the Transfer Bay area to assist the basin water flow from the settlers to the annular filter vessels

Flexible nonmetallic hoses connect the pump discharge nozzles to a common stainless-steel header located on a table in the middle of the 105KW Basin’s West Bay.

2.5.4.3.1.2 Filtration Units

The filtration units include basket-type strainers for large particulate, particulate settlers for mid-sized particulate, and annular filters for small particulate. Valved connections in the system provide the capability to add filtration units, if necessary. Due to completion of fuel cleaning and KOP processing, many of the filtration capabilities are no longer available.

Modified “off-the-shelf” strainers have been historically installed downstream from the PCM, and one has been installed on the backwash line between the annular filters and the settlers (see Figure 2-18). The strainer vessels accommodate strainer basket changeout when needed. The strainer baskets are constructed of 30 mesh and effectively capture particles larger than approximately 600 µm. The strainer on the backwash line uses the same type of strainer basket, but uses a 10-µm filter bag (other sizes also may be used) to capture roaming particles. The strainer on the backwash line may also be bypassed as its use is optional. The strainer vessels are designed to ASME VIII, Division 1 Standards (ASME BPVC).

Two banks of two strainer vessels were historically added downstream from the fuel retrieval system pumps (see Figure 2-17) so that one bank can be valved in while the other is valved out for maintenance and strainer basket replacement. Manual isolation valves have been added upstream of each bank of strainers. Check valves prevent backflow through the valved-out strainer train while the fuel retrieval system pumps are operating and during the top sparge and backwash operation.

Pressure-indicating equipment is available to aid the operators in determining when strainer basket changeout is necessary and in troubleshooting strainer operation. On reaching a preset differential pressure, the strainer basket is removed. The strainer baskets are weighed before being placed into a canister for storage.
Note: Not to scale.

Figure 2-18. Strainer Housing and Strainer Basket

*Optional lid configuration available (See H-1-87474)
The particulate settlers, shown in Figure 2-19, are located in the weasel pit at the east end of the basin. The particulate settlers are pressure vessels designed to the requirements of Section VIII of the ASME BPVC (1995). These settlers consist of an array of 16-ft long, 20-in. diameter, schedule 10 stainless-steel pipes. The array is configured as two side-by-side stacks of five pipes 6 in. apart horizontally and vertically. A manifold is provided to evenly divide flow among the 10 pipes. Each settler has a high-point vent manifolded together with other settler vents and discharged through an air-water combination valve beneath the water surface. The settler tanks are supported by tube sheet supports.

Three stainless-steel annular filter vessels, located in the Transfer Bay area, are designed to the requirements of Section VIII of the ASME BPVC (1995). The stainless-steel annular filter vessels, shown in Figure 2-20 and Figure 2-21, have a nominal 5 μm filtration capability and are deep-bed sand filters with a volume of approximately 170 ft³ each. Each annular filter vessel is constructed of an inner and an outer tank. The bottom of the inner tank has an open pipe drain at the bottom.

The vessels are located in a shielded enclosure (above water) in the Transfer Bay area. The rectangular enclosure is made up of steel-lined concrete or lead-filled walls with a steel plate covering the enclosure. The enclosure provides shielding for personnel working in the area of the filters. IWTS piping with normal geometries is shielded with steel (pipe-in-pipe) for personnel working in the area of the piping. IWTS piping with difficult geometries is shielded with lead for personnel working in the area of the piping.

The filter vessels are sized for a cross-sectional flow rate of 5 gal/min/ft² and a volumetric flow of 0.67 gal/min/ft³, with a nominal design flow rate of 110 gal/min. These flow rates optimize filter efficiency and improve effluent quality. Each vessel contains about 80 ft³ of filter media. The filter media consist of fine sand and garnet, with a foundation layer of coarse sand to improve under-drain and backwash performance. Normal flow enters the top of the filter vessels and exits the bottom.

The filter vessels have valves and flanges to allow for connecting compressed air for air sparging.

The filter vessel system includes three separate radiation monitors, one for each filter vessel. These monitors activate audible and visual alarms on reaching predetermined setpoints for cesium activity levels or for loss of monitoring capability. The alarms are hard wired and do not rely on the computer control system for operation. Operators respond to the alarms as prescribed by the alarm response procedures. The radiation monitors are labeled for indication only and are no longer scheduled for periodic calibration.

2.5.4.3.1.3 Ion-Exchange Modules

The IXMs and associated control piping and valves are located above the water in the Transfer Bay area near the NLOP. Instrumentation includes conductivity, flow, and pressure sensors for each of the IXMs. Samplers are included at the common inlet and individual outlet of each IXM to provide reliable monitoring and control of TRU loading. IXMs are loaded with ion-exchange resin optimized to remove cesium and other dissolved radionuclides from the basin water. Piping connects the IXM discharge to supply treated water to basin users. See Section 2.5.4.2, “Skimmer Water Cleanup System,” for a discussion of IXM construction.
Figure 2-19. Particulate Settler
Figure 2-20. Annular Filter Vessel
Figure 2-21. Annular Filter Vessel Enclosure
2.5.4.3.1.4 Basin Recirculation Cooling

The BRC System was required to maintain pool temperature during spent fuel storage. The BRC enables part of the recirculation pump flow to be directed to the IWTS equipment. Valving allows recirculated water from the recirculation pump to be directed through the filter or IXM portion of the IWTS. The portion of the flow from the main recirculation header that is not diverted to the IXMs is discharged into the basin.

2.5.4.3.1.5 Skimmer Loop

The skimmer loop draws water off the surface of the basin for treatment by the filtration units and the IXMs. Flow from the skimmer loop is used to remove excess water, provide water for top sparging, and backwashing the IWTS annular filter vessel bed, and if required, may be directed to the DEP. The water is taken from the discharge side of the skimmer pump before it enters the filter.

2.5.4.3.1.6 Treated Water Supply

The treated-water supply receives water from the IWTS-IXM discharge and supplies feed to sludge and debris removal stations and the basin. Any additional water needed by the system to offset water loss from evaporation or fuel and sludge removal will be supplied by the fresh demineralized make-up water subsystem.

Excess treated basin water can be removed through the IWTS piping. Water can be removed via a connection located in the Transfer Bay and pumped to a tanker truck. The excess water would then be transported to the 200 Area Effluent Treatment Facility.

2.5.4.3.2 Integrated Water Treatment System Operation Description

The IWTS is used as a backup to the SKW System to maintain water quality. When basin water quality cannot be maintained by the skimmer loop, basin water can be routed through the booster pump to the annular filter vessels and the IXMs. If one submerged pump fails or is taken off line, the system will be shut down. If the booster pump suction falls below a specific pressure setpoint, indicating loss of suction, the system will be shut down.

On reaching a preset weight or differential pressure, the strainer housing is opened and the strainer basket removed. The strainer baskets are weighed under water to determine storage options.

If the annular filter vessels’ differential pressure or radiation level exceeds the high setpoints, the booster pump and the system will be shut down. An audible alarm and a visual alarm are activated when the radiation high-high setpoint is exceeded. The alarms are hard wired and do not rely on the computer control system.

The filters are regenerated individually before returning the system to service. Filter regeneration is accomplished using water, air, or a combination of water and air in various flow paths into and out of the filter vessel. Regeneration sequences are selected and controlled by Operations personnel from a control area. These sequences may be manual or automated, except for the infrequently used air sparge that requires manual action to supply air. The regeneration techniques provided for each vessel are the top sparge, full-bed backwash, and air sparge.

In the top sparge process, water is introduced through the top of the filter media via a distribution pipe, and exits the top of the filter vessel through the backwash outlet valve. During this process,
the top layer of the filter media (highest concentration of particulate) is agitated with a water sparge, using skimmer loop or recirculation system water, and the top sludge particles trapped in the layer of media are carried out by a sweeping action to the particulate settlers for hold-up and subsequent processing. The reduced flow from the top sparge will allow the settlers to retain more of the smaller particles. This process is used to reduce differential pressure without disturbing the bottom half of the filter bed. This process is the preferred method of filter regeneration when the process water contains a mixture of particulate with a bias toward large particles.

Backwash is required when the top sparge action does not lower the pressure differential to the desired point. Water flow is reversed by entering the vessel bottom and exiting the top via the backwash outlet valve. During this process, the entire bed is backwashed using skimmer loop water to sweep particulate from throughout the media to the particulate settlers. A nominal backwash flow rate (approximately half the normal process flow rate) is expected to be used, which should provide an adequate carrying velocity to fluidize and remove the particles. This flow rate will allow the settlers to retain more of the small particles.

The filter bed can be air sparged if excessive backwashing is required to maintain acceptable differential pressures or radiation levels in the filter. Air sparging consists of injecting compressed air into the filter vessel media bed to disturb the aggregate. In similar equipment, air sparging has been shown to restore filter efficiency. The filter vessels have valves and flanges to connect to a compressed air source. Air sparging, when performed, typically involves airflows of approximately 140 standard ft$^3$/min for approximately 1 hour. Only one filter vessel will be sparged at any given time.

The venting system (Figure 2-22) for the annular filter vessels is an emission point for the 105KW Basin. The annular filter vessels are not vented while the IWTS is in operation with the pumps running. When the pumps shut down and water flow to the filters stops, the annular filter vessels are passively vented to the HEPA-filtered emission point. During air sparging, the filters will be actively vented through the HEPA-filtered emission point. DOE/RL-98-02, *Radioactive Air Emissions Notice of Construction for 105-KW Filter Vessel Sparging Vent*, was approved by the Washington State Department of Health (Letter AIR 98-307).
Figure 2-22. Venting Arrangement for Normal Operation of Filter Vessels

The IWTS is operated and controlled manually from a remote computer interface located in the Equipment Operations Center, Room 20A. Remotely air-actuated valve positions, alarms, instrumentation readouts, process flow mimic, and an alarm summary are graphically displayed. The position of the annular filter vent valves may be inferred operationally if they cannot be remotely determined. The control system has manual and automatic modes. In the automatic mode, any of several preprogrammed sequences can be selected and started. These include system standby, normal operation, top sparge, and air scrub. In the manual mode, all remotely actuated valves and pumps can be operated individually from the computer screen. In both automatic and manual modes, all process variables, actuated valve positions, and pump running status are displayed.

When any mode is selected by the operator, all valves, pumps, alarms, and instruments are activated and the process proceeds. If any shutdown alarm setpoint is exceeded, or any automatic valve is positioned incorrectly, the system is shut down and returned to mode 1, “System Standby.” Operators are required to shut down the system (or verify shutdown if in automatic mode) in the case of a high-high alarm on the annular filter vessel radiation monitoring system, and operator action is required to restart any mode following shutdown.
Two IWTS control loops maintain a total system flow of (nominal) 320 gal/min and a discharge header pressure of 20 lb/in² gauge plus or minus 2 lb/in² (preset) at all times. The two parameters are maintained by the booster pump variable-speed drive and flow control valve located on the discharge to the SLOP. The control valve positions to maintain system pressure, and system flows are maintained by increasing or decreasing pump speed.

A 480-V, 3-phase motor control center distributes the power supply to meet IWTS power requirements. The IWTS instruments and controls are monitored by a programmable logic controller (PLC) and interface with the operator control console. The IWTS is designed to be capable of automatic or manual operation in all modes.

### 2.5.4.4 Water Chemistry

The water treatment system at the 105KW Basin serves two purposes: to remove radionuclides from the basin water thus minimizing worker exposure and offsite releases, and to control the basin’s water quality to minimize corrosion of the many different materials exposed to the basin water.

Two water chemistry parameters are monitored: temperature and radionuclide concentration. Radionuclide concentrations are monitored frequently by sending samples to laboratories for radiochemical analysis. In addition, the concentrations of dissolved ions, elements, and organic compounds are determined on a non-routine basis by laboratories performing chemical analyses.

### 2.5.4.5 Water Temperature

The operating temperature of the basin water impacts basin water quality for two reasons. The concentration of $^{137}$Cs in the basin water is a function of the rate that $^{137}$Cs is released from the corroding uranium and the rate that it is removed by the cleanup system. The release rate for $^{137}$Cs is referred to as the “leach rate,” and the resulting $^{137}$Cs concentration in the basin is termed the “equilibrium concentration.” Uranium corrosion rates are extremely sensitive to temperature, as the temperature increases, so does the corrosion rate. If the basin water temperature increases from 50°F to 70°F, the leach rate for $^{137}$Cs will increase by a factor of approximately 3. Thus, higher water temperatures result in much higher radionuclide concentrations and a proportional reduction in the service life of the IXMs. The second benefit of lower water temperatures is that lower temperatures limit biological growth, particularly algae, in the basin water. The 105KW Basin has experienced problems with biological growth in the past. Currently, only hydrogen peroxide is used to combat biological growth in the basin.

### 2.5.4.6 Basin Radionuclides

Samples are routinely collected and analyzed for radiological constituents to monitor performance of the water treatment and to characterize spent water treatment components for disposal. The radionuclides of particular interest are the fission products $^{137}$Cs, $^{90}$Sr, tritium, TRU isotopes, $^{241}$Am, $^{238}$Pu, and $^{239/240}$Pu. Because of the passage of time, short-lived activation products such as $^{54}$Mn, $^{59}$Fe, and to a lesser extent, $^{60}$Co, are no longer present in significant amounts.

Cesium is present in the water as a highly soluble cation (positively charged ion). It is removed from the water by the ion-exchange resin of the IXMs. Only a small fraction is removed by filtration. The service life of an IXM is determined by several factors, one of which is its cesium
removal efficiency. Cesium is one of the first ions to elute (be released) from the IXM when it becomes depleted. An IXM can actually discharge a large quantity of $^{137}$Cs back into the basin over a short period of time, if operated past exhaustion. For this reason, IXMs are normally removed from service when the $^{137}$Cs removal efficiency drops below 70 percent.

The $^{90}$Sr is a beta emitter that is released directly to basin water from the corroding fuel fragments and sludge. Because the beta radiation is easily shielded, $^{90}$Sr does not contribute much to basin dose rates. Its primary hazard is in the form of contamination and internal deposition. Like cesium, strontium is a cation that is removed by the ion-exchange resin of the IXMs. It is not necessary to monitor the strontium removal efficiency of an IXM because strontium would be the last of the radioactive ions to elute from the ion-exchange resin.

Tritium is a radioactive isotope of hydrogen and is present in the basin water as part of the water molecule. The basin water systems cannot filter or ion exchange the tritium out of the basin water. The concentration of tritium is a function of its release rate from the corroding fuel fragments and evaporation or leakage from the basin.

The chemistry of TRU isotopes is very complex. They are present as both cations and anions (negative ions) that can be removed by the IXMs. They can also be removed as large particles by filtration. In addition, they can exist as colloidal (very small) particles that cannot be exchanged or filtered. The form that the TRUs take will change depending on the work going on in the basin and water chemistry conditions. Changes in chemistry (e.g., pH or the presence of certain chemicals) can either increase or decrease the solubility of the TRUs.

### 2.5.5 105KW Annex Process/Exhaust Ventilation System

The Process/Exhaust Ventilation System services 105KW Annex process equipment and maintains negative air pressure differentials such that air flows from areas of lower contamination potential to areas of higher contamination potential. The 105KW Annex is divided into four ventilation zones and other areas:

- Zone 1 (-1.0 in. w.g. relative to atmospheric): STSC
- Zone 2 (-0.5 in w.g. relative to atmospheric): TLSB, Decant Pump Box, and Sand Filter Skid, including annulus of the HIH sludge transfer and decant/backwash hoses
- Zone 3 (-0.05 in w.g. relative to atmospheric): Sludge Loading Bay
- Zone 3A (slightly negative relative to atmospheric): HEPA Filter Room

The Process/Exhaust Ventilation System provides approximately 3265 cfm supply air and exhausts approximately 4100 cfm of HEPA-filtered air out the building stack. Approximately 835 cfm supply air is provided through inleakage.

The Process/Exhaust Ventilation System includes hydronic equipment to heat and cool the 105KW Annex. The system is designed to maintain an inside temperature of 80°F when the outside temperature is 105°F, and to maintain an inside temperature of 65°F when the outside temperature is 0°F.
2.5.5.1 Zone 1 and Zone 2

Zone 1 services the STSC and provides a confinement function by maintaining the STSC headspace at a nominal pressure of negative 1.0 in. w.g. or lower, relative to atmospheric. In addition, as described in HNF-SD-SNF-FHA-001, Section 14.2, “Explosion Prevention,” Zone 1 maintains the hydrogen concentration in the STSC to less than 25 percent of the LFL during normal and upset conditions in accordance NFPA 69, Standard on Explosion Prevention Systems, requirements for explosion prevention by combustible concentration reduction. To accomplish this, the Process/Exhaust Ventilation System provides a nominal flow rate of 5 cfm (PRC-STP-CN-M-00809, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Pressure Drop within the Low Pressure Air Purge Piping) through the STSC. This nominal flow rate is significantly higher than the 1.0 scfm required to maintain the STSC headspace below 25 percent of the LFL indefinitely given a hydrogen generation rate of approximately 175 L per day, as documented in PRC-STP-CN-N-00935, Sludge Treatment Project – Thermal and Gas Analyses of the Process/Exhaust and Auxiliary Ventilation Systems for the Sludge Transport and Storage Container (STSC) in the 105-KW Annex Building, given an operating HVAC system. The approximately 175 L per day value is a reasonably conservative, unmitigated hydrogen generation rate for a bounding STSC containing 0.4 m\(^3\) of safety basis Settler Tank sludge and 1.6 m\(^3\) of safety basis KE sludge. See also Section 2.7.1.1 for a description of the Auxiliary Ventilation System, which provides the hydrogen purge flow if the Process/Exhaust Ventilation decreases below 1 scfm.

Zone 2 services the TLSB, Decant Pump Box, Sand Filter Skid, and the annular spaces of the slurry and decant transfer line HIHs. Zone 2 is maintained at a nominal pressure of negative 0.5 in. w.g. relative to atmospheric pressure. The amount of negative pressure in each zone may fluctuate based upon the operational configuration of the STSC hose connections, but Zone 1 will always be more negative than Zone 2, thereby assuring airflow from less contaminated areas toward areas of greater potential contamination.

The airflow from Zones 1 and 2 has the potential to have increased relative humidity due to contact with process water streams. The air from these two zones enters moisture separators (demisters) and connects to the building exhaust ventilation immediately downstream of the demister assemblies. The inclusion of moisture separators ensures that liquid moisture does not enter the final HEPA filter trains.

The moisture separators, HEPA filter plenums, STS drain, oxygen monitoring cabinet drain, and exhaust stack are connected to the Condensate Sealpot, ECRT-TK-502, to collect potentially contaminated water. The sealpot connection legs extend below the operating water level of the tank to prevent air from bypassing the HEPA filters due to the negative pressures in the system. The sealpot level is monitored with high and low level switches to ensure that the proper level is maintained in the sealpot. The condensate tank and demisters are for precautionary purposes only since development testing has shown that the demisters did not collect water during any transfer and hose drying operations.

2.5.5.2 Zone 3, Zone 3A, and Other

The Sludge Loading Bay is designated Zone 3. Approximately 2935 cfm of conditioned air is supplied to the bay from the air-handling unit located in the Mechanical Equipment Room. The approximately 3630 cfm of air exhausted from the Sludge Loading Bay and the STSC Rad Con
Hood maintains the bay at a pressure of negative 0.05 w.g. relative to atmospheric pressure, and results in approximately four air changes per hour which are HEPA-filtered and then exhausted via the building stack. A hot water unit heater supplements the heating to the Sludge Loading Bay when conditions require supplemental heat.

The HEPA Filter Room is designated Zone 3A. It houses normal and standby filter trains and fans, which provide two stages of HEPA filtration for the four designated ventilation zones. Conditioned air is supplied to the HEPA Filter Room from the air-handling unit located in the Mechanical Equipment Room. A small amount of inleakage is designed to maintain airflow into the room (slightly negative with respect to atmosphere during static conditions). A small hydronic fan coil unit provides supplemental conditioning of room air.

The Mechanical Equipment Room houses the 105KW Annex primary air-handling unit (which distributes conditioned supply air to other areas of the building), fan coil unit, electric hot water boiler, and hydronic system pumps and expansion tank. A small hydronic fan coil unit recirculates air in the room to provide heating and cooling. Two 3-ton split system air conditioning units provide supplemental cooling within the room. This room is maintained at approximately atmospheric pressure and has no zone designation.

The Interior Stair is provided with conditioned air from the air-handling unit located in the Mechanical Equipment Room. An equal amount of return air is removed from the stairwell and recirculated back through the Mechanical Equipment Room’s air handler. The supply and exhaust airflow rate is approximately equal; therefore, the stairwell has no zone designation.

The Personnel Change Room is provided with a small hydronic fan coil unit for heating and cooling. This unit filters and recirculates air within the change room area. This area operates at approximately atmospheric pressure and has no zone designation.

### 2.6 Confinement Systems

#### 2.6.1 Basin Water Level

The failure of pressurized or potentially pressurized underwater piping/hoses and equipment do not result in release of radioactive material that present a significant hazard to the public or workers. The design of underwater sludge retrieval and transfer piping/hoses and equipment credit this “confinement” function to prevent radioactive and toxic material hazards from sprays. Retrieval and transfer operations will not be initiated if basin level is below 15 ft above the basin floor.

The design of the above-water sludge transfer lines provide the “confinement” function.

### 2.7 Safety Support Systems

The safety support systems consist of the following major elements, which are described in detail below:

- Auxiliary Ventilation and Inerting Systems
- 105KW Basin Instrumentation System
2.7.1 Auxiliary Ventilation System and Inerting

2.7.1.1 Auxiliary Ventilation System

The Auxiliary Ventilation System uses nitrogen gas to provide active ventilation to the STSC in the event of the Process/Exhaust Ventilation System cannot maintain a flow of 1 scfm or greater. To provide redundancy, there are two trains, each capable of delivering the requisite nitrogen flow rate. Nitrogen gas is supplied to each redundant train by an installed and connected cylinder cradle located outside the north side of the 105KW Annex, spare cylinder cradles are installed but not connected. Each cylinder cradle contains 12 standard industrial high-pressure (2400 psi U.S. Department of Transportation [DOT] service pressure) nitrogen cylinders. These cylinders are 56 in. tall and 10.7 in. in diameter, with a minimum internal volume of 64.7 L. The system includes a pressure control valve, set to approximately 40 psig, and a pressure safety valve, set at 80 psig. Pressure and flow indication is provided at the nitrogen supply panel, located outside the 105KW Annex, and flow is also indicated at the nitrogen purge panel, located within the 105KW Annex. The distribution piping of this system intersects with distribution piping for the Inert Gas System at the nitrogen supply panel. Check valves and pressure regulators at this location ensure that the Inert Gas System cylinder cradles described in Section 2.7.1.2 provide the initial gas supply for the Auxiliary Ventilation System if it is actuated. The auxiliary ventilation gas supply is not consumed unless the inert gas supply pressure falls below 150 psig.

The Auxiliary Ventilation System nitrogen distribution piping is permanently connected to the STSC purge inlet line. During operation of the Process/Exhaust Ventilation System, this line is supplied by room air; the purge inlet supply line is equipped with a HEPA filter to protect against the release of radiological contamination from this line to the room. The Auxiliary Ventilation System is actuated automatically on detection of low flow in the purge inlet line, which causes the opening of redundant solenoid valves located at the Nitrogen Purge Panel. If negative pressure is not present in the STSC, redundant vacuum breaker/back flow preventer valves close to prevent loss of Auxiliary Ventilation System flow to the room. The opening of the solenoid valves initiates the flow of nitrogen into the STSC headspace via the purge inlet line at a minimum flow rate of 0.5 standard cubic feet per minute (scfm). The exhaust pathway for the Auxiliary Ventilation System is through the purge outlet line, which discharges to the Process/Exhaust Ventilation System. The Auxiliary Ventilation System is classified as safety-significant for the prevention of a hydrogen explosion in an STSC, which has the potential to cause a facility worker serious injury or death. The system is more fully described in Section 4.4.6, “Auxiliary Ventilation System.”

2.7.1.2 Inert Gas System

Nitrogen gas is provided from a nitrogen cylinder cradle located outside the north side of the 105KW Annex. The Inert Gas System, which is used for purging and inerting the STSC and for
purging and pressurizing of the STS Cask, is supplied by a cylinder cradle containing 12 standard industrial high-pressure (2400 psi DOT service pressure) nitrogen cylinders. These cylinders are 56 in. tall and 10.7 in. in diameter, with a minimum internal volume of 64.7 L. The system includes a pressure control valve, set at 65 psig, and a pressure safety valve, set at 80 psig. Pressure indication is provided at the Nitrogen Supply Panel outside the 105KW Annex; pressure and flow indication are provided at the Nitrogen Purge Panel located in the 105KW Annex. The Inert Gas System is designed to be connected either to the STSC via the purge inlet nozzle located on the top of the STSC, or to the STS Cask via the cask drain port, located near the bottom of the cask wall. The flow of nitrogen is directed to either the purge inlet line or the cask purge/pressurization line via a pair of manually operated valves.

The Inert Gas System interfaces with the normal supply ventilation for the STSC via a connection to the purge inlet line. During slurry transfer operations, this ventilation inlet line takes supply air from the room. For purging operations, the normal room air supply to the STSC is isolated using a manual valve on the purge inlet line.

The exhaust side of the Inert Gas System is equipped with a sampling cabinet, which provides monitoring of the purge outlet stream for oxygen content. The STSC is purged with nitrogen until the oxygen concentration in the purge outlet line is less than 0.5 vol% as measured by an oxygen analyzer. The STS Cask is similarly purged until the oxygen concentration is less than 1.2 vol%. Monitoring of the oxygen concentration in the exhaust line is required for compliance with NFPA 69. A pressure sensor on the inlet purge to the cask allows a predetermined pressure to be set in the cask to prevent inleakage of air during transportation.

2.7.2 105KW Basin Instrumentation System

The basin instrumentation system consists of two distinct subsystems: (1) 105KW Basin water monitoring and (2) site communication. The basin water monitoring system measures the basin water level and the basin temperature. This subsystem also allows for the periodic collection of composite and grab samples. The site communication system consists of the 100K Area emergency signal system and the normal networks (e.g., telephone and Hanford Local Area Network computer) that are used to support STP management. The emergency signal system is designed to alert basin personnel of area or site-wide emergency situations. This system generates Hanford Site standard emergency signals and transmits voice emergency instructions.

The functions of the basin instrumentation subsystems are as follows:

- Monitor key basin parameter variables and alert plant operators with audio and visual signals of an out-of-tolerance situation
- Monitor and record basin water level and temperature
- Provide for the automatic and manual collection of basin water from various locations for laboratory analysis
- Provide alarm sirens and public address systems to alert all personnel in the 100K Area facilities of emergency conditions in the 105KW Basin or other Hanford Site facilities
2.7.2.1 Water Monitoring System

The basin water monitoring system is physically contained within the 105KW Basin. This system has components in several locations around the fuel storage pools and is used to continuously monitor the basin’s water level and temperature. The water monitoring system alerts the operators when an out-of-normal condition exists. The system also provides manual readings of certain parameters and water grab samples to back-up the continuous monitoring capability.

2.7.2.1.1 Basin Water Level Monitoring

Basin water level instruments continuously measure and record the level of the basin water and trigger high- and low-level alarms when the basin water level is either increased or decreased beyond the probe set levels. The basin water level recording is obtained from a bubbler probe assembly. Auxiliary water level instruments include a magnetically coupled basin stick indicator, which can also be used to record the level.

2.7.2.1.2 Basin Water Temperature Monitoring

The basin water temperature-sensing elements are thermocouple probes. The basin has temperature probes and their output is recorded.

2.7.2.1.3 Basin Water Samples

Water samples are collected both automatically and manually to be analyzed for the removal efficiency of the various water cleaning systems and for the presence of $^{137}$Cs, to obtain data for the basin’s air permit, and to predict TRU and fissile isotope loadings. Auto-sampler stations at the 105KW Basin supply the samples for the water cleaning analysis.

2.7.2.1.4 Computer-Driven Monitor Alarm Display

A computer-driven monitor alarm display, located in the Equipment Operations Center, Room 20A, provides audio and visual status for monitoring physical parameters and equipment of the basin. When any of these signals are off-normal, the corresponding annunciator changes to the alarm state and remains in this alarm state until the condition returns to normal. When an alarm is acknowledged by Operations personnel, the audible signal will be silenced and the visual signal will change from flashing to solid.

2.7.2.2 Communication System

The primary function of the communications system is to generate emergency signals. The base station for this system is in the 200E Patrol Operations Center. One tower with sirens and speakers is located outside the 105-KW Building. The radio receivers and the signal generation amplifiers at the base of the tower and the siren itself are battery operated. The batteries are charged from the utility alternating current power. Failure of utility alternating current power will not affect the system operation because the battery charge provides service for two days. This system generates Hanford Site standard emergency signals and transmits voice emergency instructions.
2.7.2.2.1 Emergency Signal Generating Base Station

The emergency signal generating base station was designed to control multiple alarm functions at separately addressable remote alarm stations. This equipment uses standard dual-tone, multi-frequency coding to generate the different alarm codes. The codes are transmitted from a control station to the remote alarm stations by radio. The code sequence determines the siren response (i.e., take-cover, evacuation, public address).

2.7.2.2.2 Remote Alarm Stations

The remote alarm stations at the 100K Area are pole-mounted siren assemblies located near the 105-KW Building. The remote alarm stations are designed to be companion units to the emergency signal-generating control station. This equipment decodes standard dual-tone, multi-frequency codes, generates alarms as indicated by the decoded signal, and passes voice messages directly to the speaker and horn assemblies. The remote alarm stations are equipped with a radio receiver tuned to the control station frequency. The remote alarm stations are operated via battery power supply.

2.7.3 105KW Annex Instrumentation System

The functions of the 105KW Annex instrumentation subsystems are as follows:

- Monitor STSC level and weight
- Monitor STSC and STS Cask oxygen concentration
- Monitor other parameters important for process control

2.7.3.1 STSC Level and Weight Monitoring and Control

STSC level and weight instruments monitor the amount of sludge (volume and mass) transferred from an engineered container to an STSC. They are used to ensure that the STSC Buoyant Load Weight setpoints are reached, but not exceeded. The STSC liquid level is measured by a radar level element/transmitter mounted on the STSC. The weight of the STS Trailer and its contents is measured by four load cells installed on a truck scale. Further details are provided in Section 4.4.12.

2.7.3.2 STSC and STS Cask Oxygen Monitoring and Control

The Oxygen Analyzer monitors the purge outlet stream for oxygen content during either STSC or STS Cask inerting and is used to ensure that the sludge-filled STSC and STS Cask are sufficiently inerted to prevent a potential hydrogen gas deflagration. Further details are provided in Section 4.4.7.
2.7.3.3 Other Important Instruments for Process Control

Other instruments primarily perform support functions, although important ones are summarized below:

- **Seismic Sensor and Shutdown Switches**: Redundant seismic shutdown switches are mounted in two different locations. Either seismic shutdown switch in alarm will actuate Safety Shutdown Interlock I-1 to terminate slurry transfers. Further details are provided in Section 4.4.4.

- **Low Pressure Air Purge Flow Sensor and Indicator/Transmitter**: Flow sensors are used to ensure a minimum air flow rate (1 scfm) through the STSC is maintained. A safety-significant Auxiliary Ventilation System will automatically actuate if the Process/Exhaust Ventilation System fails to maintain the requisite flow rate. Further details are provided in Section 4.4.6.

- **STS Cask Pressurization Check Tool**: The pressure indicator is used to monitor the STS Cask pressure in the event there are delays in shipping the STS Cask to T Plant. The tool is connected, if required, to the STS Cask Vent Tool. The two tools are used to prevent over pressurization of the STS Cask. Further details are provided in Section 4.4.9.

- **STS Cask Pressure Indicator**: The pressure inside the STS Cask is indicated by a mechanical gauge located on the inert gas supply line. The pressure indicator is used to prevent a hydrogen explosion by ensuring that the STS Cask is sufficiently pressurized to prevent air inleakage during staging and transport to T Plant. Further details are provided in Section 4.4.10.

- **STS Cask Initial Purge Pressure Gauge**: A low-range pressure gauge is used to prevent over-pressurizing the STS Cask and floating the STS Cask Lid, before the STS Cask Lid is bolted in place. This gauge is collocated on the Nitrogen Purge Panel with the STS Cask Pressure Gauge.

- **Leak Detectors and Relays**: Leaks from the primary hose drain from the annulus between the primary and secondary hoses to the leak detector at the Ingress/Egress Assembly. The TLSB is also equipped with a leak detector. Receipt of a leak alarm from either redundant channel of the general service leak detectors location in the TLSB and Ingress/Egress Assembly will actuate Safety Shutdown Interlock I-1 to terminate slurry transfers.

2.7.4 Fire Protection Systems

The fire protection systems for the 105KW Facility are described and evaluated in HNF-SD-SNF-FHA-001. The FHA and this description reflect the long-standing fire protection features of the 105KW Basin and the newly installed SSCs in the 105KW Annex. Further detail of the fire protection analysis is available in the FHA and in Section 11.4 of this DSA.
2.7.4.1 Fire Sprinkler System

2.7.4.1.1 105KW Basin

There is no fire suppression system in the 105KW Basin or in the associated Transfer Bay area. Fire protection measures in the Transfer Bay include administrative combustible controls and physical protection of critical Transfer Bay columns to prevent pooling of possible fuel spills thus preventing structural damage that could lead to a loss of basin water. In addition, operator response actions in the event of a fuel spill in the Transfer Bay area include the application of clay absorbent material and/or the application of firefighting foam from wheeled fire extinguishers to contain and cover the spill and minimize the potential for ignition.

A fire suppression system is provided in office and administrative areas of the 105KW Building. The fire suppression system consists of a water supply fed from the export water system, an underground sprinkler system lead-in from the water supply to the sprinkler system riser with a network of feed and branch line piping to the sprinklers. A fire alarm control panel installed at the main entrance to the facility includes associated alarm, trouble and supervisory devices. A radio fire alarm reporter (RFAR) installed outside the facility entrance transmits signals from these devices to the Hanford Fire Department dispatch. The systems were installed to help minimize the potential for, or the effects of, an occurrence of a fire or related hazards.

2.7.4.1.2 105KW Annex

The 105KW Basin FHA has been revised to incorporate the ECRTS equipment and 105KW Annex structure. As documented in HNF-SD-SNF-FHA-001, the Maximum Possible Fire Loss (MPFL) for the 105KW Annex is approximately $89M. In accordance with DOE guidance, facilities having an MPFL in excess of $5M require an automatic sprinkler system designed in accordance with applicable NFPA standards.

The 105KW Annex is provided with an automatic fire sprinkler system, hydraulically designed to meet the design criteria for an Ordinary Hazard Group 2 classification. Hydraulic calculations demonstrate that the sprinkler system demand, with a 250-gal/min hose stream allowance, was at least 10 percent below the least robust supply curve in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems.

The sprinkler design provides protection for the Mechanical Equipment Room, the HEPA Filter Room, the Personnel Change Room, the Interior Stair area, and the Sludge Loading Bay, including coverage under the Mezzanine level. Sprinkler coverage is not provided within the Horizontal Shielded Hose Chase. As discussed in HNF-SD-SNF-FHA-001, the chase qualifies as a space that does not require sprinkler protection under NFPA 13 as a concealed space of noncombustible construction with limited access does not permit occupancy or storage of combustibles.

2.7.4.2 Fire Detection Systems

2.7.4.2.1 105KW Basin

The HVAC unit serving the administration area is provided with a duct-mounted smoke detector; however, those serving the 105KW Basin and Transfer Bay are not. No other smoke detectors are provided. The sprinkler system is equipped with sprinkler flow and tamper switches. Alarms are transmitted to the Hanford Fire Department via Radio Fire Alarm Reporter Box 1270.
at the 105-KW Building. The system complies with the applicable requirements of NFPA 72, *National Fire Alarm and Signaling Code*, at the time of installation.

### 2.7.4.2.2 105KW Annex

As discussed in HNF-SD-SNF-FHA-001, when the MPFL exceeds $50M, a redundant fire protection system is required. The full-coverage smoke detection system in the 105KW Annex, described below, meets this requirement.

The 105KW Annex supply ventilation system is provided with duct smoke detection as required under NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, downstream from the air filters and supply air-handling unit and ahead of any branch connections in the air supply system. There is also general area smoke detection coverage in every room, and a duct smoke detector in the supply ventilation duct. As discussed in HNF-SD-SNF-FHA-001, an exemption is being requested relative to the installation of heat detection before the first stage of the HEPA filtration system.

The design also includes fire and smoke dampers located at ventilation penetrations into the inside stair area; activation of area smoke detection will close these dampers. The design also locates the Fire Alarm Control Panel in an area not continuously occupied; a smoke detector is therefore provided at that location. The Fire Alarm Control Panel interfaces with the ventilation system to shut down the supply fan upon activation of a duct smoke detector as required by NFPA 90A.

### 2.7.4.3 Fire Alarm System

#### 2.7.4.3.1 105KW Basin

A fire alarm system is installed in the 105KW Basin. The installation includes manual pull stations located at primary exit access doors and along the paths of egress for occupant use, and bells located throughout the active areas of the facility for occupant notification. Due to the potential for a high noise environment, combination strobe-horn devices are installed in several locations in the basin area.

#### 2.7.4.3.2 105KW Annex

The fire alarm system for the 105KW Annex is designed to provide supervision of the new fire sprinkler and fire detection systems installed in the 105KW Annex. Alarm initiating devices include manual pull stations at each exit access door and a fire sprinkler flow switch. Alarm notification appliances installed in every room of the 105KW Annex are combination horn-strobe devices. The fire alarm provides input to Interlock I-3, Process Emergency Shutdown Interlock. Alarm notification is provided in accordance with the requirements of NFPA 72 and HNF-36174, *DOE Fire Protection Handbook – Hanford Chapter*.

The Fire Alarm Control Panel is located on the inside west wall of the Mechanical Equipment Room. The radio fire alarm reporting unit is located on the outside west wall of the Mechanical Equipment Room.

Additional details are provided in HNF-SD-SNF-FHA-001.
2.7.4.4 Fire Suppression Water Discharge Containment

The 105KW Annex fire suppression system is provided with water discharge containment meeting the requirements of NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, to prevent the release of potentially contaminated fire suppression water to the environment. Facility floors are designed to slope to grated floor drains and sumps in each room, including the inside stair. In the event of discharge from the fire suppression system, a signal from the Fire Alarm Control Panels opens air-operated butterfly valves located in each sump, allowing water to gravity drain to an exterior sump. The 1800 gal exterior sump is equipped with two 1000-gal/min submersible pumps that are automatically activated by level detection in the sump. Liquid from the sump is pumped to two 21,000-gal, fixed-axle, portable water tanks located west of the 105KW Annex.

The credible volume of discharge is calculated conservatively, based on a hydraulic calculation for the least hydraulically challenging contiguous 1500 ft$^2$ of sprinkler coverage (44577-F-CALC-006, *KW Annex Fire Water Discharge Containment Quantity*). The supply assumed in this calculation is the system of three industrial pumps, which provide normal system pressure, at a flow rate significantly greater than either the fire pump or the direct connection to the export water system. A sprinkler discharge duration of 30 minutes is assumed, with a 250-gal/min hose stream allowance in accordance with DOE-STD-1066-99.

Adequacy of piping size and slope for the gravity-drain piping system is demonstrated by Calculation 44577-M-CALC-009, *KW Annex Fire Water Drain Pipe Sizing and Lift Station Pump Sizing*. In order to support final design for the fire water collection system, calculations were performed to quantify a room-by-room sprinkler discharge rate. The calculation estimates the maximum discharge rate on a room-by-room basis to ensure adequate capacity of the runoff containment pumping/retention system.

Because the fire water runoff retention system provided for the 105KW Annex requires active components, reasonable assurance of their operation in the event of a loss of power is required. The activation signal for the valves in the retention sump is generated by the Fire Alarm Control Panel, which has back-up power provided by batteries. The drain valve actuators are powered closed with pneumatic air and will fail open upon a loss of power. The pumps that transfer water to the external storage tanks do not have a source of back-up power but are fed from a separate power supply and not from the 105KW Annex. As a result, they are unlikely to be impacted by a fire event resulting in fire-flow in the 105KW Annex, and thus are judged to adequately satisfy the back-up power requirement.

2.7.5 Radiation Monitoring Systems

Radiation monitoring systems provide real-time surveillance of gamma field dose rates, unconfined contamination levels, and airborne radioactivity concentrations throughout the 105KW Facility. Monitoring helps identify possible mitigative actions necessary to ensure that radiological conditions are maintained ALARA, thereby enhancing worker safety. See Chapter 7.0 for program-related information.
The 105KW Basin Facility radiological protection systems consist of the following four subsystems.

- Area radiation monitoring used to provide early warning of rising gamma dose rates
- Continuous air monitors (CAMs), fixed head, and portable air samplers are used to provide warning of rising airborne radioactivity concentrations and document airborne radioactivity concentrations
- Portable monitoring equipment, including contamination detection instrumentation and personnel contamination monitors are used to detect unconfined contamination on facility surfaces, personnel, and equipment
- Area dosimetry used to document the ambient dose conditions in the 105KW Facility

The overall function of the radiation protection systems is to provide information on the radiological conditions in the facility work areas and to provide early warning of transient conditions such as rising dose rates or increasing concentrations of airborne radioactive material. Specific functions include providing the following:

- Radiological information on area radiation levels in the 105KW Facility
- Radiological information on airborne contamination in work areas
- Detection of radioactive contamination on personnel and equipment
- A means to analyze radioactive samples obtained from the 105KW Facility
- A means to document radiation dose conditions at various locations throughout the 100K Area

The radiation protection systems are designated general service. CHPRC-00073, *CHPRC Radiological Control Manual*, provides requirements and guidance on the minimum safety measures this system must be able to support.

### 2.7.5.1 Area Radiation Monitoring Subsystem

Area radiation monitoring is accomplished in the 105KW Facility through the use of portable radiation area monitors (see Section 2.7.5.2) and fixed gamma detector assemblies installed at locations where it is expected that dose rates may increase due to ongoing work activities. The portable monitors and gamma detector assemblies have visual and audible alarms that provide warning to workers in the event that dose fields in the area have increased past the alarm setpoint.

Area radiation monitoring equipment may be added using the selection and placement criteria of the Radiological Protection Program discussed in Chapter 7.0.

### 2.7.5.2 Air Monitoring Subsystem

In addition to real-time air monitoring with CAMs, both fixed head air samplers and portable high-volume air samplers are used to monitor airborne contamination levels in the 105KW Facility. Air sampling equipment may be added using the selection and placement criteria of the Radiological Protection Program discussed in Chapter 7.0.
CAMs are used at various work locations in the 105KW Facility to constantly monitor the airborne concentrations of radioactive materials generated during the work activities. The CAMs are equipped with both audible and visual alarms to alert personnel of increasing airborne concentrations, so that they may stop work and exit the air space. Although airborne radioactive material in the area consists of both beta-gamma and alpha emitters, CAMs only monitor for alpha contamination due to the increased sensitivity of the alpha CAM detection system. A technical workplace air monitoring document prepared using criteria of the Radiological Protection Program discussed in Chapter 7.0 provides the basis for the airborne radioactive material as discussed here (TE-DWF&RS-14-016-000, Sludge Treatment & Surveillance Project (ST&SP) Workplace Air Monitoring Program).

2.7.5.3 Portable Equipment Subsystem

The portable equipment provides a means to detect unconfined contamination in the work areas to ensure that radioactivity is contained at the source wherever practical. Radiological control equipment includes hand-held dose rate instruments, contamination instruments, and automated personnel monitors capable of detecting both alpha and beta-gamma contamination. Hand-held instruments are used to determine the unconfined radioactive material levels, in units of dpm/100 cm², that are present on material and equipment being physically handled during work. They are also used to perform surveillance activities in the facilities, and ensure that radiological contamination conditions in the work area are documented when work is completed.

The automated personnel monitors are located within the 105KW Facility at the exit points from radiological buffer areas and contamination areas. These locations have been determined by the Health Physics Organization using criteria established by the Radiation Protection Program discussed in Chapter 7.0.

2.7.5.4 Area Dosimetry Subsystem

The area dosimetry program provides a means to measure long-term radiation dose at various locations around the 100K Area site, along the perimeter fence line, and within buildings.

The information gathered by the area dosimetry program is used to validate the placement of radiological area boundaries. The area dosimetry equipment consists of a holder and card containing a variety of thermoluminescent detector chips. The equipment is self-contained and passive, and has no interface with other systems except in the physical mounting of the units at various monitoring locations.

The nuclear accident dosimeters located in the 105KW Facility areas provide a means of analyzing the magnitude and nature of a nuclear accident and provides data to estimate doses to workers that possibly have been exposed to radiation in the event of an incident.

The location of area dosimetry equipment is controlled through criteria specified in the Radiation Protection Program. Dosimeters may be added using the selection and placement criteria of the Radiological Protection Program discussed in Chapter 7.0.

2.7.6 Environmental Monitoring Systems

The 100K Area environmental systems consist of monitoring equipment, collection systems, and handling and support equipment used to protect the air, water, and ground surrounding the
100K Area. Additional equipment is used to contain and collect material used for locating, measuring, and characterizing effluents from the facility.

The environmental protection systems are composed of the following subsystems:

- Air effluent monitoring
- Basin drains
- Sub-basin collection drain/sump
- Well monitoring
- Low-level waste packaging

2.7.6.1 Air Effluent Monitoring

The air effluent monitoring subsystem provides continuous sampling of the air in and around the 105KW Facility. The subsystem consists of fixed head record air samplers located inside the basin, 105KW Annex stack sampling system and the near-field ambient air samplers located outside of the 100K buildings.

2.7.6.2 Basin Drains

The basin drain subsystem consists of drains, pumps, and delivery piping that leads to and from the 105KW Facility structures. The basin’s drain arrangement is shown in Figure 2-23. This subsystem includes the chiller area drains, basin drains and sump, basin overflow weirs, Transfer Bay area drains (connected to C Sump, inactive), waste transfer, and the 105KW Reactor rear face drain and sump (B Sump, inactive).
Figure 2-23. Basin Drains
An inactive portion of the basin drains and sumps consist of the three 12-in. valves and five 4-in. valves in the floor of the basin. These valves are located in drain sumps filled with concrete. The drain lines from these valves merge into one 12-in. line that contains a drain system isolation valve just before a concrete collection box. The drain lines are blocked with grout plugs upstream of the isolation valve. As previously noted in Section 2.4.2, one of the drain lines above the main 12 in. drain header is not fully blocked.

2.7.6.3 Sub-Basin Collection Drain and Sump

The 105KW Basin was constructed with an asphalt-lined, piped sub-basin collection drain and sump. This subsystem lies below the lowest part of the fuel storage basin, technical view pit, spacer pit, and transfer pit, but not the discharge chute. Water is collected from each under-basin collection field and is routed to an underground caisson (D Sump) located 40 ft north of the 105KW Basin. The subsystem also pumps, filters, and directs the drain water back into the basin. The sub-basin collection drain and sump subsystem are shown in Figure 2-24.

2.7.6.4 Sub-Discharge Chute Drain

The sub-discharge chute drain subsystem is under the discharge chute located on the south side of the fuel storage basin, which was once under a water-filled transfer area between the reactor and the fuel basin. The concrete floor construction joint in this area has been blocked. The discharge chute was grouted as part of remedial actions for deactivation. Therefore, the water leakage pathway is blocked by the grout.

2.7.6.5 Well Monitoring

The well monitoring subsystem provides a means for obtaining samples of groundwater from a field of groundwater monitoring wells that surround the 100K Area. These samples are analyzed for radionuclides. Certain wells are configured to allow continuous water level monitoring as well as an indication of flow field direction and flow field velocity. Well monitoring is performed by the CHPRC Soil & Groundwater Remediation Project.

2.7.6.6 Low-Level Waste Packaging

The low-level waste packaging subsystem includes the storage, handling, treatment, preparation, packaging, and shipping of radioactive liquid, solid, and gaseous materials and wastes from the 105KW Basin during normal operation. Federal and state regulations identify the acceptable activities at each location where materials are handled and stored. Packaged waste is stored in outside Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) waste-staging areas. These areas are identified in Figure 2-2. Grouting of 55-gal drums and some waste boxes, to prepare them for disposition, may be performed adjacent to a CERCLA waste-staging area. After temporary storage, the waste is shipped to other Hanford Site areas for storage or disposal.
Figure 2-24. Sub-Basin Collection Drain and Sump
2.8 Utility Distribution Systems

2.8.1 Electrical Power System

The Bonneville Power Administration (BPA) provides the main source of power to the Hanford Site by means of the Midway Substation, which is located near Priest Rapids Dam. The Midway Substation is supplied by lines connected to the Grand Coulee 230-kV Substation and to 230-kV substations in the lower Columbia River power system. The Grand Coulee and lower Columbia River Substations are interconnected to the BPA 500-kV transmission system. The 500-kV and 230-kV transmission systems are interconnected to all the Columbia and Snake River hydroelectric generating stations and northwest steam generating plants and also are interconnected to California and British Columbia power network systems.

In addition to supplying power to the Hanford Site and other DOE substations, the site’s 230-kV loop normally supplies power to the Ashe Substation, located near the intersection of Route 11A and Route 2 South, and the White Bluffs Substation, located west of the 300 Area. In the event that both Midway power sources are lost, sufficient power for normal operations will flow into the Hanford Site 230-kV loop from the Ashe Substation. Onsite transmission lines are shown in Figure 2-25.

Power from the Ashe Substation into the Hanford Site’s 230-kV loop is supplied by a 115-kV line connected to the White Bluffs Substation. One 115-kV line at the White Bluffs Substation is connected to the Franklin Substation, located east of the Columbia River; the other 115-kV line is connected to the Benton Switch Substation, located west of the Columbia River and east of the Energy Northwest commercial reactors.

Electrical power enters the 100K Area at the A9 Substation (151KE) from the 230-kV loop. The power is transformed to a voltage of 13.8 kV at the A9 Substation, then distributed west via the C9L4 line to supply the 100B Area and east via the C9L3 line to supply the remainder of the 100 Areas. Power for 100K Area facilities is also supplied via these 13.8-kV lines: from the C9L4 line for 105-KW, 142K, and 189K; and from the C9L3 line for the 100-KW pump and treat system. Electrical power is provided to the 105KW Annex through a new Utility Transformer 300KVA (C7230P) fed from the C9L4 line. The 105KW Annex is provided with a receptacle to connect a portable standby generator, if needed, to supply backup power to one of the facility exhaust fans in the event of power loss. This generator will be operated manually and connected electrically to the exhaust fans via a manual transfer switch. The location of the portable generator receptacle is south of the HEPA Filter Room, between the south wall of the 105KW Annex and the north wall of the FTS Annex.

2.8.1.1 Protective Relaying

The protective relaying for the 230 kV and 13.8 kV switchgear is currently located inside Building 152-K in the 151-KE substation. The 480-V system does not have protective relays as such but is protected by solid-state trips in the 480-V switchgear. Individual loads on the motor control centers are protected by molded-case circuit breakers.
Figure 2-25. Hanford Site Electrical Distribution System
2.8.1.2 Grounding

The 105KW Basin electrical grounding system consists of a network of bare-stranded copper grounding cable (generally size 4/0 but sometimes 1/0) directly buried or run in concrete. The grounding cable runs through the foundation to the exterior of the building at least 3 ft below grade and is connected (brazed) to 0.75-in. by 10-ft grounding rods (copperweld rod) that are sunk vertically around the perimeter of the building, spaced approximately 40 ft apart. The grounding network is connected to structural steel members and metal piping systems throughout the building. Grounding networks for all building elevations are of similar design, and are connected by risers made of the same copper cable. All equipment is connected to the grounding network by either brazing or bolting. The buildings are interconnected via cables run through piping ducts or tunnels so that most of the buildings are connected.

The 105KW Annex employs a ground ring embedded in the building foundation. This ground ring is connected to the 105KW Basin ground grid at the FTS Annex.

All structural steel, mechanical equipment with integral electric motors, and electrical equipment is grounded. The 105KW Basin has an existing grounding electrode system constructed in accordance with NFPA 70®\textsuperscript{15}, *National Electrical Code*, Article 250. Interconnected elements include building reinforcing steel, metal water piping, and a concrete-encased grounding electrode. A separate equipment ground conductor is routed with all power conductors and lighting circuits in accordance with NFPA 70, Article 250. The existing ground system does not provide a credited safety function. Grounding for the 105KW Annex also meets the requirements of NFPA 70, Article 250. The ground system for the 105KW Annex also does not provide a credited safety function.

2.8.2 100K Area Water Supply and Distribution

The 100K Area water supply and distribution system provides a pressurized water source for the fire water system, supplies make-up water to the KW fuel storage basin, and provides potable water for human consumption and sanitary services. The 100K Area water supply and distribution system is divided into four subsystems: raw water, service water, demineralized water, and potable water.

The following are the functions of the water supply and distribution system:

- Supply water to the water treatment plant
- Provide a constant pressurized-water source for the fire water system
- Provide service water storage capability and supply to end users
- Supply potable water to end users
- Supply demineralized water to end users
- Provide make-up water to the fuel storage basin

Service water is also an emergency or alternate source of make-up water for the fuel storage basin. Demineralized water is used for normal makeup to the fuel storage basin. The

\textsuperscript{15} NFPA 70 is a registered trademark of the National Fire Protection Agency, Quincy, Massachusetts.
189-K Water Treatment Facility also provides potable water, which has the greatest water flow demand and is used for 105KW Basin drinking water needs and sanitary services.

2.8.2.1 Raw Water Subsystem

The raw water subsystem is supplied by the 100BC export water line, which draws water from the Columbia River and passes it through a screen prior to distribution to the 200E and 200W Areas. Water enters the river water pump house (181-B) from the Columbia River and is pumped via four active pumps: one 250-hp pump, two 500-hp pumps and one 1000-hp pump. Raw water is pumped to the 200 Areas (south of the 100K Area site) via a 42-in. concrete/steel line.

The system provides water for the 100K Area, via a 12 in. pipeline from the export water line. The tie-in point is at Helen’s Junction, southwest of the 100K Area. The water supply provides raw water to the 100K Area, at a nominal delivery rate in excess of 1500 gal/min. The raw water feed is to a 750,000-gal tank, located near the 189-K Water Treatment Facility in the southwest corner of the 100K Area. This tank is sized to provide water for fire suppression (360,000 gal), emergency basin makeup (180,000 gal), and up to 24 hours of potable water demand at a nominal rate of 50 gal/min.

2.8.2.2 Service Water Subsystem

The service water subsystem supplies water for the fire protection and demineralized water systems. The fire suppression water distribution system provides a 12-in. fire main throughout the 100K Area, with a combination 12- and 8-in. looped and grided system on the west side of the 100K Area, supplying the 142-K and 105-KW Buildings. Piping exterior to the 105-KW Building provides seven fire hydrants and the water supply to the 105-KW Building administrative area automatic sprinkler system. A single 12-in. fire main serves facilities in the central corridor (MO-500 and hydrants in the central corridor) and on the east side of the 100K Area (including hydrants in the vicinity of the 105-KE Building). A 4-in. line off the system provides water for dust suppression to two truck fill stations located southwest of the 100K Area (one south of the 189-K Water Treatment Facility) and at the southeast corner of the 100K Area. Normal system pressure is maintained by new service water pumps, which are sized and controlled to maintain system pressure at approximately 120 lb/in².

The design also provides the capability to bypass the water storage tank, providing feed for the 100K Area service and fire systems from the supply line, to be used in the event of required maintenance, inspection, or repair of the water storage tank, or low system pressure. The system also provides a fire pump, designed to provide system pressure to deliver the supply from the fire reservoir portion of the water tank, in the event of a fire demand occurring during any loss of supply from the export water system or low pressure from the service water pumps or the bypass system.

The service water system is required to operate during differing water demand conditions. Demineralized water use is low and fire water use is essentially standby only.

The fire suppression water supply distribution system, shown in Figure 2-26, provides a looped and grided system on the west side of the 100K Area. The existing piping exterior to the 105KW Facility has been replaced with a new polyvinyl chloride (PVC) loop, providing six new fire hydrants and the water supply to the existing 105KW Basin administrative area automatic
sprinkler system. This loop also supplies the automatic sprinkler system for the 105KW Annex. The majority of the 100K Area fire main is 12 in. in diameter, as required for mixed-use (industrial and fire water) systems. The looped and gridded system on the west side of the 100K Area, supplying the 142-K and 105-KW Buildings, is 8 in. pipe. RL approval is required for use of this system to supply the automatic sprinkler system for the 105KW Annex, to ensure that water supply system testing has been satisfactorily completed, as described in HNF-SD-SNF-FHA-001.

Figure 2-26. 100K Area West Side Raw Water Distribution System

Normal fire water distribution pressure in the 100K Area is maintained by four electric-motor-driven industrial pumps located in the 189-K Building, which are sized and controlled to maintain system pressure at an acceptable level. In a normal configuration, these pumps take suction directly from the 750,000-gal water tank. One, two, or three pumps will run simultaneously depending on demand, based on a measurement of system pressure drop. Each
pump is variable-frequency drive-controlled to maintain a set pressure of 125 psig for one pump; 120 psig for two pumps; and 115 psig for three pumps. The flow provided by the three industrial pumps running simultaneously is approximately 2600 gal/min at 130 psig. The fourth pump is provided only as a backup in case of pump failure; the control system contains no provision for all four pumps running simultaneously.

Should the service-water pumps fail to maintain sufficient volume and pressure during fire demands, an automatic feed through a pressure-reducing valve on the incoming export water line will open and provide additional water (in excess of 1500 gal/min at 110 psig). Should this second supply be insufficient or unavailable, a diesel-driven fire pump located in the 189-K Building will activate, taking suction from the 750,000-gal water tank.

2.8.2.3 Demineralized Water Subsystem

The demineralized water subsystem draws water from the service water subsystem and supplies high-purity water to the KW fuel basin. The demineralized water subsystem is a relatively small subsystem of the water supply and distribution system that receives service water as its source from a local service water branch pipe installed overhead in 105KW Basin. The system discharge connects to demineralized water basin piping.

The demineralizer consists of a vendor-supplied and serviced prepackaged water treatment system that is dedicated to the 105KW Basin. The package uses mixed bed resin bottles. The package is piped with isolation valves and fittings. Particulate filters and a flow meter/totalizer are installed at the inlet to the package, and a backflow preventer and a conductivity indicator are installed at the discharge of the package. When the particulate filters become loaded, they are replaced as required. When the resins are depleted, they are replaced as required.

An indicator light illuminates as long as the water is of high purity. A flow totalizer (water meter) is used to accurately record the amount of water added to the fuel basin.

The demineralized water passes through a reduced pressure backflow assembly before the water enters the basin area. The backflow preventer is installed to prevent downstream water from contaminating the system and equipment upstream of the backflow prevention valve.

The demineralizer package takes up very little floor space and is installed against the north wall in Corridor 5 near the basin entrance. This affords convenient access for servicing, replacement, and performance monitoring (i.e., checking if the conductivity indicating light is “ON” or “OFF”). The use of corrosion-resistant materials reduces the amount of piping corrosion deposits that can be picked up in the piping and discharged into the fuel storage basin.

2.8.2.4 Potable Water Subsystem

Potable water is distributed throughout the 100K Area via a 3-in. PVC line that supplies sanitary water for the 142-K, 105KW Basin, MO-500, various trailers, and shower trailers.

2.8.3 105KW Basin Annex Instrument Air System

The 105KW Annex is provided with a dedicated instrument air system to produce and distribute compressed instrument-quality air at a pressure of 125 psig throughout the 105KW Annex. This system provides air for solenoid-operated valves; the air-operated, double-diaphragm decant and overfill recovery pumps; and a service tap to supply air-operated hand tools.
The instrument air system is located in the Mechanical Equipment Room, with distribution piping to various locations in the Sludge Loading Bay. The system consists of a single-stage, rotary-screw compressor, a 30-gal wet air receiver tank, a particulate prefilter and coalescing filter, a desiccant compressed air dryer, a particulate after-filter, two 500-gal dry air receiver tanks, pressure control valves, and distribution piping. This system performs no credited safety function, as safety-significant isolation valves dependent on instrument air for operation are specified as fail-safe on loss of instrument air.

2.8.4 105KW Basin Compressed Air System

The instrument and valve operating air for components of the ECRTS located within the 105KW Basin is supplied by the 105KW Basin compressed air system. This system supplies compressed air at 105 to 115 psig with a capacity of at least 30 cfm. This air is supplied by a 10-hp duplex air compressor with a 120-gal receiver. This air passes through a refrigerated dryer to a 200-ft³ air receiver then on to the distribution system. When the 10-hp compressor is not available due to maintenance, a portable compressor is connected to the system that provides unconditioned air.

2.9 Auxiliary Systems and Support Facilities

2.9.1 105KW Basin HVAC

The basin air handling subsystem includes all air movement equipment and associated controls required to exhaust, cool, and heat the air in the 105KW Basin. Air quality is maintained suitable for operating personnel and equipment operation and is consistent with state and federal guidelines. The primary heating and cooling source for the basin and the Transfer Bay area are three HVAC units. The electric hot water boilers previously used to heat the basin and Transfer Bay area are out of service. The centralized forced-air heat pump system provides heating and cooling for the office section of 105KW Basin. Roof ventilators are provided to exhaust air from occupied areas within the office section of the building.

The basin uses roof-mounted exhausters to remove air from the facility. The evaporative coolers previously used to condition the air are abandoned in place and may be removed. The roof exhausters exhaust the air to keep indoor airborne contamination levels below guidelines. The basin has no controlled air inlet or supply. The only source of make-up air to the basin is infiltration. Two split system 5-ton air conditioners were installed in the Transfer Bay area in the 105KW Basin to provide comfort cooling for operations and maintenance personnel during summer months, but these units are currently out of service and may be deactivated, removed, or abandoned in place.

The basin area is often posted as an Airborne Radioactivity Area because of basin operations that disturb the water in the basin, or activities such as debris removal that disturb waterborne contamination. Work under these conditions often requires workers to use air-purifying respirators. Three HVAC units have been installed so that the workers do not need respirators when performing such work, or if respirators are required, to support the area to be downposted from an Airborne Radioactivity Area as soon as possible after the activity has been completed, as well as for heating and cooling. The HVAC system is shown in Figure 2-27.
Figure 2-27. 105KW Basin HVAC Plan View
Skids for the three HVAC units are located on concrete pads approximately 23 ft from the north exterior wall of the 105KW Basin. Air is removed from the basin through three 48-by-48-in. return grills mounted at a 3-ft centerline height in the basin north wall, and then travels through a 30-in. duct (insulated 10 gauge steel) to the HVAC skids. Filtered, conditioned air exits the HVAC skids and travels through the 30-in. duct to basin wall penetrations located at a 13-ft height. The air flow is distributed through an insulated ductwork run above the basin white iron at a height of approximately 12 ft. The system was designed to provide a comfortable indoor work environment while external conditions range from -10° to 105°F.

Each skid has a sealpot to capture condensation from the cooling coil and direct it back to the basin pool. Assuming worst case temperate and humidity conditions, each cooling coil is expected to collect 1.3 gal/min of water (1872 gal/day). The sealpot was designed to collect 8 hours of condensate while keeping the tank level between 30 percent and 70 percent full. Condensate is pumped to the basin pool through a 1-in. steel pipe that is heat-traced and insulated to protect against freezing. Each condensate return line is equipped with a totalizing flow meter.

Photohelic® differential gauges installed across the pre-filter and HEPA filter banks allow tracking of filter differential pressures. The PLC displays sealpot level, temperature setpoint, and indoor temperature readings, as well as operating mode and alarms.

A thermostat for each HVAC skid is mounted in the basin enclosure but acts only as a temperature sensor because temperature setpoints are handled by the HVAC skid PLC.

### 2.9.2 Sanitary Sewers and Septic System and Site Drainage System

#### 2.9.2.1 Sanitary Sewers

The sanitary system is a series of localized installations consisting of conventional gravity systems or pressurized systems, and associated septic tanks and leach fields. They are not interconnected with either the process or area waste sewers.

Some buildings are served by a sewage holding tank without a leaching field. These tank-only systems require periodic pumping for disposal.

#### 2.9.2.2 Site Drainage System

Water spills within the KW Complex were previously directed to the 1908 Outfall structure on the Columbia River shore via a 66 by 66-in. concrete culvert that initiated at the thrust block in the water tunnel south of the reactor. The concrete culvert has been severed south of Winlock Street and any residual water that makes its way to the Outfall culvert is absorbed into soils at that point. Identified drains in the KW Complex that could drain to the culvert have been plugged.

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Chapter 3.0

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3.0 Hazard and Accident Analysis

3.1 Introduction
This chapter describes the process used to systematically identify and assess hazards, select and analyze accidents, identify and classify controls for significant hazards, and specify the associated seismic and other natural phenomena design criteria. This chapter also presents results of the hazard analysis, accident analysis, and control selection process. Based on the design basis accident analyses presented in Section 3.4.2, no safety class controls are required. Safety-significant controls are required for facility worker protection for spray releases during sludge retrieval and transfer, for a hydrogen explosion in an STSC, STS Cask, or process enclosure, and for over-pressurization of an STSC or STS Cask.

3.2 Requirements

3.3 Hazard Analysis
This section describes the hazard identification and evaluation performed for the facility. The purpose of this information is to present a comprehensive evaluation of potential, process-related, natural events, and man-made external hazards that can affect the public, workers, and the environment due to single or multiple failures.

3.3.1 Methodology
Hazard identification and evaluation provide a thorough, predominantly qualitative evaluation of the spectrum of risks to the public, workers, and the environment from accidents involving the hazards identified in the analysis. The hazard analysis focuses on abnormal and accident conditions. The hazard analysis determines the material, system, radiological material processing and storage, and facility characteristics that can produce undesirable consequences, followed by the assessment of hazardous conditions associated with a process or activity. Largely qualitative techniques are used to pinpoint weaknesses in design or operation of the facility that could lead to accidents. The hazard analysis examines the spectrum of potential accidents that could expose members of the public, onsite workers, facility workers, and the environment to hazardous materials. A selection process is used to identify accidents with the potential to cause unacceptable risk, as discussed in Section 3.3.2.3.5, “Accident Selection.” These accidents are further analyzed, and a set of controls is selected and implemented to ensure that the facility can be designed, constructed, operated, and decommissioned safely and can meet DOE requirements.

The objective of these hazard analyses was to present a comprehensive evaluation of potential process-related, natural phenomena, and external hazards that can affect facility workers, onsite
workers, the offsite public, and/or the environment due to single or multiple failures, and provide
the following:

- Characterization of the radioactive and hazardous materials
- Identification of the potential energy sources capable of interacting with the radioactive
  and hazardous materials
- Identification of the possible accident scenarios from potential energy sources near
  hazardous and radioactive materials that may lead to a significant release

3.3.1.1 Hazard Identification

Hazards associated with routine basin operations were identified using an energy source
checklist as documented in DD-53838, 105-KW Basin Streamline Hazards Analysis. The
checklist was a combination of checklists taken from DOE-76-45/19, Job Safety Analysis, and
PRC-PRO-NS-700, Safety Basis Development. The hazards specifically associated with the
Engineered Container Retrieval and Transfer System (ECRTS) were identified using the energy
source checklist from PRC-PRO-NS-700, as documented in PRC-STP-00697, Sludge Treatment
Project Engineered Container Retrieval and Transfer System Hazard Analysis Supplement 1.
The information obtained was used to group potentially hazardous material and energy sources
as they were identified in each major facility area.

For both routine basin operation and ECRTS, identified hazards were evaluated to determine if
they were standard industrial hazards (SIH). As defined in DOE-STD-3009-94, SIHs are
hazards that are routinely encountered in general industry and construction, and for which
national consensus codes and/or standards exists to guide safe design and operation without
the need for special analysis to design safe design and/or operational parameters. Examples of SIHs
cited in DOE-STD-3009-94 includes burns from hot objects, electrocution, and falling objects.
Standard industrial hazards and radiological control hazards identified for ECRTS were found to
be the same as those routinely encountered in the 105KW Basin and which have been effectively
controlled for many years through the imposition of Safety Management Programs (SMPs).
CHPRC SMPs are described in HNF-11724, CH2M HILL Plateau Remediation Company Safety
Management Programs, and are implemented at the 105KW Facility as a Technical Safety
Requirement Administrative Control (see Section 5.5.3.2.1, “Administrative Control 5.7.1 –
Safety Management Programs”).

3.3.1.2 Hazard Evaluation

Hazards associated with routine basin operations were evaluated using the What-If methodology.
As described in Guidelines for Hazard Evaluation Procedures (AIChE 2008), a What-if analysis
is performed by an experienced group of people who identify possible abnormal situations, their
consequences, and possible safeguards. Consequences can be categorized as either an
operational upset (e.g., delay in processing) or as a specific hazardous condition
(e.g., uncontrolled release). Accidents occur when abnormal conditions that can result in a
hazardous condition are not prevented or adequately mitigated.

For ECRTS, two hazard evaluation techniques were used, HAZOP and What-If. The HAZOP is
documented in PRC-STP-00687, Sludge Treatment Project Engineered Container Retrieval and
Transfer System Hazard and Operability Study. As described in AIChE 2008, in a HAZOP
study a group of experienced professionals systematically review a process to determine if
deviations from the design or operational intent can lead to undesirable consequences. The HAZOP methodology was developed for application in the chemical industry and is best suited to processes with defined material and energy flow paths. Accordingly, the HAZOP methodology was applied to the following ECRTS Processes:

- Retrieving sludge as a sludge-water slurry from an engineered container
- Transferring the slurry to a Sludge Transport and Storage Container (STSC)
- Decanting and filtering STSC supernate
- Backwashing the ECRTS Sand Filter into the STSC
- Purging the STSC with nitrogen
- Purging the STS Cask with nitrogen
- Pressurizing the STS Cask with nitrogen
- Adding flocculant to the slurry during transfer
- Adding flocculant to the supernate
- Recovering excess sludge from an overfilled STSC

The What-if methodology was applied to ECRTS activities that do not have defined material and energy flow paths and is documented in PRC-STP-00697. Accordingly, the What-if methodology was applied to the following activities:

- Preparing the STSC for sludge retrieval and transfer
- Disconnecting the STSC
- Preparing the STSC and STS Cask for shipping
- Spare hose utilization
- Transfer/decant line “pigging”

The What-if methodology also was used to address natural phenomena hazards (NPHs), external events, facility fires, and internal explosions.

The ECRTS hazard analyses have been continuously updated from the conceptual design to the as-built facility configuration to ensure that changes in design and planned operations are evaluated and that necessary safety controls are integrated into the design. Beginning with the submittal of Sludge Treatment Project Engineered Container Retrieval and Transfer System Preliminary Safety Design Report (PRC-STP-00461), an Unreviewed Safety Question (USQ)-Like process has been employed consistent with DOE-STD-1189-2008, Section 6.4, “Change Control for Safety Reports as Affected by Safety-in-Design Activities.” After submittal of the DSA to RL for review and approval, the formal USQ process was used to evaluate any design change as required by PRC-PRO-NS-062, Unreviewed Safety Question Process.

Not all hazardous conditions identified and evaluated by the hazard analyses warrant quantitative accident analysis. This determination is based on a qualitative estimate of potential accident consequences performed as part of the hazard evaluation. Similarly, not all analyzed accidents warrant development as design basis accidents. This determination is based on a comparison of
the quantitative accident consequences to evaluation guidelines for the facility worker, collocated worker, and offsite public, and whether the accident is unique or representative.

3.3.2 Hazard Analysis Results

3.3.2.1 Hazard Identification

Hazardous conditions associated with routine basin operations are identified in DD-53838. Hazardous conditions associated with ECRTS are identified in PRC-STP-00687 and PRC-STP-00697.

Table 3-1 and Table 3-2 are derived from the hazard analyses and summarize the specific hazards resulting in a hazardous condition judged to warrant accident analysis.

The hazard analyses identified potential accident scenarios that are further evaluated in this document to determine quantitatively the consequences of postulated accidents.

**Table 3-1. Summary of Accident Scenarios Identified in Hazard Analysis DD-53838**

<table>
<thead>
<tr>
<th>Hazard/Accident</th>
<th>Summary</th>
<th>Accident Analyses References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality event</td>
<td>Analysis in CSER demonstrates that criticality is not credible.</td>
<td>PRC-STP-CN-N-00947b, Section 5.7, “Criticality”</td>
</tr>
<tr>
<td>Release by Aerodynamic Entrainment of Sludge from dry basin</td>
<td>Uncontrolled vehicle strikes building structure or gantry structure causing damage, potentially damaging 105KW Basin floor. Vehicle impact damages building structure or gantry resulting in basin drainage.</td>
<td>PRC-STP-CN-N-00947b, Section 5.3.6, “Aerodynamic Entrainment of Sludge from Dry Basin”</td>
</tr>
<tr>
<td></td>
<td>Load drop that damages 105KW Basin boundary resulting in loss of 105KW Basin water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use of vehicles or lifting of heavy weights near the weirs and north wall yields accident that damages 105KW Basin boundary resulting in loss of 105KW Basin water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Load drop that damages 105KW Basin drain valve resulting in loss of 105KW Basin water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Failure of piping or component or equipment mis-operation that pumps water out of the 105KW Basin.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design Basis Earthquake</td>
<td>PRC-STP-CN-N-00947b, Section 5.5.2, “Seismic Induced Basin Water Loss”</td>
</tr>
<tr>
<td>Hydrogen deflagration in annular filter vessel</td>
<td>Accumulation of hydrogen in annular filter vessel due to radiolysis resulting in deflagration.</td>
<td>PRC-STP-CN-N-00947b, Section 5.3.5, “Hydrogen Deflagration Outside of STSC”</td>
</tr>
<tr>
<td>Spray Release</td>
<td>Operator error, equipment failure, or seismic event damages IWTS equipment (IXMs, annular filter vessels, and associated above-water piping and pumps) resulting in a spray release.</td>
<td>PRC-STP-CN-N-00947b, Section 5.3.2, “Integrated Water Treatment System Spray Releases”</td>
</tr>
</tbody>
</table>
Table 3-1. Summary of Accident Scenarios Identified in Hazard Analysis DD-53838

<table>
<thead>
<tr>
<th>Hazard/Accident</th>
<th>Summary</th>
<th>Accident Analyses References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release of radioactive water to the environment (Radiological Consequences)</td>
<td>Overflow of the fuel storage 105KW Basin water, with possible release of radioactivity to the environment.</td>
<td>PRC-STP-CN-N-00947⁷, Section 5.3.10, “Release of Radioactive Water to the Environment”</td>
</tr>
<tr>
<td>Release of radioactive material from the annular filter vessel(s), from fire⁵</td>
<td>Vehicle impact with fuel pool fire results in structural members dropping onto the annular filter vessel(s), which release radioactive contents.</td>
<td>PRC-STP-CN-N-00947⁷, Section 5.3.11.4 “Fire in Basin Transfer Bay”</td>
</tr>
<tr>
<td>Release of radioactive material from CERCLA waste in staging area⁴</td>
<td>Fire involving wastes at CERCLA staging area.</td>
<td>PRC-STP-CN-N-00947⁷, Section 5.3.11.3, “Fire in CERCLA Waste Staging Area”</td>
</tr>
<tr>
<td>Hydrogen deflagration from containerized sludge hydrogen release</td>
<td>Release and deflagration of accumulated hydrogen from uranium oxidation and radiolysis in the containerized sludge with potential significant hazard to the facility worker. Beyond Extremely Unlikely Event.</td>
<td>PRC-STP-CN-N-00970⁴</td>
</tr>
</tbody>
</table>

Notes:
- b. PRC-STP-CN-N-00947, 105-KW Basin Accident Analysis Calculations.
- c. Fire identified in HNF-SD-SNF-FHA-001, Fire Hazards Analysis for the 105-KW Facility.
- d. PRC-STP-CN-N-00970, 105-K West Basin Engineered Container SCS-CON-230 Thermal Analyses For Settler Sludge, evaluates sludge behavior basin drain with and without water in the engineered containers. Results showed than maximum temperature increase is less than 34°C (peak less than 60°C). Overall, sludge thermal and gas generation behavior in the container is benign even with the loss of basin water. No further analysis needed.

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CSER Criticality Safety Evaluation Report
IWTS Integrated Water Treatment System
IXM Ion exchange module

Table 3-2. Summary of Accident Scenarios Identified in PRC-STP-00687 and PRC-STP-00697

<table>
<thead>
<tr>
<th>Hazard/Accident</th>
<th>Summary</th>
<th>Accident Analyses References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release (Sludge Retrieval and Transfer)</td>
<td>Release of aerosolized slurry because of system containment failure under pressure, assumed to occur in a hard-piped section of the sludge transfer line.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.1, “ECRTS Spray Leaks”</td>
</tr>
<tr>
<td>Spray Release (Overfill Recovery)</td>
<td>Release of aerosolized slurry because of system containment failure while the system is under pressure during overfill recovery of slurry from STSC.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.1, “ECRTS Spray Leaks”</td>
</tr>
</tbody>
</table>
Table 3-2. Summary of Accident Scenarios Identified in PRC-STP-00687 and PRC-STP-00697

<table>
<thead>
<tr>
<th>Hazard/Accident</th>
<th>Summary</th>
<th>Accident Analyses References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release (Decant)</td>
<td>Release of aerosolized slurry because of system containment failure while the system is under pressure during decanting of the STSC.</td>
<td></td>
</tr>
<tr>
<td>Spray Release (ECRTS Sand Filter Backwash)</td>
<td>Release of aerosolized slurry because of system containment failure while the system is under pressure during backwash of the ECRTS Sand Filter.</td>
<td></td>
</tr>
<tr>
<td>STSC Deflagration (Hydrogen)</td>
<td>Accumulation and ignition of a flammable concentration of hydrogen gas in the STSC headspace.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.4, “Hydrogen Deflagration Inside the STSC”</td>
</tr>
<tr>
<td>TLSB Deflagration (Hydrogen)</td>
<td>Slurry spill into the TLSB and subsequent accumulation and ignition of a flammable concentration of hydrogen in the TLSB.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.5, “Hydrogen Deflagration Outside the STSC”</td>
</tr>
<tr>
<td>Decant Pump Box Deflagration (Hydrogen)</td>
<td>Slurry spill into the Decant Pump Box and subsequent accumulation and ignition of a flammable concentration of hydrogen in the Decant Pump Box.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.5, “Hydrogen Deflagration Outside the STSC”</td>
</tr>
<tr>
<td>Sand Filter Skid Deflagration (Hydrogen)</td>
<td>Slurry spill into the Sand Filter Skid and subsequent accumulation and ignition of a flammable concentration of hydrogen in the ECRTS Sand Filter or Sand Filter Skid.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.5, “Hydrogen Deflagration Outside the STSC”</td>
</tr>
<tr>
<td>Splash &amp; Splatter (Spill) (Sludge Retrieval and Transfer)</td>
<td>Release of slurry because of system containment failure of the sludge transfer line.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.7, “Spill (Splash/Splatter Release of Sludge)”</td>
</tr>
<tr>
<td>STSC/STS Cask Over-Pressurization</td>
<td>Excess hydrogen generation due to the uranium metal-water reaction while the STSC/STS Cask is isolated.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.9, “Over-pressurization”</td>
</tr>
<tr>
<td>STSC Impact</td>
<td>Lid drop on STSC.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.8, “Impact (Load Drop on STSC)”</td>
</tr>
<tr>
<td>Facility Fires</td>
<td>A fire inside the 105KW Annex during a sludge transfer that directly or indirectly damages the slurry transfer line, resulting in a spray release or ventilation system damage leading to a hydrogen explosion. HEPA filter fire was identified.</td>
<td>PRC-STP-CN-N-00947, Section 5.3.11.1, “Fire in Annex HEPA Filter Room” (Fires Identified in HNF-SD-SNF-FHA-001)</td>
</tr>
<tr>
<td>Natural Phenomena</td>
<td>Seismic event, lightning, high winds, low temperature, or snow and ash fall loading induce transfer line failure resulting in a spray release or ventilation system damage leading to a hydrogen explosion.</td>
<td>PRC-STP-CN-N-00947, Section 5.5, “Natural Phenomena Design Basis Accidents” Section 5.5.1, “Seismic-Induced Spray Event” Section 5.5.3, “Wind-Induced Spray Event”</td>
</tr>
</tbody>
</table>
Table 3-2. Summary of Accident Scenarios Identified in PRC-STP-00687 and PRC-STP-00697

<table>
<thead>
<tr>
<th>Hazard/Accident</th>
<th>Summary</th>
<th>Accident Analyses References</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Events</td>
<td>External fire or vehicle impact induces: (1) transfer line failure resulting in a spray release, (2) ventilation system damage leading to a hydrogen explosion, (3) strikes building structure or gantry structure causing damage, potentially damaging 105KW Basin floor leading to Loss of 105KW Basin water.</td>
<td>PRC-TP-CN-N-00947, Section 5.6, “External Events”</td>
</tr>
<tr>
<td>Criticality</td>
<td>CHPRC-02459, Section 5.5, “Incredibility Discussion,” concluded that a criticality accident is judged to be not credible at the 105KW Facility given the current inventory and type of fissile material present.</td>
<td>PRC-TP-CN-N-00947, Section 5.7 “Criticality”</td>
</tr>
</tbody>
</table>

Notes:

a. HNF-SD-SNF-FHA-001.
b. CHPRC-02459, CSER 14-006 Criticality Safety Evaluation Report for Limited Fissile Material Operations as the K West Basin, Rev.0.

SCS Sludge Containerization System
STS Sludge Transport System

3.3.2.2 Hazard Categorization

The final hazard categorization for the 105KW Basin/105KW Annex is evaluated consistent with PRC-PRO-NS-8366, Facility Hazard Categorization, which requires use of DOE-STD-1027-92. The hazard categorization tabulates the radionuclide inventory of the sludge to be retrieved from the engineered containers. Additional radiological inventory (e.g., fuel fragments, ion exchange modules, garnet filter media, residual material in settler tanks, and sand filter media) is present in the facilities, but is not tabulated. The tabulated inventory of sludge is sufficient to determine the facility hazard category.

3.3.2.2.1 Radionuclide Inventories

Engineered container sludge volumes and radionuclide inventories are taken from Table 4-26 of HNF-SD-SNF-TI-015, Spent Nuclear Fuel Project Technical Databook, Volume 2, Sludge. Radionuclide inventories are decay corrected to August 1, 2018. The measured volumes and sources of sludge in the six engineered containers are shown in Table 3-3. The isotopic content for each of the sludge streams is shown in Table 3-4.

Table 3-3. Volume of Sludge in Individual KW Engineered Containers

<table>
<thead>
<tr>
<th>Volume* (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-210)</td>
</tr>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-220)</td>
</tr>
<tr>
<td>Settler Tank Sludge (SCS-CON-230)</td>
</tr>
</tbody>
</table>
### Table 3-3. Volume of Sludge in Individual KW Engineered Containers

<table>
<thead>
<tr>
<th>KE Basin Containerized Sludge (SCS-CON-240)</th>
<th>Volume* (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KE Basin Containerized Sludge (SCS-CON-250)</td>
<td>7.7</td>
</tr>
<tr>
<td>KE Basin Containerized Sludge (SCS-CON-260)</td>
<td>8.1</td>
</tr>
<tr>
<td>Total Sludge Volume</td>
<td>27.1</td>
</tr>
</tbody>
</table>

Notes:
*The volume of sludge in each container is based on lowest visible level indication above the sludge. This estimate provides a bounding value for the sludge volumes with the actual volumes of sludge in the engineered container being up to 0.4 m³ less than the value shown in the table.

KE 105-K East

### Table 3-4. Safety Basis Sludge Radionuclide Inventories Settled Sludge Basis

<table>
<thead>
<tr>
<th>Isotope</th>
<th>KW Originating</th>
<th>Settler Tank</th>
<th>KE Originating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCS-CON-210 (Ci/m³)</td>
<td>SCS-CON-220 (Ci/m³)</td>
<td>SCS-CON-230 (Ci/m³)</td>
</tr>
<tr>
<td>²⁴¹Am</td>
<td>2.79E+1</td>
<td>1.13E+2</td>
<td>2.16E+2</td>
</tr>
<tr>
<td>²³⁷Np</td>
<td>2.95E-3</td>
<td>8.47E-3</td>
<td>2.12E-2</td>
</tr>
<tr>
<td>²³⁸Pu</td>
<td>3.58</td>
<td>1.66E+1</td>
<td>2.60E+1</td>
</tr>
<tr>
<td>²³⁹Pu</td>
<td>1.76E+1</td>
<td>6.07E+1</td>
<td>1.13E+2</td>
</tr>
<tr>
<td>²⁴⁰Pu</td>
<td>9.88</td>
<td>3.58E+1</td>
<td>6.74E+1</td>
</tr>
<tr>
<td>²⁴¹Pu</td>
<td>1.43E+2</td>
<td>5.00E+2</td>
<td>1.46E+3</td>
</tr>
<tr>
<td>²⁴²Pu</td>
<td>3.42E-3</td>
<td>1.40E-2</td>
<td>3.82E-2</td>
</tr>
<tr>
<td>⁶⁰Co</td>
<td>1.15E-1</td>
<td>1.25E-1</td>
<td>3.50E-1</td>
</tr>
<tr>
<td>¹³⁴Cs</td>
<td>NR</td>
<td>4.72E-4</td>
<td>NR</td>
</tr>
<tr>
<td>¹³⁷Cs</td>
<td>6.63E+2</td>
<td>7.73E+2</td>
<td>3.63E+3</td>
</tr>
<tr>
<td>¹³⁷ᵐBa</td>
<td>6.26E+2</td>
<td>7.29E+2</td>
<td>3.43E+3</td>
</tr>
<tr>
<td>¹⁵⁴Eu</td>
<td>5.25E-1</td>
<td>2.78</td>
<td>4.05</td>
</tr>
<tr>
<td>¹⁵⁵Eu</td>
<td>5.86E-2</td>
<td>2.17E-1</td>
<td>4.44E-1</td>
</tr>
<tr>
<td>⁹⁰Sr</td>
<td>5.15E+2</td>
<td>8.66E+2</td>
<td>1.77E+3</td>
</tr>
<tr>
<td>⁹⁰⁶Yb</td>
<td>5.15E+2</td>
<td>8.66E+2</td>
<td>1.77E+3</td>
</tr>
<tr>
<td>⁹⁹⁰Tc</td>
<td>NR</td>
<td>1.39E-1</td>
<td>NR</td>
</tr>
<tr>
<td>²³⁴U</td>
<td>7.34E-2</td>
<td>1.80E-1</td>
<td>3.89E-1</td>
</tr>
<tr>
<td>²³⁵U</td>
<td>2.60E-3</td>
<td>6.92E-3</td>
<td>1.29E-2</td>
</tr>
<tr>
<td>²³⁶U</td>
<td>8.24E-3</td>
<td>2.35E-2</td>
<td>4.43E-2</td>
</tr>
<tr>
<td>²³⁸U</td>
<td>5.75E-2</td>
<td>1.54E-1</td>
<td>2.81E-1</td>
</tr>
</tbody>
</table>

Notes:
Table 3-4. Safety Basis Sludge Radionuclide Inventories Settled Sludge Basis

<table>
<thead>
<tr>
<th>Isotope</th>
<th>KW Originating</th>
<th>Settler Tank</th>
<th>KE Originating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCS-CON-210 (Ci/m³)</td>
<td>SCS-CON-220 (Ci/m³)</td>
<td>SCS-CON-230 (Ci/m³)</td>
</tr>
<tr>
<td>a. $^{137}$Ba</td>
<td>$0.944 \times ^{137}$Cs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. $^{90}$Y</td>
<td>$= ^{90}$Sr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>not reported</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The maximum volumes that can be loaded into an STSC are shown in Table 3-5.

Table 3-5. Maximum Sludge Volume per Sludge Transport and Storage Container

<table>
<thead>
<tr>
<th></th>
<th>SCS-CON-210</th>
<th>SCS-CON-220</th>
<th>SCS-CON-230 with SCS-CON-240, -250, or -260</th>
<th>SCS-CON-240, -250, or -260</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum volume of settled sludge in an STSC</td>
<td>1.6 m³</td>
<td>1.0 m³</td>
<td>2.0 m³</td>
<td>2.1 m³</td>
</tr>
<tr>
<td>Volume of Supernate Above Settled Sludge During Storage at T Plant</td>
<td>1.54 m³</td>
<td>2.1 m³</td>
<td>0.96 m³</td>
<td>0.84 m³</td>
</tr>
<tr>
<td>STSC operating volume for storage at T Plant</td>
<td>3.14 m³</td>
<td>3.1 m³</td>
<td>2.96 m³</td>
<td>2.94 m³</td>
</tr>
</tbody>
</table>

Notes:

a. 0.4 m³ Settler Tank with 1.6 m³ KE.
b. These values are based on maximum STSC loading for long-term storage at T Plant (HNF-41051, STP Container and Settler Sludge Process System Description and Material Balance, Table 2-2).

3.3.2.2.2 Hazard Categorization Results

The HC ratio per m³ for each 105KW Basin Engineered Container is shown in Table 3-6 and is based on the HC-2 thresholds and on the sludge radionuclide inventories from Table 3-4.

Table 3-6. Hazard Category 2 Ratios per m³ for Each Sludge Stream

<table>
<thead>
<tr>
<th>Isotope</th>
<th>HC-2 Thresholdb (Ci)</th>
<th>SCS-CON-210</th>
<th>SCS-CON-220</th>
<th>SCS-CON-230</th>
<th>SCS-CON-240, -250, and -260</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{241}$Am</td>
<td>5.50E+1</td>
<td>5.07E-1</td>
<td>2.05</td>
<td>3.93</td>
<td>2.24E-1</td>
</tr>
<tr>
<td>$^{237}$Np</td>
<td>5.80E+1</td>
<td>5.09E-5</td>
<td>1.46E-4</td>
<td>3.66E-4</td>
<td>1.61E-5</td>
</tr>
<tr>
<td>$^{238}$Pu</td>
<td>6.20E+1</td>
<td>5.77E-2</td>
<td>2.68E-1</td>
<td>4.19E-1</td>
<td>2.34E-2</td>
</tr>
<tr>
<td>$^{239}$Pu</td>
<td>5.60E+1</td>
<td>3.14E-1</td>
<td>1.08</td>
<td>2.02</td>
<td>1.27E-1</td>
</tr>
<tr>
<td>$^{240}$Pu</td>
<td>5.60E+1</td>
<td>1.76E-1</td>
<td>6.39E-1</td>
<td>1.20</td>
<td>7.34E-2</td>
</tr>
</tbody>
</table>
Table 3-6. Hazard Category 2 Ratios per m$^3$ for Each Sludge Stream

<table>
<thead>
<tr>
<th>Isotope</th>
<th>HC-2 Threshold$^a$ (Ci)</th>
<th>SCS-CON-210</th>
<th>SCS-CON-220</th>
<th>SCS-CON-230</th>
<th>SCS-CON-240, -250, and -260</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{241}$Pu</td>
<td>2.90E+3</td>
<td>4.93E-2</td>
<td>1.72E-1</td>
<td>5.03E-1</td>
<td>1.78E-2</td>
</tr>
<tr>
<td>$^{242}$Pu</td>
<td>5.90E+1</td>
<td>5.80E-5</td>
<td>2.37E-4</td>
<td>6.47E-4</td>
<td>2.44E-5</td>
</tr>
<tr>
<td>$^{60}$Co</td>
<td>1.90E+5</td>
<td>6.05E-7</td>
<td>6.58E-7</td>
<td>1.84E-6</td>
<td>3.37E-7</td>
</tr>
<tr>
<td>$^{134}$Cs</td>
<td>6.00E+4</td>
<td>0.0</td>
<td>7.87E-9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>$^{137}$Cs</td>
<td>8.90E+4</td>
<td>7.45E-3</td>
<td>8.69E-3</td>
<td>4.08E-2</td>
<td>1.38E-3</td>
</tr>
<tr>
<td>$^{137m}$Ba$^b$</td>
<td>NR</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>$^{154}$Eu</td>
<td>1.10E+5</td>
<td>4.77E-6</td>
<td>2.53E-5</td>
<td>3.68E-5</td>
<td>1.90E-6</td>
</tr>
<tr>
<td>$^{155}$Eu</td>
<td>7.30E+5</td>
<td>8.03E-8</td>
<td>2.97E-7</td>
<td>6.08E-7</td>
<td>0.0</td>
</tr>
<tr>
<td>$^{90}$Sr$^c$</td>
<td>2.20E+4</td>
<td>2.34E-2</td>
<td>3.94E-2</td>
<td>8.05E-2</td>
<td>5.05E-3</td>
</tr>
<tr>
<td>$^{90}$Y</td>
<td>NR</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>$^{99}$Tc</td>
<td>3.80E+6</td>
<td></td>
<td>3.66E-8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>$^{234}$U</td>
<td>2.20E+2</td>
<td>3.34E-4</td>
<td>8.18E-4</td>
<td>1.77E-3</td>
<td>3.94E-4</td>
</tr>
<tr>
<td>$^{235}$U</td>
<td>2.40E+2</td>
<td>1.08E-5</td>
<td>2.88E-5</td>
<td>5.38E-5</td>
<td>3.89E-6</td>
</tr>
<tr>
<td>$^{236}$U</td>
<td>5.50E+1</td>
<td>1.50E-4</td>
<td>4.27E-4</td>
<td>8.05E-4</td>
<td>8.96E-5</td>
</tr>
<tr>
<td>$^{238}$U</td>
<td>2.40E+2</td>
<td>2.40E-4</td>
<td>6.42E-4</td>
<td>1.17E-3</td>
<td>8.63E-5</td>
</tr>
<tr>
<td>Totals</td>
<td>1.1</td>
<td>4.3</td>
<td>8.2</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

b. $^{137m}$Ba = 0.944 × $^{137}$Cs.
c. $^{90}$Y = $^{90}$Sr.

Using the total HC-2 ratio per m$^3$ from Table 3-6, and the engineered container volumes of Table 3-3, the HC-2 ratio for each engineered container are given in Table 3-7 along with the total for all the sludge types.

Table 3-7. Hazard Category 2 Ratio for Each Engineered Container Sludge Totals

<table>
<thead>
<tr>
<th>Sludge Volume</th>
<th>KW Basin Originating</th>
<th>Settler Tank Sludge</th>
<th>KE Basin Originating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Volume</td>
<td>4.2 m$^3$</td>
<td>1.0 m$^3$</td>
<td>3.5 m$^3$</td>
</tr>
<tr>
<td>HC-2 ratio per m$^3$</td>
<td>1.1</td>
<td>4.3</td>
<td>8.2</td>
</tr>
<tr>
<td>HC-2 ratio for Sludge Streams</td>
<td>4.6</td>
<td>4.3</td>
<td>29</td>
</tr>
</tbody>
</table>
Table 3-7. Hazard Category 2 Ratio for Each Engineered Container Sludge Totals

<table>
<thead>
<tr>
<th>SCS-CON-210 Originating</th>
<th>SCS-CON-220 Originating</th>
<th>KE Basin Originating</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW Basin</td>
<td>Settler Tank Sludge</td>
<td>KE Engineered Container</td>
</tr>
<tr>
<td>Stockpile</td>
<td>Stockpile</td>
<td></td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>SCS-CON-220</td>
<td>SCS-CON-230</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCS-CON-240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCS-CON-250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCS-CON-260</td>
</tr>
</tbody>
</table>

Total HC-2 Ratio for Engineered Containers = 47.2

Again using the total HC-2 ratio per m³ from Table 3-6 and the STSC volumes from Table 3-5, the HC-2 ratio for STSCs for each of the engineered containers are given in Table 3-8.

Table 3-8. Hazard Category 2 Ratio per STSC for Each Sludge Stream

<table>
<thead>
<tr>
<th>Maximum settled sludge volume per STSC</th>
<th>SCS-CON-210</th>
<th>SCS-CON-220</th>
<th>KE Layered over Settler Tank Sludge</th>
<th>KE Engineered Container</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.6 m³</td>
<td>1.0 m³</td>
<td>0.4 m³ Settler Tank</td>
<td>2.1 m³</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.6 m³ KE</td>
<td>0.5 KE</td>
</tr>
<tr>
<td>HC-2 ratio per m³</td>
<td>1.1</td>
<td>4.3</td>
<td>8.2 Settler Tank</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>4.3</td>
<td>4.0 KE</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Based on the evaluations in the preceding sections, the final HC for ECRTS activity is clearly HC-2 based on sludge inventories and maximum available sludge volumes for unmitigated accident. Since the spray release or spill accidents can occur in either the 105KW Basin or the 105KW Annex, segmentation of is not an option. Thus the 105KW Facility is a categorized as HC-2.

3.3.2.3 Hazard Evaluation

Hazard evaluation characterizes the identified hazards in the context of the actual facility and process. To perform this evaluation, unmitigated consequence and frequency levels were qualitatively assigned to the hazardous conditions identified in DD-53838, PRC-STP-00687, and PRC-STP-00697. The collocated and offsite public radiological consequence levels and frequency levels are shown in Table 3-9 and Table 3-10. The consequence and frequency levels can be combined to assign a Risk Rank to a hazardous condition as shown in Table 3-11.
### Table 3-9. Collocated Worker and Offsite Public Consequence Thresholds

<table>
<thead>
<tr>
<th>Consequence Level</th>
<th>Collocated Worker&lt;sup&gt;b, c, d&lt;/sup&gt;</th>
<th>Public&lt;sup&gt;a, c, d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>≥ 100 rem TED or ≥ PAC-3</td>
<td>≥ 25 rem TED or ≥ PAC-2</td>
</tr>
<tr>
<td>Moderate</td>
<td>≥ 25 rem TED or ≥ PAC-2</td>
<td>≥ 5 rem TED or ≥ PAC-1</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 25 rem TED or &lt; PAC-2</td>
<td>&lt; 5 rem TED or &lt; PAC-1</td>
</tr>
</tbody>
</table>

Notes:

a. Maximally-exposed Offsite Individual (MOI). A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public.
b. A collocated worker at a distance of 100 m from a facility (building perimeter) or estimated release point.
c. The term TED has replaced the term total effective dose equivalent, as used in DOE-STD-3009-94.
d. DOE’s Protective Action Criteria are defined by Advanced Technologies and Laboratories International, Inc. in “Protective Action Criteria (PAC): Chemicals with AEGLs, ERPGs, & TEELs,” Rev. 27, February 2012. This is available at: [http://www.atlintl.com/DOE/teels/teel.html](http://www.atlintl.com/DOE/teels/teel.html).

### Table 3-10. Qualitative Likelihood Classification

<table>
<thead>
<tr>
<th>Frequency Level</th>
<th>Likelihood Range (per year)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipated</td>
<td>Likelihood &gt; 10&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Events that may occur several times during the lifetime of the facility (incidents that commonly occur).</td>
</tr>
<tr>
<td>Unlikely</td>
<td>10&lt;sup&gt;2&lt;/sup&gt; &lt; Likelihood &lt; 10&lt;sup&gt;-4&lt;/sup&gt;</td>
<td>Events that are not anticipated to occur during the lifetime of the facility.</td>
</tr>
<tr>
<td>Extremely Unlikely</td>
<td>10&lt;sup&gt;-4&lt;/sup&gt; &lt; Likelihood &lt; 10&lt;sup&gt;-6&lt;/sup&gt;</td>
<td>Events that will probably not occur during the lifetime of the facility.</td>
</tr>
<tr>
<td>Beyond Extremely Unlikely</td>
<td>Likelihood &lt; 10&lt;sup&gt;-6&lt;/sup&gt;</td>
<td>All other accidents.</td>
</tr>
</tbody>
</table>

### Table 3-11. Risk Rank

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beyond Extremely Unlikely</td>
</tr>
<tr>
<td>High</td>
<td>III</td>
</tr>
<tr>
<td>Moderate</td>
<td>IV</td>
</tr>
<tr>
<td>Low</td>
<td>IV</td>
</tr>
</tbody>
</table>

### 3.3.2.3.1 Planned Design and Operational Safety Improvements

The purpose of this section is to discuss commitments for planned, but not yet implemented, major design or operational improvements. However, there are currently no outstanding major improvements identified or planned at this time.

### 3.3.2.3.2 Defense-in-Depth

Defense-in-depth is achieved by providing layers of protection with successive physical and administrative barriers to prevent or mitigate the release of hazardous material to the environment. It includes integrated safety management programs (SMP) that control and discipline operations. The layers of protection supporting defense-in-depth principles generally follow a progression from accident prevention to accident management (e.g., detection and isolation), and finally accident mitigation as a last line of defense. Relevant design basis accidents are used to structure the discussion of defense-in-depth features.

Safety-significant SSCs and specific administrative controls (SACs) identified in the following subsections are described in detail in Chapter 4, Sections 4.4 and 4.5, respectively.

#### 3.3.2.3.2.1 ECRTS Spray Releases

Safety-significant, above-water slurry transfer lines provide the primary barrier to slurry spray releases during sludge retrieval and transfer. “Above-water slurry transfer lines” includes connections and equipment that is part of the pressure boundary. The above water slurry transfer lines are protected from over-pressurization by safety-significant below-water rupture disks.

General service secondary confinement with associated leak detection interlocked to terminate slurry transfers provides defense-in-depth mitigation should the primary barrier fail. Secondary confinement is provided by the Outer Pipe of Ingress/Egress Assembly, In-Basin/Horizontal Shielded Hose Chase, Outer Hose of Slurry Transfer Line HIH, and the TLSB. Basin water provides secondary confinement for below-water transfer lines and equipment. The assumption of secondary confinement by basin water is protected by a SAC to verify a minimum basin water level prior to initiating a transfer.

In the event a spray release occurred, the general service Process/Exhaust Ventilation System provides defense-in-depth against radiological/toxicological release. This system provides ventilation zone confinement in which air flows from areas of lesser contaminating potential to areas of greater contamination potential. The ventilation exhaust passes through two stages of HEPA filters prior to discharge via the building stack.

A SAC to prohibit personnel entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer provides an additional layer of defense-in-depth for facility worker
protection. This control was classified as a SAC as it was judged to be a major contributor to defense-in-depth.

3.3.2.3.2.2 STSC/STS Cask Hydrogen Explosion

Under normal operating conditions, the general service Process/Exhaust Ventilation System prevents an explosion during sludge retrieval and transfer. It maintains the hydrogen concentration in the STSC headspace below 25 percent of the LFL in air.

If the general service Process/Exhaust Ventilation System fails to maintain a minimum air flow rate through the STSC, the safety-significant Auxiliary Ventilation System will automatically activate. The Auxiliary Ventilation System uses pressurized nitrogen gas to provide a flow rate through the STSC to maintain the hydrogen concentration below 25 percent of the LFL in air.

3.3.2.3.2.3 Process Enclosure Hydrogen Explosion

Under normal operating conditions, the ECRTS process enclosures do not contain sludge. However, if a transfer line within an enclosure failed, then sludge could collect in the enclosure potentially leading to a flammable hydrogen concentration. The primary control strategy is to prevent hydrogen explosions by preventing slurry leaks within the enclosures.

The safety-significant, above-water slurry transfer lines provide the primary barrier to releasing sludge to the various ECRTS process enclosures.

General service secondary confinement with associated leak detection interlocked to terminate slurry transfers provides defense-in-depth mitigation should the primary barrier fail.

Terminating the transfer limits the volume of slurry released into an enclosure thus limiting the rate at which hydrogen is generated and alerting operations to the upset condition such that corrective actions can be taken. In addition, the general service Process/Exhaust Ventilation System provides active ventilation for process enclosures. Although provided primarily for Radiological Protection, in the event of a spill this ventilation would also function to sweep hydrogen from the TLSB thus reducing the likelihood of a hydrogen explosion.

3.3.2.3.2.4 STSC/STS Cask Over-Pressurization

The safety-significant STSC is an ASME BPVC, Section VIII, Division 1, pressure vessel rated at 150 psig and full vacuum. Safety-significant STSC Transport Vent Assemblies prevent STSC over-pressurization by venting pressure. The assemblies are designed with check valves that open at a specific cracking pressure and vent the STSC through a HEPA filter. The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying installation of the Transport Vent Assemblies.

The safety-significant STS Cask has a pressure rating of 80 psig. The STS Cask Staging Limit SAC is used to ensure that the STS Cask is vented prior to its reaching 80 psig with an appropriate design margin. The safety-significant STS Cask Vent Tool and STS Pressurization Check Tool prevent STS Cask over-pressurization by venting the cask.

In the event of an over-pressurization event, the general service Process/Exhaust Ventilation System provides defense-in-depth against a radiological/toxicological release. This system provides ventilation zone confinement in which air flows from areas of lesser contaminating potential to areas of greater contamination potential. The ventilation exhaust passes through two stages of HEPA filters prior to discharge via the building stack. This protects against
uncontrolled radiological releases from the facility. Air flows from less contaminated areas toward areas of greater potential contamination. The exhaust is HEPA filtered prior to discharge via the building stack.

3.3.2.3.2.5 105KW Annex Fire

The principal control strategy is to prevent the occurrence of a fire of sufficient magnitude to result in structural damage to the 105KW Annex. This is accomplished by (1) establishing a SAC to control the quantity and location of combustible materials in the Sludge Loading Bay, (2) crediting the Fire Protection Program mandated combustible material program in other areas of the 105KW Annex, and (3) crediting the control of hot work as a key element of the Fire Protection Program.

As a secondary control strategy, the safety-significant 105KW Annex structure is of noncombustible construction consistent with its classification as an IBC Type IIB building.

The controls identified above function to prevent fire-induced spray releases and fire-induced hydrogen explosions. In addition, the safety-significant Auxiliary Ventilation System is credited with preventing hydrogen explosions for fires that result in a loss of STSC ventilation.

To provide an additional layer of defense-in-depth, the Personnel Access Prohibition SAC is credited for fire-initiated spray releases, and the Emergency Preparedness SMP is credited for fire-initiated hydrogen explosions. The Personnel Access Prohibition SAC prohibits personnel entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.

The 105KW Annex is also protected by an automatic fire sprinkler system. The system is designed to Ordinary Hazard Group 2 Requirements in accordance with NFPA 13, 2010 edition. There is general area smoke detection coverage in every room, and duct smoke detection in the supply ventilation system. The fire alarm system for the 105KW Annex provides supervision of the installed fire sprinkler and fire detection systems. The fire alarm provides input to the interlock to shutdown slurry transfers. Fire alarms are transmitted to the HFD. The HFD provides fire suppression, rescue, emergency medical and ambulance services, and hazardous material response that are capable of dealing with and terminating emergency situations.

3.3.2.3.3 Worker Safety

The DBAs analyzed in Section 3.4.2 below quantify the offsite public and collocated worker radiological and toxicological consequences. In addition, they qualitatively estimate facility worker consequences including the potential for serious injury or death.

Safety-significant controls are required for slurry spray releases based on the facility worker radiological and toxicological consequences. Safety-significant controls are required for hydrogen explosions and STSC/STS Cask over-pressurization due to the potential for facility worker serious injury or death. The DBA analyses address operational, NPH, and external-event initiators. They also identify the selected safety-significant SSCs and SACs and their associated safety functions. The controls were primarily identified either for facility worker protection or because they were a major contributor to defense-in-depth. A summary of the safety-significant SSCs and SACs are provided in Table 3-12. Additional details are provided in Chapter 4, Sections 4.4 and 4.5.
Table 3-12. **Summary of Facility Worker Controls**

<table>
<thead>
<tr>
<th>DBA</th>
<th>Safety-Significant SSCs</th>
<th>SACs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Accident—ECRTS Spray Releases</td>
<td>Above-water slurry transfer lines</td>
<td>Slurry Settling Duration</td>
</tr>
<tr>
<td></td>
<td>Slurry transfer line rupture disk</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td></td>
<td>Double-valve isolation</td>
<td>Basin Water Level</td>
</tr>
<tr>
<td></td>
<td>Handswitch ECRT-HS-123, Valve</td>
<td>XAGO Pre-Operational Testing and Operational Readiness Controls</td>
</tr>
<tr>
<td></td>
<td>ECRT-SOV-123, and Valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECRT-AOV-123</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hoist Chain Stops</td>
<td></td>
</tr>
<tr>
<td>Operational Accident—STSC Hydrogen Explosion</td>
<td>Auxiliary Ventilation System</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
<tr>
<td></td>
<td>Oxygen Analyzer</td>
<td>Gas Composition Verification</td>
</tr>
<tr>
<td></td>
<td>STSC: Boundary, sloped fin, key dimensions</td>
<td>Sludge Source Verification</td>
</tr>
<tr>
<td></td>
<td>Pressure indicator</td>
<td>Sludge Buoyant Weight Limits</td>
</tr>
<tr>
<td></td>
<td>STS Cask pressure boundary</td>
<td>STSC Inerting Limit</td>
</tr>
<tr>
<td></td>
<td>STS Cask Leak Tester</td>
<td>STS Cask Inerting and Pressurization Limits</td>
</tr>
<tr>
<td></td>
<td>STSC liquid level instrumentation</td>
<td>STSC Final Liquid Level Limits</td>
</tr>
<tr>
<td></td>
<td>Truck Scale instrumentation</td>
<td>STS Cask Leak Rate Limit</td>
</tr>
<tr>
<td></td>
<td>STSC liquid level instrumentation</td>
<td>STS Cask Lid Critical Lift</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-230 divider plate</td>
<td>STS Cask Staging Limit</td>
</tr>
<tr>
<td></td>
<td>Hoist Chain Stops</td>
<td>XAGO Pre-Operational Testing and Operational Readiness Controls</td>
</tr>
<tr>
<td>Operational Accident—Process Enclosure Explosion</td>
<td>Above-water slurry transfer lines</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Slurry transfer line rupture disk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double-valve isolation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handswitch ECRT-HS-123, Valve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECRT-SOV-123, and Valve</td>
<td></td>
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<tr>
<td></td>
<td>ECRT-AOV-123</td>
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</tr>
<tr>
<td>Operational Accident—STSC Over-Pressurization Release</td>
<td>STSC Transport Vent Assembly</td>
<td>STS Cask Staging Limit</td>
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<tr>
<td></td>
<td>STS Cask Vent Tool</td>
<td>Sludge Source Verification</td>
</tr>
<tr>
<td></td>
<td>STS Pressurization Check Tool</td>
<td>Sludge Buoyant Weight Limits</td>
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<tr>
<td></td>
<td>STSC liquid level instrumentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Truck Scale instrumentation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STSC liquid level instrumentation</td>
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<td></td>
<td>SCS-CON-230 divider plate</td>
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<tr>
<td>Operational Accident—105KW Annex Fire</td>
<td>105KW Annex</td>
<td>Combustible Material Control</td>
</tr>
<tr>
<td></td>
<td>Truck Stop/Concrete Platform</td>
<td>Auxiliary Ventilation Actuation Notification</td>
</tr>
<tr>
<td></td>
<td>Trailer Entrance Ramp</td>
<td>Personnel Access Prohibition</td>
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<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td></td>
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Table 3-12. Summary of Facility Worker Controls

<table>
<thead>
<tr>
<th>DBA</th>
<th>Safety-Significant SSCs</th>
<th>SACs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Phenomenon–Seismic Event</td>
<td>Seismic shutdown switches</td>
<td>Personnel Access Prohibition</td>
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<tr>
<td></td>
<td>Safety Shutdown Interlock I-1</td>
<td>Auxiliary Ventilation System</td>
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<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td>Actuation Notification</td>
</tr>
<tr>
<td></td>
<td>STSC boundary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STS Cask pressure boundary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>105KW Annex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>105KW Annex Mezzanine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge crane and associated supports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>105KW Annex Exhaust Stack</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire protection sprinkler systemsupports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC duct supports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cable tray supports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hose cradles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South Tool Tray</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nitrogen Cylinder Storage Awning</td>
<td></td>
</tr>
<tr>
<td>Natural Phenomenon–High Winds</td>
<td>105KW Annex</td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td>Actuation Notification</td>
</tr>
<tr>
<td>Natural Phenomenon–Snow or Ashfall</td>
<td>105KW Annex</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td></td>
<td>Horizontal Shielded Hose Chase</td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td>Actuation Notification</td>
</tr>
<tr>
<td>Natural Phenomenon–Lightning Strike</td>
<td>105KW Annex</td>
<td>Combustible Material Control</td>
</tr>
<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td>STS Cask Inerting and Pressurization Limits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actuation Notification</td>
</tr>
<tr>
<td>Natural Phenomenon–Low Temperatures</td>
<td>None</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td>External Events–Vehicle Impact</td>
<td>Auxiliary Ventilation System</td>
<td>Vehicle Access Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actuation Notification</td>
</tr>
<tr>
<td>External Events–Range Fire</td>
<td>105KW Annex</td>
<td>Combustible Material Control</td>
</tr>
<tr>
<td></td>
<td>Auxiliary Ventilation System</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Actuation Notification</td>
</tr>
</tbody>
</table>

DBA  design basis accident
ECRTS  Engineered Container Retrieval and Transfer System
HVAC  heating, ventilation, and air conditioning
SAC  Specific Administrative Controls
Table 3-12. Summary of Facility Worker Controls

<table>
<thead>
<tr>
<th>DBA</th>
<th>Safety-Significant SSCs</th>
<th>SACs</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSC</td>
<td>structure, system, and component</td>
<td></td>
</tr>
<tr>
<td>STS</td>
<td>Sludge Transport System</td>
<td></td>
</tr>
<tr>
<td>STSC</td>
<td>Sludge Transport and Storage Containers</td>
<td></td>
</tr>
</tbody>
</table>

3.3.2.3.4 Environmental Protection

The 105KW Annex Process/Exhaust Ventilation System is controlled by the Radiation Protection Program and the Environmental Protection Program.

3.3.2.3.5 Accident Selection

The hazard analysis identified and evaluated a complete spectrum of facility accidents using the qualitative frequency and consequence bins shown in Tables 3-9 and 3-10. The unmitigated frequency and consequences of hazardous conditions that result in uncontrolled releases of radioactive and toxicological material are summarized in Table 3-13. For the hydrogen explosion and STSC/STS Cask over-pressurization, a high consequence is assigned to the facility worker based on the potential for prompt fatality or serious injury. As previously stated, the complete hazard rankings are documented in DD-53838, Appendix C, “Hazard Analysis Worksheets;” PRC-STP-00687, Appendix D, “Frequency and Consequence Levels;” and PRC-STP-00697, Appendix E, “Frequency and Consequence Level Results.”

Based on the hazard evaluation ranking in Table 3-13, slurry spray releases during sludge retrieval and transfer, hydrogen explosions in an STSC, STS Cask, or process enclosure, and the over-pressurization of an STSC or STS Cask were identified as accidents potentially exceeding guidelines. As identified by the HAZOP (PRC-STP-00687) and What-if (PRC-STP-00697) studies, these accidents can be initiated by operational events, external events (e.g., vehicle impacts), fires, and NPH. Although unmitigated frequency levels were qualitatively assigned, the identification of operational DBAs was based only on the unmitigated consequences in accordance with DOE-STD-3009-94, Appendix A, “Evaluation Guideline,” which states that there is no predetermined cutoff value, such as 1.0E-6 per year, for excluding low frequency operational accidents.

The hazardous conditions selected in Table 3-13 for analysis as DBAs are the same as those analyzed as DBAs in PRC-STP-00718, Preliminary Documented Safety Analysis for the Sludge Treatment Project Engineered Container Retrieval and Transfer System (PDSA). The ECRTS PDSA was developed in accordance DOE-STD-1189-2008. The final ECRTS hazard analyses performed in support of the as-built DSA development (PRC-STP-00687, PRC-STP-00697) did not identify any operational hazards or upset conditions that would result in a hazardous condition not previously considered in the PDSA. The selected DBAs bound and are representative of the hazardous conditions identified in Tables 3-1 and 3-2.
Table 3-13. Summary of Unmitigated Frequency and Consequence Levels

<table>
<thead>
<tr>
<th>Hazardous Condition</th>
<th>Source Material</th>
<th>Unmitigated Frequency</th>
<th>Unmitigated Consequences</th>
<th>Design Basis Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Facility Worker</td>
<td>Onsite</td>
<td>Offsite</td>
</tr>
<tr>
<td>Operational Spray Release</td>
<td>IXM water</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Slurry (retrieval and transfer-operational)</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>STSC supernate</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Filtered supernate</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>ECRTS Sand Filter backwash</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Slurry (overflow recovery line failure)</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>IWTS Annular Filter Vessel backwash</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Operational Spray Release</td>
<td>IXM water</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Slurry (retrieval and transfer)</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>STSC supernate</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Filtered supernate</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>ECRTS Sand Filter backwash</td>
<td>A</td>
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</tr>
<tr>
<td></td>
<td>Slurry (overflow recovery line failure)</td>
<td>A</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Operational KW Basin Overflow</td>
<td>Basin water</td>
<td>U</td>
<td>L</td>
<td>L</td>
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<tr>
<td>Operating Loss of Basin Water</td>
<td>Dryout and resuspension of sludge</td>
<td>A</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Operational Hydrogen Explosion</td>
<td>STSC, STS Cask</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>TLSB</td>
<td>A</td>
<td>H</td>
<td>L</td>
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<tr>
<td></td>
<td>Decant Pump Box</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>ECRTS Sand Filter</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Sand Filter Skid</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>IWTS Annular Filter Vessel</td>
<td>U</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Operational STSC/STS Cask Over-Pressurization</td>
<td>Sludge slurry</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Operational 105KW Annex Fire</td>
<td>Fire-initiated spray release</td>
<td>EU</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Fire-initiated hydrogen explosion</td>
<td>A</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Operational 105KW Basin Fire</td>
<td>Fire-initiated Annular Filter Vessel spill</td>
<td>EU</td>
<td>L</td>
<td>L</td>
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</table>
Table 3-13. Summary of Unmitigated Frequency and Consequence Levels

<table>
<thead>
<tr>
<th>Hazardous Condition</th>
<th>Source Material</th>
<th>Unmitigated Frequency</th>
<th>Unmitigated Consequences</th>
<th>Design Basis Accident</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Facility Worker</td>
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</tr>
<tr>
<td>Operational CERCLA Waste Staging Area Fire</td>
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<td>A</td>
<td>L</td>
<td>L</td>
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<td>NPH–Seismic Event</td>
<td>Seismic-initiated spray release (sludge retrieval and transfer)</td>
<td>EU</td>
<td>H</td>
<td>M</td>
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<td></td>
<td>Seismic-initiated hydrogen explosion in a process enclosure</td>
<td>EU</td>
<td>H</td>
<td>L</td>
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<tr>
<td></td>
<td>Seismic-initiated explosion in an STSC or STS Cask</td>
<td>U</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Seismic-initiated loss of basin water</td>
<td>U</td>
<td>L</td>
<td>L</td>
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<tr>
<td>NPH–High Winds</td>
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<td>L</td>
<td>L</td>
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<tr>
<td></td>
<td>High wind-initiated hydrogen explosion</td>
<td>U</td>
<td>H</td>
<td>L</td>
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<td>NPH–Snow and Ashfall</td>
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<td>Snow and ashfall-initiated hydrogen explosion</td>
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<td>H</td>
<td>L</td>
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<td>NPH–Lightning Strike</td>
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<td>L</td>
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<tr>
<td></td>
<td>Lightning-initiated hydrogen explosion</td>
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<td>H</td>
<td>L</td>
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<td>NPH–Low Temperatures</td>
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<td>Range fire-initiated spray release</td>
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<td>L</td>
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<tr>
<td></td>
<td>Range fire-initiated hydrogen explosion</td>
<td>A</td>
<td>H</td>
<td>L</td>
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</tbody>
</table>

Notes:
*High consequence to facility worker based on potential for significant injury or death from explosion.

Frequency: Anticipated (>1E-2/yr), Unlikely (1E-4/yr to 1E-2/yr), Extremely Unlikely (1E-6/yr to 1E-4/yr)
Consequences: High, Low

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Table 3-13. Summary of Unmitigated Frequency and Consequence Levels

<table>
<thead>
<tr>
<th>Hazardous Condition</th>
<th>Source Material</th>
<th>Unmitigated Frequency</th>
<th>Unmitigated Consequences</th>
<th>Design Basis Accident</th>
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<tbody>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act</td>
<td></td>
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<td>ECRTS</td>
<td>Engineered Container Retrieval and Transfer System</td>
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<td></td>
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<tr>
<td>IWTS</td>
<td>Integrated Water Treatment System</td>
<td></td>
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<tr>
<td>IXM</td>
<td>Ion exchange module</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPH</td>
<td>Natural Phenomena Hazard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STSC</td>
<td>Sludge Transport and Storage Container</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STS</td>
<td>Sludge Transport System</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4 Accident Analysis

This section presents the accident analysis for the DBAs identified in Section 3.3.2.3.5. This accident analysis considers releases of radioactive and hazardous material during accident conditions.

3.4.1 Methodology

This section identifies the specific methods, assumptions, or methodology used to quantify the consequences of the DBAs.

3.4.1.1 Radiological and Toxicological Hazards

For the formal quantification of DBAs, radiological consequences are estimated using methodologies and parameters identified in PRC-STD-NS-8739, CHPRC Safety Analysis and Risk Assessment Handbook (SARAH). Standardized factors are used to account for the source term, atmospheric dispersion factor, and the unit dose.

For this project, the approved dose calculation tool for dose calculations of a postulated nonreactor, nuclear facility accident is the RADIDOSE software program as described in HNF-26181, User’s Guide and Model Description for RADIDOSE Version 3.0. The RADIDOSE spreadsheet provides a standardized methodology for evaluating accident consequences and uses the analysis methods recommended in SARAH.

The airborne pathway is of primary interest for the radiological dose received by an individual downwind of the accident. As stated in DOE-STD-3009-94, Appendix A, “Evaluation Guideline,” the dose estimate is that received during a 2-hour exposure to the plume considering inhalation, direct shine, and ground shine. Other slow developing release pathways, such as ingestion of contaminated food stuffs, water supply contamination, or resuspension are not included.

DOE-STD-1027-92 quotes observations from NUREG-1140, A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees, that “for all materials of greatest interest for fuel cycle and other radioactive material licenses, the dose from the inhalation pathway will dominate the (overall) dose.” This is the case for KW Facility
accidents that result in an uncontrolled release of sludge. As documented in PRC-STP-CN-N-00947, Appendix L, “Estimation of Radiological Consequences from a Slurry Pool,” the direct shine at 100 m from a slurry pool containing SCS-CON-230 sludge is approximately 0.2 rem for a 2-hour exposure. This is less than 4 percent of the dose due to inhalation. There is no contribution from ground shine as it is conservatively assumed that there is no deposition from the plume. This is conservative in that it maximizes the dose due to inhalation.

3.4.1.2 Source Term Analysis

The radiological source term is developed based on the terms required for input to RADIDOSE, as shown in Equation 3-1 and discussed in more detail in the remainder of this section.

\[ Q = MAR \times DR \times ARF \times RF \times LPF \]  
(Eq. 3-1)

where:

- \( Q \) = source (m³ or kg)
- \( MAR \) = material at risk, radioactive material affected in the accident (m³ or kg)
- \( DR \) = damage ratio, fraction of the MAR that is acted on by the forces caused by the accident
- \( ARF \) = airborne release fraction, fraction of the (MAR \times DR) that is made airborne
- \( RF \) = respirable faction, fraction of the airborne material that is respirable
- \( LPF \) = leak path factor, fraction of the respirable material that is transported to the environment.

Material at Risk: The material at risk (MAR) is the volume or mass of material available to be acted upon by a given physical stress. For the purposes of this analysis, the MAR is taken to be the maximum quantity of radioactive material present or reasonably anticipated to be present at each accident location.

Damage Ratio: The damage ratio (DR) is the fraction of the MAR actually affected by the accident-generated conditions. The DR is estimated based on engineering analysis of the response of structural hazardous materials and materials of construction for containment to the type and level of stress or force generated by the event.

Airborne Release Fraction or Airborne Release Rate: The airborne release fraction (ARF) and airborne release rate (ARR) are used to estimate the amount of radioactive material suspended in air as an aerosol and available for transport because of a physical stress from a specific accident. For discrete events, the ARF is the fraction of the total amount of material that is suspended and transported. For ongoing events, the ARR is the fraction of the total material suspended and transported per unit of time. The ARF and ARR values used in the analyses in this chapter are taken primarily from SARAH (PRC-STD-NS-8739). Where relevant factors are

**Respirable Fraction:** The respirable fraction (RF) is the fraction of airborne material that can be transported through the air and inhaled into the human respiratory system. It is commonly assumed to include particles 10 \( \mu \text{m} \) aerodynamic equivalent diameter (AED) and less. A particle with a 10 \( \mu \text{m} \) AED would have the same settling speed in air as a unit-density sphere with a diameter of 10 \( \mu \text{m} \). The actual diameter could differ from 10 \( \mu \text{m} \) because of differences in density or shape, as is the case for the high-density uranium oxide particulate.

**Leak Path Factor:** The leak path factor (LPF) is the fraction of the radionuclides in the aerosol transported through SSCs used to deplete or filter particles. When evaluating the consequences of an unmitigated event, the LPF is taken to be one.

### 3.4.1.3 Consequence Analysis

The radiological dose received by an individual, who may be the MOI at the Hanford Site boundary or the collocated worker at 100 m, can be calculated using the following equation coded in the RADIDOSE spreadsheet:

\[
D = Q \times \frac{\chi}{Q'} \times BR \times DCF
\]  
(Eq. 3-2)

where:

- \( Q \) = source term (m\(^3\) or kg)
- \( \chi/Q' \) = atmospheric dispersion factor (s/m\(^3\))
- \( BR \) = breathing rate (m\(^3\)/s)
- \( DCF \) = dose per quantity of radioactive material inhaled (rem/m\(^3\) or rem/kg).

**Atmospheric Dispersion Factor:** The atmospheric dispersion factor (\( \chi/Q' \)) is based on specific release parameters, such as the elevation and duration of the release, atmospheric conditions, and the distance from the release to the receptor. The atmospheric dispersion factor is defined as the concentration in air per unit release rate of the material from an upwind source at a particular receptor location. The atmospheric dispersion factor accounts for the dilution of an airborne contaminant caused by atmospheric mixing and turbulence. Adjustment for plume meander (i.e., time-dependent horizontal displacement from the plume centerline) is performed in accordance with the methodology specific in NUREG-1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*.

Table 3-14 contains the atmospheric dispersion values and distances used to determine radiological dose consequences for onsite and offsite receptors based on the accident calculations documented in Appendix M of PRC-STD-CN-N-00947.

Receptor’s distances are taken from HNF-SD-SNF-TI-059, *A Discussion on the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*. Radiological inhalation dose consequences are calculated for two receptor locations.
• Collocated worker at 100 m—Evaluation criteria defined from DOE-STD-1189-2008; used for calculation of onsite doses and selection of safety-significant features.

• Offsite public (10,070 m)—This hypothetical receptor is the MOI, located at the Hanford Site boundary. The evaluation guideline from DOE-STD-3009-94 and the challenge threshold from DOE-STD-1189-2008 are defined for this location and are used to calculate offsite doses and select safety-class features.

An individual at the receptor location is exposed for the duration of the plume passage consistent with the guidance in DOE-STD-3009-94. This duration is nominally less than 2 hours, but it could be up to the maximum of 8 hours for a slowly developing event.

**Table 3-14. Atmospheric Dispersion Factors ($\chi/Q'$)**

<table>
<thead>
<tr>
<th>DOE-STD-1189-2008 (from NUREG 1140, Figure 1, building wake, ground level, 0.5 hr and 1 cm/s deposition velocity)</th>
<th>Collocated Worker (s/m$^3$)</th>
<th>Offsite Public (s/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration up to 1 hr (without plume meander) with building wake</td>
<td>2.03E-2</td>
<td>4.60E-5</td>
</tr>
<tr>
<td>Duration greater than 1 hr (with plume meander) with building wake</td>
<td>1.15E-2</td>
<td>3.21E-5</td>
</tr>
</tbody>
</table>

**Notes:**
Distances and atmospheric dispersion factors used are described in Appendix M of PRC-STP-CN-N-00947.
- Collocated worker–onsite (100 m)
- Offsite public–MOI–Hanford Site boundary (10,070 m, W)
Plume meander adjustment consistent with guidance in NUREG-1.145.

**Breathing Rate:** The breathing rate (BR) is the rate at which the receptor inhales contaminated air. The BRs used in the RADIDOSE spreadsheet, shown in Table 3-15, are taken from ICRP-68, *Dose Coefficients for Intake of Radionuclides by Workers*, and ICRP-72, *Age-dependent Doses to the Members of the Public from Intake of Radionuclides Part 5, Compilation of Ingestion and Inhalation Dose Coefficients, International Commission on Radiological Protection*.

**Table 3-15. RADIDOSE Breathing Rates**

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Breathing Rate (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collocated Worker</td>
<td>3.35E-4</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>3.29E-4</td>
</tr>
</tbody>
</table>

**Dose Conversion Factor:** The dose conversion factor (DCF) is the 50-year committed effective dose for the relevant exposure pathways per unit of material; the material units may be weight or activity. The RADIDOSE spreadsheet uses DCFs from ICRP-68 for the onsite receptor and DCFs from ICRP-72 for the offsite receptor.
Because of the complexity of the K Basins sludge source term, the consequence calculations use a unit DCF. This unit DCF is the sum of the products of the concentration of each radiological constituent of the sludge and the DCF for that radionuclide. This is calculated as shown in Equation 3-3.

\[
DCF_{total} = 3.7 \times 10^{10} \frac{Bq}{Ci} \sum_{K} C_K DCF_K
\]

(Eq. 3-3)

where:

- \(DCF_{total}\) = 50-year committed effective dose equivalent for inhalation of a unit quantity of sludge as respirable particles, rem/m³ or rem/kg
- \(C_K\) = concentration of the \(K^{th}\) nuclide in the sludge, Ci/m³ or Ci/kg
- \(DCF_K\) = dose conversion factor, 50-year committed effective dose equivalent per unit activity inhaled of the \(K^{th}\) nuclide, rem/Bq.

The safety basis isotopic composition used to estimate the unit dose for each of the sludge types in the engineered containers is shown in Table 3-16. The DCF solubility classes shown in the table are the RADIDOSE default solubility conditions when the source term is defined as “generally insoluble compounds.” For K Basins sludge in the engineered containers, the significant dose-contributing radionuclides are associated with the low solubility uranium oxide. Sampling and characterization results for the K Basins sludge have shown that over 90 percent of the uranium is present in highly insoluble forms such as UO₂ and U₃O₈. Because the americium and plutonium are known to remain within the uranium matrix, they are treated as the same solubility as the uranium oxide. As shown in Table 3-16, \(^{90}\)Sr and \(^{137}\)Cs are assigned a “fast” solubility class for worker dose consequence calculations. Although more soluble than the transuranic isotopes, these fission products are minor contributors (i.e., approximately 1%) to the total dose.

Samples have been obtained and analyzed of the sludge present in all the engineered containers. The characterization results from these sampling results are available in HNF-SD-SNF-TI-015. Values provided in Table 3-16 for sludge radionuclide composition are decay-corrected to August 1, 2018. The safety-basis values were developed to apply to the containerized sludge type as a whole. It should be recognized that, because of the manner in which the containers were loaded, some variability in radionuclide concentration between individual containers is likely.
### Table 3-16. Safety Basis Isotopic Settled Composition by Sludge Type, Decay corrected to August 1, 2018

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICRP 68</td>
<td>ICRP 72</td>
<td>(Ci/m³)</td>
<td>(Ci/m³)</td>
<td>(Ci/m³)</td>
</tr>
<tr>
<td>241Am</td>
<td>M</td>
<td>S</td>
<td>2.79E+1</td>
<td>1.13E+2</td>
<td>2.16E+2</td>
</tr>
<tr>
<td>237Np</td>
<td>M</td>
<td>S</td>
<td>2.95E+3</td>
<td>8.47E-3</td>
<td>2.12E-2</td>
</tr>
<tr>
<td>238Pu</td>
<td>S</td>
<td>S</td>
<td>3.58</td>
<td>1.66E+1</td>
<td>2.60E+1</td>
</tr>
<tr>
<td>239Pu</td>
<td>S</td>
<td>S</td>
<td>1.76E+1</td>
<td>6.07E+1</td>
<td>1.13E+2</td>
</tr>
<tr>
<td>240Pu</td>
<td>S</td>
<td>S</td>
<td>9.88</td>
<td>3.58E+1</td>
<td>6.74E+1</td>
</tr>
<tr>
<td>241Pu</td>
<td>S</td>
<td>S</td>
<td>1.43E+2</td>
<td>5.00E+2</td>
<td>1.46E+3</td>
</tr>
<tr>
<td>242Pu</td>
<td>S</td>
<td>S</td>
<td>3.42E+3</td>
<td>1.40E+2</td>
<td>3.82E+2</td>
</tr>
<tr>
<td>60Co</td>
<td>S</td>
<td>S</td>
<td>1.15E+1</td>
<td>1.25E-1</td>
<td>3.50E-1</td>
</tr>
<tr>
<td>134Cs</td>
<td>F</td>
<td>S</td>
<td>—</td>
<td>4.72E-4</td>
<td>—</td>
</tr>
<tr>
<td>137Cs</td>
<td>F</td>
<td>S</td>
<td>6.64E+2</td>
<td>7.73E+2</td>
<td>3.63E+3</td>
</tr>
<tr>
<td>137Ba</td>
<td>D</td>
<td>D</td>
<td>6.26E+2</td>
<td>7.29E+2</td>
<td>3.43E+3</td>
</tr>
<tr>
<td>154Eu</td>
<td>M</td>
<td>M</td>
<td>5.25E+1</td>
<td>2.78</td>
<td>4.05</td>
</tr>
<tr>
<td>155Eu</td>
<td>M</td>
<td>M</td>
<td>5.86E+2</td>
<td>2.17E+1</td>
<td>4.44E-1</td>
</tr>
<tr>
<td>90Sr</td>
<td>F</td>
<td>M</td>
<td>5.15E+2</td>
<td>8.66E+2</td>
<td>1.77E+3</td>
</tr>
<tr>
<td>90Yd</td>
<td>S</td>
<td>S</td>
<td>5.15E+2</td>
<td>8.66E+2</td>
<td>1.77E+3</td>
</tr>
<tr>
<td>99Tc</td>
<td>M</td>
<td>S</td>
<td>—</td>
<td>1.39E+1</td>
<td>—</td>
</tr>
<tr>
<td>234U</td>
<td>S</td>
<td>S</td>
<td>7.34E+2</td>
<td>1.80E+1</td>
<td>3.89E+1</td>
</tr>
<tr>
<td>235U</td>
<td>S</td>
<td>S</td>
<td>2.60E+3</td>
<td>6.92E+3</td>
<td>1.29E+2</td>
</tr>
<tr>
<td>236U</td>
<td>S</td>
<td>S</td>
<td>8.24E+3</td>
<td>2.35E+2</td>
<td>4.43E+2</td>
</tr>
<tr>
<td>238U</td>
<td>S</td>
<td>S</td>
<td>5.75E+2</td>
<td>1.54E+1</td>
<td>2.81E+1</td>
</tr>
</tbody>
</table>

**Total Curies (Ci/m³)**

| 2.52E+3 | 3.96E+3 | 1.25E+4 | 5.37E+2 |

Notes:

- **a.** HNF-SD-SNF-TI-015.
- **b.** SCS-CON-220 with uniform SSM.
- **c.** $^{137}$Ba = $0.944 \times ^{137}$Cs.
- **d.** $^{90}$Y = $^{90}$Sr.

SSM Segregated Settler Material

Conversion of the unit dose from rem/m³ to rem/kg of uranium requires knowledge of the total uranium concentration. Values for the total uranium concentration for each sludge type can be found in HNF-SD-SNF-TI-015 and PRC-STP-CN-N-00947, and are provided in Table 3-17.
Table 3-17. Sludge Safety Basis Uranium Concentrations

<table>
<thead>
<tr>
<th>Engineered Container</th>
<th>Total Uranium (kg/m³)</th>
<th>Uranium Metal (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-210)</td>
<td>170</td>
<td>59.3</td>
</tr>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-220 with SSM distributed in container)</td>
<td>462</td>
<td>95.4</td>
</tr>
<tr>
<td>Settler Tank Sludge (SCS-CON-230, south section¹)</td>
<td>840</td>
<td>22</td>
</tr>
<tr>
<td>Settler Tank Sludge (SCS-CON-230, north section average²)</td>
<td>840</td>
<td>144</td>
</tr>
<tr>
<td>Settler Tank Sludge (SCS-CON-230, north section based on installation of divider plate³)</td>
<td>840</td>
<td>163</td>
</tr>
<tr>
<td>KE Basin Containerized Sludge (SCS-CON-240, -250, and -260)</td>
<td>62</td>
<td>4.57</td>
</tr>
<tr>
<td>Settler/KE Layered (0.4 m³ SCS-CON-230 combined with 1.6 m³ SCS-CON-240, -250, or -260)</td>
<td>218</td>
<td>36.3</td>
</tr>
</tbody>
</table>

Notes:

a. The safety basis uranium metal concentration in the south section of SCS-CON-230 and the average, safety basis uranium metal concentration in the north section are derived in PRC-STP-CN-CH-00545, Safety Basis Uranium Metal Concentration Derivation for Sludge in Engineered Container SCS-CON-230.

b. The northern half of SCS-CON-230 is uniform in total uranium concentration but has a non-uniform distribution of uranium metal.

c. By partitioning the sludge in the north section of SCS-CON-230 into four volumes and retrieving a single partition at a time, the desired mass of uranium metal can be transferred to an STSC. It is also recognized that the process of partitioning the north half of SCS-CON-230 may not be completely effective and some sludge may flow between partitions during retrieval. Thus, the maximum volume concentration for a transfer of uranium metal to an STSC is estimated to be 163 kg/m³ (see PRC-STP-CN-CH-00712, Evaluation of Sludge Leakage from Divider Panel in SCS-CON-230). Since the total uranium concentration is uniform throughout SCS-CON-230, the total uranium concentration remains the same.

The results of the radiological unit dose calculations for the different sludge types in the engineered containers are provided in PRC-STP-CN-N-00947, Table B-3 and reproduced in Table 3-18. It should be noted that the unit doses on a volume basis for Settler Tank sludge are approximately 2.5 times those for KW Basin containerized sludge, and over 10 times those for KE Basin containerized sludge. These unit dose results demonstrate that consequence calculations based on Settler Tank sludge are bounding on an equal volume basis. As shown in PRC-STP-CN-N-00947, Table B-5, for Settler Tank sludge, greater than 98 percent of the unit dose is associated with transuranic isotopes (e.g., ²⁴¹Am, ²³⁹Pu).
Table 3-18. Unit Doses by Sludge Type (Decayed to 08/01/2018)

<table>
<thead>
<tr>
<th>Sludge Source Location</th>
<th>Using ICRP-68 Dose Conversion Factors</th>
<th>Using ICRP-72 Dose Conversion Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-210)</td>
<td>3.90E+9 rem/m³ (2.29E+7 rem/kgU)</td>
<td>3.75E+9 rem/m³ (2.21E+7 rem/kgU)</td>
</tr>
<tr>
<td>KW Basin Containerized Sludge (SCS-CON-220 with SSM distributed in container)</td>
<td>1.52E+10 rem/m³ (3.29E+7 rem/kgU)</td>
<td>1.39E+10 rem/m³ (3.01E+7 rem/kgU)</td>
</tr>
<tr>
<td>Settler Tank Sludge (SCS-CON-230)</td>
<td>2.89E+10 rem/m³ (3.44E+7 rem/kgU)</td>
<td>2.67E+10 rem/m³ (3.18E+7 rem/kgU)</td>
</tr>
<tr>
<td>Settler Tank (SCS-CON-230)/KE Layer Sludge</td>
<td>7.12E+9 rem/m³ (3.27E+7 rem/kgU)</td>
<td>6.58E+9 rem/m³ (3.02E+7 rem/kgU)</td>
</tr>
<tr>
<td>KE Basin Containerized Sludge (SCS-CON-240, -250, and -260)</td>
<td>1.67E+9 rem/m³ (2.69E+7 rem/kgU)</td>
<td>1.55E+9 rem/m³ (2.50E+7 rem/kgU)</td>
</tr>
</tbody>
</table>

For the accident analysis calculations with an STSC loading with two sludge types, the unit dose, on a rem/m³ basis is based on the volume of each sludge type involved in the accident. For example, the spray leak for the STSC with Settler Tank sludge layered with KE Basin containerized sludge is based on a transfer of only Settler Tank sludge. However, for the Over-pressure and Impact events, the unit doses are a volume weighted combination of both sludge types.

3.4.1.4 Control Classification and Selection

3.4.1.4.1 Offsite Public and Collocated Worker Criteria

Guidelines for the safety classification of SSCs are established in DOE-STD-3009-94 and DOE-STD-1189-2008, Integration of Safety into the Design Process. The offsite public and collocated worker radiological protection criteria are presented in Table 3-19 and Table 3-20.

Table 3-19. Offsite Public Radiological Protection Criteria

<table>
<thead>
<tr>
<th>Safety-Class Controls</th>
<th>Unmitigated Consequence (rem TED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>&gt; 25</td>
</tr>
<tr>
<td>To be considered</td>
<td>≥ 5</td>
</tr>
</tbody>
</table>

TED total effective dose
Table 3-20. Collocated Worker Radiological Protection Criteria

<table>
<thead>
<tr>
<th>Safety-Significant Controls</th>
<th>Unmitigated Consequence (rem TED)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

In addition to the criteria in Table 3-19 and Table 3-20, the following qualitative criteria for elevating SSCs to a safety-significant classification was incorporated:

1. Defense-in-depth controls that are common to multiple accident scenarios may be considered to provide a significant contribution to defense-in-depth in the context of all the scenarios taken together and should be considered for classification as safety-significant. In this evaluation, accident scenarios are scrutinized for common hazards, considering how often a particular potential control appears in different scenarios.

2. If a support SSC is common to several safety-significant SSCs (but not necessarily required to ensure operability alone of any single safety-significant SSC), then this control should be considered for designation as a safety-significant SSC.

3. If a candidate control further significantly reduces the consequences of an accident scenario that has required a safety-class or safety-significant control, then this control should be considered for designation as a safety-significant SSC.

4. If a candidate control further significantly reduces the frequency of an accident scenario that has required a safety-class or safety-significant SSC, then this control should be considered for designation as a safety-significant SSC.

5. The control appreciably reduces the risk of significant energetic events that potentially threaten multiple safety systems.

6. If the reliability of a single control (preventive or mitigative) is not as high as desired, SSCs designed to increase reliability by providing multiple layers of protection should be identified as safety-significant SSCs.

The offsite public and collocated worker chemical hazard criteria in Table 3-21 provide threshold levels for consideration of SSC classification as safety-significant to prevent or mitigate exposures.
Table 3-21. Offsite Public and Collocated Worker Chemical Hazard Protection Criteria*

<table>
<thead>
<tr>
<th>Safety-Significant Controls</th>
<th>Offsite Public</th>
<th>Collocated</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be considered</td>
<td>&gt; AEGL-2/ERPG-2/TEEL-2</td>
<td>&gt; AEGL-3/ERPG-3/TEEL-3</td>
</tr>
</tbody>
</table>

Notes:
*The order of preference for evaluating a chemical is as follows: (1) AEGLs promulgated by the U.S. Environmental Protection Agency, (2) ERPGs published by the American Industrial Hygiene Association, and (3) TEELs developed by DOE for other chemicals not provided for in either the AEGL or ERPG guidelines.

AEGL  Acute Exposure Guideline Level
ERPG  Emergency Response Planning Guideline
TEEL  Temporary Emergency Exposure Limit

3.4.1.4.2 Facility Worker Criteria

While SMPs address most facility worker hazard controls, some conditions warrant consideration of safety SSCs. These include the following:

- Energetic releases of high concentrations of radiological or toxic chemical materials where the facility worker normally would be immediately present and may be unable to take self-protective actions.

- Deflagrations or explosions within process equipment or confinement and containment structures or vessels where serious injury or death to a facility worker may result from fragmentation of the process equipment or the confinement/containment failing with the facility worker close by.

- Chemical or thermal burns to a facility worker that could reasonably cover a significant portion of the facility worker’s body where self-protective actions are not reasonably available because of the speed of the event or where there may be no reasonable warning to the facility worker of the hazardous condition.

- Leaks from process vessels where asphyxiation of a facility worker normally present may result.

- Significant exposure of the facility worker to radiological or hazardous materials as shown in Table 3-22.

Table 3-22. Facility Worker Radiological and Toxicological Evaluation Criteria

<table>
<thead>
<tr>
<th>Safety-Significant Controls</th>
<th>Unmitigated Radiological Consequence (rem TED)</th>
<th>Unmitigated Chemical Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>Clearly &gt; 100</td>
<td>Clearly &gt; AEGL-3/ERPG-3/TEEL-3</td>
</tr>
<tr>
<td>To be considered</td>
<td>Not clearly above or below 100</td>
<td>Not clearly above or below AEGL-3/ERPG-3/TEEL-3</td>
</tr>
<tr>
<td>Not required</td>
<td>Clearly &lt; 100</td>
<td>Clearly &lt; AEGL-3/ERPG-3/TEEL-3</td>
</tr>
</tbody>
</table>
Estimation of the radiological dose consequence to the facility worker is problematic, primarily because the exposure of the facility worker depends greatly on that individual’s proximity to the release location, and to the dispersion of the release through the facility. For the purposes of this analysis, radiological and toxicological consequences to the facility worker are qualitatively estimated to be a factor of 3 to 4 times greater than those estimated for the collocated worker, for events where the facility worker can be reasonably assumed to recognize the occurrence of the event and to evacuate the immediate area of the release. The factor of 3 to 4 is supported by scoping calculations documented in PRC-TP-CN-N-00947, Appendix N, “Estimate of Bounding Worker Dose,” that take into consideration facility worker proximity and residence time for inhalation and, for a spray release, direct dose from contact with the slurry.

3.4.1.4.3 Protection of Assumptions

Safety SSCs and Technical Safety Requirements (TSRs) also can be required to protect initial conditions assumed in the accident or hazard analysis. In accordance with DOE-STD-1189-2008, Appendix D, “Additional Functional Classification Considerations,” SSCs that function to monitor initial conditions assumed in the accident analyses are not required to be safety classified based on the monitoring function, if all of the following conditions are met.

- They do not generate a signal (indication, alarm, or interlock function) that causes an action (operator action or change of state) that is required to prevent or mitigate an accident.
- Their failure is not the initiator of an accident.
- Violation of the monitored parameter is not the initiator of an accident.

3.4.1.4.4 Other Equipment Important to Safety

As stated in DOE G 424.1-1B, Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements, equipment important to safety (ITS) includes safety-class and safety-significant SSCs and other systems that perform an important defense-in-depth function, equipment relied upon for safe shutdown, and in some cases, process equipment.

The identification of equipment ITS and its discussion in safety basis documents is intended to facilitate USQ evaluations. There is no intent to imply or establish additional design, procurement, construction, installation, testing, operation, surveillance, or maintenance requirements other than the USQ consideration based on the ITS designation.

PRC-PRO-NS-700, Safety Basis Development, provides guidance for the identification of equipment ITS not already designated as safety-class or safety-significant. Consistent with DOE G 424.1-1B, consideration of an ITS designation should be given to:

- SSCs, including process equipment, that perform an important defense-in-depth function
- Equipment ITS for workers, including collocated workers and facility workers in proximity to identified hazards
- Equipment relied on for safe shutdown

Equipment ITS should have one or more of the following characteristics:

- A greater level of protection, availability, effectiveness, or reliability
• The safety function is effective for multiple hazards or accident scenarios
• The ability to protect workers or the public when primary or credited barriers do not function as designed, or are not fully effective, or may be unreliable in the analyzed conditions
• An implicit reduction in risk
• Identifiable equipment attributes associated with the safety function being performed or maintained

However, PRC-PRO-NS-700 also states that ITS designation is not necessary for equipment associated with standard industrial hazards, or when the equipment controlled by an implemented SMP where the magnitude or characteristics of the hazard is typical for the program. Examples considered include:
• The 105KW Annex Process/Exhaust Ventilation System is controlled by the Radiation Protection Program and the Environmental Protection Program.
• The automatic fire sprinkler system (designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*) and the Process/Exhaust Ventilation System (which provides STSC ventilation in accordance with NFPA 69, *Standard on Explosion Prevention Systems*) are controlled by the Fire Protection Program.

Therefore, there is no ITS equipment beyond the safety-significant SSCs identified herein.

**3.4.1.4.5 Natural Phenomena Design Criteria**

DOE-STD-1189-2008, Appendix A, “Safety System Design Criteria,” provides guidance for selecting seismic design category (SDCs) and associated limit states to be implemented through ASCE/SEI 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*. The guidance for selecting the seismic design category (SDC) is based on the unmitigated consequences of SSC failures in a seismic event, as shown in Table 3-23.

<table>
<thead>
<tr>
<th>Category</th>
<th>Collocated Worker (rem TED)</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC-1</td>
<td>dose &lt; 5</td>
<td>Not applicable*</td>
</tr>
<tr>
<td>SDC-2</td>
<td>5 &lt; dose &lt; 100</td>
<td>5 &lt; dose &lt; 25</td>
</tr>
<tr>
<td>SDC-3</td>
<td>100 &lt; dose</td>
<td>25 &lt; dose</td>
</tr>
</tbody>
</table>

Notes:
*An HC-1, -2, or -3 nuclear facility with consequences to a collocated worker from failure of an SSC in a seismic event will require that SSC to be classified as SDC-1 at a minimum. Therefore, a public criterion for SDC-1 is not needed.

HC hazard category

In contrast to seismic events, there is no guidance that correlates wind or snow and ashfall design criteria to unmitigated accident consequences. This issue has been addressed, in part, in “Implementation of DOE-STD-1189, Integration of Safety into the Design Process, for Environmental Management Activities” (Owendoff 2009). Specifically, Owendoff states that
safety-significant SSCs credited in non-seismic NPH events that could result in a dose greater than or equal to 100 rem to the collocated worker are to be designed to performance category (PC)-3. This approach provides a similar level of protection for both seismic and non-seismic NPH events.

3.4.1.4.6 Control Selection

Safety-significant SSCs, SACs, and Administrative Controls were selected by the Safety Design Integration Team which included members from the following organizational disciplines:

- Operations
- Engineering
- Occupational Safety & Industrial Hygiene
- Radiological Control
- Nuclear Safety
- Fire Protection
- Emergency Preparedness
- Project Management

Controls were selected using a judgment-based process involving factors such as control selection order of preference, effectiveness, relative reliability, and cost considerations. The team followed the DOE-STD-1189-2008 control selection order of preference:

- Minimization of hazardous materials is the first priority
- Safety SSCs are preferred over administrative controls (ACs)
- Passive SSCs are preferred over active SSCs
- Preventive controls are preferred over mitigative controls
- Facility safety SSCs are preferred over personal protective equipment
- Controls closest to the hazard may provide protection to the largest population of potential receptors, including workers and the public
- Controls that are effective for multiple hazards can be resource effective

Control decisions are documented in PRC-STP-00731, *Sludge Treatment Project Engineered Container Retrieval and Transfer System Final Design Control Decision Report*, and are presented for each Design Basis Accident in the following subsections.

3.4.1.5 Margin of Safety

There are no explicit or implicit margins of safety identified in this DSA.

3.4.2 Design Basis Accidents

This section presents the results of analyses of hazardous conditions selected as DBAs in Section 3.3.2.3.5, “Accident Selection.” As discussed in Section 3.3.2.3.5, three DBAs were identified:
spray releases, hydrogen explosions, and over-pressurization. As identified by the HAZOP and What-if studies, each of these DBAs can be initiated by operational events, external events (e.g., vehicle impacts), fires, and NPH.

The hazardous conditions selected for analysis as DBAs are the same as those analyzed as DBAs in the ECRTS PDSA. The controls identified and described in the “Summary of Safety-Significant SSCs, SACs, and TSR Controls” subsection for each DBA are, for the most part, the same controls as documented in the PDSA. In some instances, the controls have been revised in response to RL comments, engineering design changes, or design changes resulting from equipment fabrication and/or installation. However, as discussed in Section 3.3.2.3.5, the design changes did not result in a hazardous condition not previously analyzed.

3.4.2.1 Operational Accident–ECRTS Spray Releases

3.4.2.1.1 Scenario Development–ECRTS Spray Releases

The operational spray release is a pressurized aerosol release, initiated by a failure in system primary containment while the system is under pressure and resulting in a spray of slurry or contaminated water. Such a failure could occur in a number of components in the system. Potential components at risk can be loosely grouped into the following categories: pumps, hoses and pipes, fittings, connectors.

The ECRTS subsystems for retrieval, transfer, and decant of sludge from engineered containers to the STSC include transfer lines and piping for sludge retrieval, for decant of supernate, and for backwash of the ECRTS Sand Filter. The sludge retrieval transfer lines include both underwater and above-water lines fabricated from hard pipe and flexible hose. A hose or pipe could fail due to over-pressurization, or could fail at normal operating pressures due to degradation (e.g., erosion, corrosion) or a manufacturing flaw. A flexible hose transfer line is connected to the STSC via a manual connection device. A connection is a likely place for a breach of primary containment to occur, resulting in the release of a slurry aerosol directly into the environment. This could be caused by a failure of the coupling seal, damage to the coupling, or human error in making the connection.

As documented in PRC-STP-CN-N-00947, the bounding spray leak radiological and toxicological consequences occur during retrieval and transfer of Settler Tank sludge from Engineered Container SCS-CON-230.

For an unmitigated scenario wherein no credit is taken for safety features, a single equipment failure or human error can initiate a spray release. Therefore, the unmitigated frequency of an operational spray release is qualitatively estimated to be anticipated (i.e., greater than 1E-2/yr).

Table 3-24 provides a summary of the operational spray release accident scenario, consequences, frequencies, and controls.

3.4.2.1.2 Source Term Analysis–ECRTS Spray Releases

Several different potential causes of containment failure leading to a spray leak were identified in the hazards analysis. An actual location for the spray leak is not identified; instead, the selected operating conditions and slurry parameters are chosen to provide bounding radiological consequences. These operating conditions and parameters include, for example, maximum pump
operating condition (i.e., pressure, flow), conservative breach configuration, and maximum transfer volume.
### Table 3-24. Operational Spray Release Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Administrative</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure of a pressurized transfer line during sludge retrieval and transfer results in a spray release of slurry. Causes include: • Over-pressurization due to equipment failure (e.g., pump over-speed) or operator error (normally-open valve closed) • Loss of integrity due to equipment failure (e.g., erosion/corrosion, manufacturing flaw) or operator error (e.g., failure to properly mate connectors, load drop)</td>
<td>A</td>
<td>Y (I)</td>
<td>L (III)</td>
<td>L (III)</td>
<td>• Primary containment  • Flow rate instrumentation  • Pressure instrumentation  • Rupture disk  • Transfer timer  • Secondary containment with leak detection  • Valve position indication  • 105KW Annex HEPA-filtered exhaust ventilation  • Continuous air monitors</td>
<td>• Procedures  • Training  • Quality Assurance Program  • 105KW Annex unmanned during transfers  • Conduct of Operations verifies proper system configuration</td>
</tr>
<tr>
<td>Misdirected transfer into a connected service line (e.g., ISM water) during sludge retrieval and transfer results in a spray release of slurry. Causes of misdirected transfer include: • Equipment failure (e.g., valve failure) • Operator error in positioning manual valve</td>
<td>A</td>
<td>Y (I)</td>
<td>L (III)</td>
<td>L (III)</td>
<td>• Transfer timer  • Secondary containment with leak detection  • Double-valve isolation  • Valve position indication  • 105KW Annex HEPA-filtered exhaust ventilation  • Continuous air monitors</td>
<td>• Procedures  • Training  • Quality Assurance Program  • 105KW Annex unmanned during transfers  • Conduct of Operations verifies proper system configuration</td>
</tr>
</tbody>
</table>
### Table 3-24. Operational Spray Release Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure of a pressurized transfer line during decanting of the STSC, or sand filter backwash, results in a spray release of supernate/sand filter backwash. Causes include: • Over-pressurization due to equipment failure (e.g., high air pressure to air-operated decant pump) or operator error (normally-open valve closed) • Loss of integrity due to equipment failure (manufacturing flaw) or operator error (failure to properly mate connectors)</td>
<td>FW CL MOI</td>
<td>Primary containment Turbidity instrumentation Sand filter inlet/outlet pressure instrumentation Decant line pressure instrumentation Secondary containment with leak detection 105KW Annex HEPA-filtered exhaust ventilation Continuous air monitors</td>
<td>FW CL MOI</td>
<td>Preventive Engineered: None Preventive Administrative: None Mitigative Engineered: None Mitigative Administrative: Slurry settling duration limit</td>
</tr>
<tr>
<td>Failure of a pressurized transfer line or a misdirected transfer during pre-operational testing or operational readiness activities results in a spray release of basin water. Causes include: • Over-pressurization due to equipment failure (e.g., pump over-speed) or operator error (normally-open valve closed) • Misdirected transfer into a connected service line (e.g., IXM water) due to valve failure or valve positioning error. • Loss of integrity due to equipment failure (e.g., erosion/corrosion, manufacturing flaw) or operator error (e.g., failure to properly mate connectors)</td>
<td>FW CL MOI</td>
<td>Primary containment Flow rate instrumentation Pressure instrumentation Rupture disk Transfer timer Secondary containment with leak detection Double-valve isolation Valve position indication 105KW Annex HEPA-filtered exhaust ventilation Continuous air monitors</td>
<td>FW CL MOI</td>
<td>Preventive Engineered: Hoist Chain Stop Preventive Administrative: XAGO pre-operational testing and operational readiness controls Mitigative Engineered: None Mitigative Administrative: None</td>
</tr>
</tbody>
</table>
It is recognized that “spray leak analysis methodology” is currently undergoing intense scrutiny and that significant uncertainty exists regarding the applicability of current spray methodologies for modeling a pressurized leak of KW Basin slurry. This uncertainty is inherent in the complex phenomena involved in a spray release event. It can be concluded that resolution will “require development of a suitable technical basis, and will likely require some research and development” (Krahn 2010).

The following topics are currently under review to address these uncertainties.

- Uncertainty in slurry rheology, including properties such as viscosity and the effect of these properties on the formation of droplets
- Applicability of spray correlations for use with multiphase flows with particles
- Suitable choice of a droplet distribution for Sludge Treatment Project (STP) spray conditions
- Droplet characteristics such as the Sauter mean diameter and shape
- Determination of distribution of solid particles in spray droplets
- Selection of appropriately conservative crack configuration

It should be recognized that a breach in a pressurized line can create a spray consisting of a distribution of droplets and particles. The droplets breakup from the interaction and aerodynamic forces, evaporate to smaller respirable sizes, and/or impact a nearby surface. To include all these phenomena in the spray calculations is exceptionally difficult, if even possible, and so the spray calculations are simplified to be tractable by using a relatively simple spray calculation to describe the droplet distributions. Therefore in the following analyses, the radiological consequences for the spray release are calculated independent of any spray correlation.

The basic premise for the correlation-independent method is to identify a conservative aerosol concentration for the 100 m collocated worker (e.g., 12.5 mg /m³, PRC-STP-CN-N-00874, *Sludge Treatment Project - Updated Methodology for Spray Leak Scenarios*). This allows an estimate of the associated radiological dose to be calculated using Equation 3-4.

\[
D_{onsite} = 12.5 \frac{mg}{m^3} \times \frac{kg}{10^6 mg} \times t_{tx} \times \frac{C_U}{\rho_{tx}} \times DCF \times BR \quad \text{(Eq. 3-4)}
\]

where:

- \(D_{onsite}\) = radiological dose consequence (rem)
- \(C_U\) = uranium concentration of the transfer slurry (kgU/m³)
- \(t_{tx}\) = duration of transfer (s)
- \(\rho_{tx}\) = density of the transfer slurry (kg/m³)
- \(DCF\) = unit dose conversion factor for collocated worker (rem/kgU)
- \(BR\) = breathing rate for collocated worker (m³/s).
Comparing Equation 3-4 with Equations 3-1 and 3-2 shows that the assumption of a concentration of 12.5 mg/m$^3$ along with the knowledge of the transfer volume, transfer flow rate, and uranium concentration alleviates the need to determine the spray release conditions at the source. Combining Equations 3-1 and 3-2 and arranging the terms gives an equation that allows the assumption of an aerosol concentration at the 100 m receptor to be used in place of a source term. It should be noted that using the prescribed aerosol concentration also eliminates the need for using a correlation to estimate the ARF and RF for the spray leak.

$$D = \left( Q \times \frac{\chi}{Q'} \right) \times BR \times DCF$$

$$= \left( MAR \times DR \times ARF \times RF \times LPF \times \frac{\chi}{Q'} \right) \times BR \times DCF$$

$$= \left( 12.5 \frac{mg}{m^3} \times \frac{t_{tx}}{\rho_{tx}} \times C_U \right) \times BR \times DCF \quad \text{(Eq. 3-5)}$$

where:

$$Q \times \frac{\chi}{Q} = 12.5 \frac{mg}{m^3} \times \frac{t_{tx}}{\rho_{tx}} \times C_U \left( \frac{kgU s}{m^3} \right).$$

The aerosol concentration at 100 m is further dispersed as the plume moves downwind. Plume dispersion at the river and at the site boundary can be found from the ratio of the atmospheric dispersion coefficients, $\chi/Q$'s. Thus, knowing a concentration at 100 m, any downwind concentration can be calculated using appropriate $\chi/Q$'s values based on related meteorological conditions.

The $\chi/Q$'s used in the calculation are derived from Gaussian atmospheric modeling using site-specific historical meteorological monitoring data based on Hanford-specific 95th percentile $\chi/Q$'s. DOE-STD-1189-2008 provides a recommended value for the onsite (100 m) $\chi/Q$ but does not provide a similar recommendation for the offsite receptor. The recommended value from DOE-STD-1189-2008 is independent of the Hanford meteorological conditions. As a $\chi/Q'$ for the offsite receptor is necessary to estimate the plume dispersion, a ratio based on the Hanford-specific 95th percentile $\chi/Q$'s for both the onsite and offsite receptors is used. This ratio can then be applied to the consequences estimated for 100 m location.

The use of the $\chi/Q'$ crediting building wake effects is based on the following considerations:

- DOE-STD-1189-2008 recommends $3.5 \times 10^{-3}$ s/m$^3$ for the collocated worker, which is consistent with small building wake values from NUREG-1140.

- The ratio of the 95th percentile using a building wake gives a more conservative offsite dose estimate than the no building wake condition by a factor of about three (PRC-STP-CN-N-00947).

- This is also consistent with the SARAH unmitigated analysis guidance that generally does not recommend crediting a building wake unless the result is more conservative.

Thus, since the $\chi/Q$'s are independent of the released quantities, the offsite doses follow directly from the onsite dose calculation given in Equation 3-6.
D_{\text{offsite}} = D_{\text{onsite}} \times \frac{\chi}{\overline{Q'}_{\text{offsite}}} \times \frac{BR_{\text{offsite}}}{BR_{\text{onsite}}} \times \frac{DCF_{\text{offsite}}}{DCF_{\text{onsite}}}

(Eq. 3-6)

where:

\begin{align*}
D_{\text{location}} &= \text{radiological dose consequence at either onsite or offsite location, (rem)} \\
\frac{\chi}{\overline{Q'}}_{\text{location}} &= \text{atmospheric dispersion factor at either onsite or offsite location, (s/m}^3) \\
BR_{\text{location}} &= \text{breathing rate at either onsite or offsite location, (m}^3/\text{s}) \\
D_{\text{location}} &= \text{unit dose factor for either onsite or offsite location, (rem/kg)}. 
\end{align*}

**Aerosol Concentration:** The aerosol concentration at 100 m is assumed to be 12.5 mg/m$^3$.

Applying a concentration of slurry of 12.5 mg/m$^3$ at 100 m is conservative. It implies meteorology conditions at 100 m where droplets are rapidly dropping out, and would require significantly higher aerosol concentrations at the spray source and during transit. Transport of such aerosol concentrations over this distance is physically questionable.

Calculation PRC-STP-CN-N-00874 provides a technical basis for using 12.5 mg/m$^3$ as the aerosol concentration at 100 m for the spray leak during the retrieval and transfer of KW Basin sludge. Although the proposed 12.5 mg/m$^3$ aerosol concentration is a reduction from the 100 mg/m$^3$ value previously used in the STP safety basis accident analysis, the proposed 12.5 mg/m$^3$ represents a reasonably conservative input parameter for use in dose consequence calculations consistent with the requirements of DOE-STD-3009-94, Appendix A, “Evaluation Guideline.” The “fog model” assumption of an aerosol concentration of 12.5 mg/m$^3$ was chosen to bound the respirable fraction for the smallest diameter commercial spray nozzle at a pressure of 200 psig shown in Figure 3-4 of DOE-HDBK-3010-94, which results in an aerosol concentration of 11.9 mg/m$^3$.

As shown in PRC-STP-CN-N-00874, dose consequences assuming an aerosol concentration of 12.5 mg/m$^3$ are larger than those estimated using five other correlations and remain reasonably conservative for the STP sludge transfer conditions, (i.e., pressure and sludge characteristics). Aerosol concentrations calculated using other correlations range from a low of 0.90 mg/m$^3$ (PNNL-22415 [WTP-RPT-221], Large-Scale Spray Release: Additional Aerosol Test Results), to a high of 7.5 mg/m$^3$ (FAI/06-55, Measured Drop Size Distribution with Cold Sprays Emanating from Small Leak Openings).

**Sludge Values:** The values for bounding sludge properties used for analyses of SCS-CON-230 sludge have been increased to provide additional conservatism.

The accident analyses and consequence calculations in PRC-STP-CN-N-00947 use an increased sludge uranium metal concentration for SCS-CON-230 sludge. This additional conservatism provides for consideration of potential refinements in sludge retrieval and STSC loading. The sludge properties used in the accident analysis for Settler Tank sludge from SCS-CON-230 are shown in Table 3-25.
Table 3-25. Sludge Properties for SCS-CON-230 Settler Tank
Sludge and Values Used in the Accident Analysis

<table>
<thead>
<tr>
<th>Property</th>
<th>SCS-CON-230 Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Uranium</td>
<td>840 kg/m³</td>
</tr>
<tr>
<td>Uranium Metal</td>
<td>163 kg/m³</td>
</tr>
<tr>
<td>Sludge Density</td>
<td>2800 kg/m³</td>
</tr>
<tr>
<td>Unit Dose ICRP 68</td>
<td>2.89E+10 rem/m³</td>
</tr>
<tr>
<td></td>
<td>(3.44E+7 rem/kgU)</td>
</tr>
<tr>
<td>Unit Dose ICRP 72</td>
<td>2.67E+10 rem/m³</td>
</tr>
<tr>
<td></td>
<td>(3.18E+7 rem/kgU)</td>
</tr>
</tbody>
</table>

**Solids Fraction:** The solids fraction used for the spray release analyses for sludge from Engineered Container SCS-CON-230 is 7.5 vol%.

The average slurry during the transfer of Settler Tank sludge slurry is anticipated to be less than 5 vol% solids. The XAGO had a nominal (average) retrieval rate for the Settler Tank sludge simulant of 4.4 vol% solids during verification testing (HNF-41051). This reference also identifies the nominal operating condition for an STSC as receiving 5 vol% retrieved slurry of K Basin sludge (HNF-41051, Table 5-4). Using a value of 7.5 vol%, the duration of the release from an unattended, seismic induced, spray leak for SCS-CON-230 is 1 hour. The radiological dose consequence for Settler Tank slurry spray is thus maximized by using the longest duration accident time without the impact of the higher dispersion effect of plume meander (PRC-STP-CN-N-00947).

**Density:** The density of the settler slurry at 7.5 vol% solids fraction is 1300 kg/m³.

For volume solid fractions other than the as-settled condition, the volume-averaged density can be evaluated according to Equation 3-7.

\[
\rho_{\text{slurry}} = \alpha_{\text{slurry}} \rho_{\text{solid}} + \left(1 - \alpha_{\text{slurry}}\right) \rho_{\text{liquid}} \tag{Eq. 3-7}
\]

where:

- \( \rho_{\text{slurry}} \) = density of sludge at solid volume fraction of \( \alpha_{\text{sludge}} \), kg/m³
- \( \alpha_{\text{slurry}} \) = solid fraction (by volume) of the slurry
- \( \rho_{\text{solid}} \) = density of solids, kg/m³
- \( \rho_{\text{liquid}} \) = density of slurry liquid, kg/m³.

Equation 3-7 can be used to determine the solid density, \( \rho_{\text{solid}} \), of as-settled sludge. For example, 45 vol% as-settled safety basis slurry from SCS-CON-230 has a solid density of 5000 kg/m³.
\[
\rho_{\text{solid}} = \frac{\rho_{\text{slurry}} - (1 - \alpha_{\text{slurry}}) \rho_{\text{liquid}}}{\alpha_{\text{slurry}}} \\
= \frac{2800 \text{ kg/m}^3 - (1 - 0.45) \times 998 \text{ kg/m}^3}{0.45} \\
= 5000 \text{ kg/m}^3
\]

(Eq. 3-8)

where:

- \( \rho_{\text{slurry}} = 2800 \text{ kg/m}^3 \) (HNF-SD-SNF-TI-015)
- \( \alpha_{\text{slurry}} = 0.45 \) (HNF-SD-SNF-TI-015)
- \( \rho_{\text{liquid}} = 998 \text{ kg/m}^3 \) (density of water at 20°C).

With the solid density known, Equation 3-7 can be used to estimate the transfer slurry density. For example, the transfer slurry density for the values used for the Settler Tank sludge from SCS-CON-230 at 7.5 vol% is 1300 kg/m³.

\[
\rho_{\text{slurry}} = \alpha_{\text{slurry}} \rho_{\text{solid}} + (1 - \alpha_{\text{slurry}}) \rho_{\text{liquid}} \\
= 0.075 \times 5000 \text{ kg/m}^3 + (1 - 0.075) \times 998 \text{ kg/m}^3 \\
= 1300 \text{ kg/m}^3
\]

(Eq. 3-9)

**Uranium Concentration:** The concentration of uranium at risk in 7.5 vol% slurry is 140 kgU/m³ for sludge from SCS-CON-230.

The unit liter dose is based on isotopic inventory of Settler Tank sludge at the as-settled volume fraction of 45 vol%. It follows, then, that the concentration of uranium particles in 7.5 vol% slurry is:

\[
C_{U7.5\%} = \frac{\alpha_{7.5\%}}{\alpha_{45\%}} C_{U45\%} \\
= \frac{(0.075)}{(0.45)} \left(840 \text{ kg/m}^3\right) \\
= 140 \text{ kg U/m}^3
\]

(Eq. 3-10)

where:

- \( C_{U7.5\%} = \) total uranium concentration in 7.5 vol% slurry
- \( \alpha_{45\%} = \) volume fraction of solids in settled sludge from SCS-CON-230, 45 vol% 
- \( C_{U45\%} = \) total uranium concentration in settled sludge from SCS-CON-230
- \( \alpha_{7.5\%} = \) volume fraction of solids in slurry, 7.5 vol%.
3.4.2.1.3 Consequence Analysis–ECRTS Spray Releases

It follows then that the radiological dose consequence for the 100 m collocated worker can be estimated using the following equation along with the assumed aerosol concentration of 12.5 mg/m³.

\[
D_{\text{onsite}} = 12.5 \frac{\text{mg}}{\text{m}^3} \times \frac{\text{kg}}{10^6 \text{mg}} \times t_{\text{tx}} \times \frac{C_U}{\rho_{\text{tx}}} \times DCF \times BR
\]

(Eq. 3-11)

where:

- \( D_{\text{onsite}} \) = radiological dose consequence (rem)
- \( C_U \) = uranium concentration of the transfer slurry (kg U/m³)
- \( t_{\text{tx}} \) = duration of transfer (s)
- \( \rho_{\text{tx}} \) = density of the transfer slurry (kg/m³)
- \( DCF \) = unit dose factor for collocated worker (rem/kg U)
- \( BR \) = breathing rate for collocated worker (m³/s).

For a spray leak, the bounding volume of sludge mobilized comes during a transfer if the retrieval equipment is not attended (i.e., no operator for the retrieval tool). For the unattended spray leak, the volume of sludge estimated is based on observation of the angle of repose of the sludge mound at the north end of SCS-CON-230 and from observation from retrieval testing with simulants.

For the Settler Tank sludge in SCS-CON-230, this estimation of the source term is 1.11 m³ of settled sludge (PRC-STP-CN-M-00900, Sludge Treatment Project - Engineered Container Retrieval and Transfer System - Retrieved Sludge Volume Estimates). It should be noted that the volume of sludge for an unattended transfer during a seismic event could potentially be greater from the increased mobility of the sludge volume due to interaction between the seismic-induced motion and the sludge volume. Calculations using enhanced sludge volumes are presented in Section 3.4.2.6.2 for the seismic-induced spray event. The actual volume of slurry transferred is based on the solid volume fraction of the slurry.

\[
\text{Vol}_{\text{transfer}} = \frac{\text{vol}\%_{\text{settled}}}{\text{vol}\%_{\text{transfer}}} \times \text{Vol}_{\text{settled}}
\]

(Eq. 3-12)

\[
= \frac{45\%}{7.5\%} \times 1.11 \text{ m}^3
\]

\[
= 6.7 \text{ m}^3 \text{ of slurry}
\]
where:

\[ V_{\text{transfer}} = \text{volume of slurry retrieved during unattended operation} \]
\[ v_{\text{settled}} = \text{solid volume fraction of as-settled sludge in SCS-CON-230} \]
\[ = 45\% \ (\text{HNF-SD-SNF-TI-015}) \]
\[ v_{\text{transfer}} = \text{solid volume fraction of transferred slurry sludge} \]
\[ = 7.5\% \ (\text{PRC-STP-CN-N-00947}). \]

The radiological dose at 100 m is then calculated from Equation 3-5. For a sludge transfer from SCS-CON-230, the collocated worker dose is:

\[
D_{\text{onsite}} = 12.5 \frac{\text{mg}}{\text{m}^3} \times \frac{t_{tx}}{\rho_{tx}} \times C_U \times DCF_{\text{onsite}} \times BR_{\text{onsite}}
\]

\[
= 12.5 \frac{\text{mg}}{\text{m}^3} \times \frac{\text{kg}}{10^6 \text{mg}} \times 25 \text{min} \times \frac{60 \text{ s}}{\text{min}} \times \left( 140 \frac{\text{kgU}}{\text{m}^3} \right) 
\times \frac{1}{1300 \frac{\text{kg}}{\text{m}^3}} \times 3.44 \times 10^7 \frac{\text{rem}}{\text{kg}} \times 3.35 \times 10^{-4} \frac{\text{m}^3}{\text{s}}
\]

(Eq. 3-13)

\[
= 23 \text{ rem}
\]

where:

\[ D_{\text{onsite}} = \text{onsite radiological dose consequence} \]
\[ C_U = \text{uranium concentration of the transfer slurry} = 140 \frac{\text{kgU}}{\text{m}^3} \ (\text{from Eq. 3-10}) \]
\[ \rho_{tx} = \text{density of the transfer slurry} = 1300 \frac{\text{kg}}{\text{m}^3} \ (\text{from Eq. 3-9}) \]
\[ DCF_{\text{onsite}} = \text{unit dose factor for collocated worker} = 3.44 \times 10^7 \frac{\text{rem}}{\text{kg}} \ (\text{Table 3-18}) \]
\[ BR_{\text{onsite}} = \text{breathing rate for collocated worker} = 3.35 \times 10^{-4} \frac{\text{m}^3}{\text{s}} \ (\text{Table 3-15}) \]
\[ t_{tx} = \text{duration of transfer} \]
\[ = \frac{6.7 \text{ m}^3 \text{ slurry}}{70 \text{ gpm}} \times \left( 264 \frac{\text{gal}}{\text{m}^3} \right) \]
\[ = 25 \text{ min.} \]

The assumed aerosol concentration of 12.5 mg/m\(^3\) at 100 m is further dispersed as the plume moves down wind. Dispersion is determined based on the \( \chi/Q' \) ratio based on a Gaussian atmospheric modeling that uses site-specific historical meteorological monitoring data. The new dose consequence is then calculated using appropriate DCFs and BRs for the receptor location.
The operational spray event occurs during the retrieval and transfer process. Calculations using Equations 3-13 and 3-14 for each of the sludge transfer operations are provided in PRC-STP-CN-N-00947. The bounding seismic spray release for sludge from SCS-CON-230 is provided in Table 3-26.

**Table 3-26. Summary of Unmitigated Radiological Dose Consequences (TED) for Operational Spray Release**

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieval and Transfer (SCS-CON-230)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
</tbody>
</table>
Table 3-26. Summary of Unmitigated Radiological Dose Consequences (TED) for Operational Spray Release

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

An evaluation of the chemical hazards of K Basin sludge was developed following the guidance in Appendix B of DOE-STD-1189-2008 (see PRC-STP-CN-N-00528). This chemical hazards evaluation is based on a process of: (1) screening of chemicals to determine those that may have the potential to immediately threaten or endanger onsite (collocated) workers or the public and (2) evaluating the severity of potential exposures against advisory classification criteria for the collocated worker and the public.

Additional sludge characterization data has become available since the release of PRC-STP-CN-N-00528. PRC-STP-CN-N-00947, uses the new characterization data from HNF-SD-SNF-TI-015 and new sum-of-fraction (SOF) ratio values were calculated for aerosol concentrations of 12.5 mg/m³ generated from a spray of each sludge type. The toxicological SOF calculations for each sludge type are summarized in Table 3-27.

Table 3-27. Toxicological Consequence Ratios by Sludge Type

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SCS-CON-210</th>
<th>SCS-CON-220</th>
<th>SCS-CON-230</th>
<th>SCS-CON-240, -250, or -260</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collocated Worker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAC-3 SOF ratio for spray leak concentration at 100 m</td>
<td>0.05</td>
<td>0.06</td>
<td>0.43</td>
<td>0.04</td>
</tr>
<tr>
<td>Offsite Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAC-2 SOF ratio for TWA spray leak concentration for Offsite Public</td>
<td>1.0E-4</td>
<td>1.1E-4</td>
<td>7.0E-4</td>
<td>7.5E-5</td>
</tr>
</tbody>
</table>

Notes:
- Based on corresponding AEGL, ERPG, or TEEL-3 concentrations for each chemical species (see DOE-STD-1189-2008, Appendix B, Chemical Hazard Evaluation).
- Since the SCS-CON-230 spray leak event lasts longer than 15 min, this concentration represents a 15-min, time-weighted average chemical concentration that can be compared to threshold values for consideration of SSC classification. For the short-duration release from SCS-CON-220, the concentration at the receptor was calculated as the time-weighted average over the release period of 1.8 min (see Section 5.7 of PRC-STP-CN-N-00528 for discussion of the effect of duration).
- These results are based on ratio of χ/Q's for times < 1 hr.
Toxicological consequences of a release are based on the peak 15-minute chemical concentrations at the receptor location that may occur any time during the duration of the release. Exposures to chemical concentrations at the receptor location depend primarily on the concentration of the chemical released, the rate of release, and the dispersion (dilution) that occurs between the release location and the receptor.

PRC-STP-CN-N-00528 identified uranium oxide and undissolved solids (treated as silicon dioxide) as dominant for toxicological risk; while other constituents, including chromium, polychlorinated biphenyls, beryllium, and biological debris, were found to be insignificant contributors. No combination of exposure to two or more of these chemicals has been identified that results in health effects greater than the sum of the effects of the individual chemicals.

Since the SCS-CON-230 spray leak event lasts longer than 15 minutes, this concentration represents a 15-minute, time-weighted average chemical concentration that can be compared to threshold values for consideration of SSC classification. For the short-duration release from SCS-CON-220, the concentration at the receptor was calculated as the time-weighted average (TWA) over the release period (see Section 5.7 of PRC-STP-CN-N-00528 for the effect of duration on TWA). The bounding spray leak for the sludge from SCS-CON-230 for the onsite receptor has a ratio less than 0.5 and does not require consideration of safety-significant mitigation.

As was the case with the radiological dose consequences, for all spray release scenarios, the offsite public and collocated worker consequences are below the criteria for the consideration of safety-significant controls.

For the facility worker, a spray release during sludge retrieval and transfer from SCS-CON-230 is qualitatively estimated\(^\text{17}\) to result in a PAC-3 SOF clearly greater than 1. Therefore, safety-significant controls are required. For sludge retrieval and transfer spray release scenarios from other engineered containers, the facility worker toxicological ratios are clearly less than 1. However, to facilitate consistent, compliant implementation, selected controls are applied to all sludge retrieval and transfers.

### 3.4.2.1.4 Comparison to the Evaluation Guideline–ECRTS Spray Release Scenario

Table 3-26 and Table 3-27 provide a summary of the unmitigated radiological dose and toxicological consequences for the operational spray release scenario

As discussed in Section 3.3.2.1.2, “Facility Worker Criteria,” facility worker consequences are estimated to be 3 to 4 times greater than the collocated worker for events where the facility worker can be reasonably assumed to recognize the occurrence of the event and to evacuate the immediate area of the release. Facility workers will not normally be present near transfer lines during transfers due to the direct dose rate and associated Radiological Control restrictions. Assuming a facility worker was present, it is reasonable to assume the worker would recognize the spray release and leave the immediate vicinity. Therefore, for sludge retrieval and transfer spray release scenarios involving SCS-CON-230, the facility worker radiological dose consequence is qualitatively estimated to range from 70 to 90 rem.

\(^\text{17}\) Facility worker toxicological consequence ratios are qualitatively estimated as 3 to 4 times the collocated worker ratios.
Although not normally present near transfer lines during transfers, in an unmitigated scenario wherein no credit is taken for passive secondary confinement (e.g., out hose of HIH transfer lines, TLSB), a facility worker could be directly contacted by the spray. As documented in PRC-STP-CN-N-00947, Appendix N, “Estimate for Bounding Worker Dose,” if a worker were to be directly in the spray and were to remain in wetted clothing for 5 minutes, the resultant dose would be on the order of 8 rem.

When facility worker radiological consequences are not clearly above or below the evaluation criteria, the need for safety-significant controls should be more closely considered (relative to when the consequences are clearly above or below). The STP considered the need for safety-significant controls for facility worker protection based on the radiological consequences and concluded that such controls are warranted for SCS-CON-230 sludge retrieval and transfer spray release scenarios.

Based on toxicological consequences shown in Table 3-27, safety-significant classification is not required for the collocated worker or the offsite public. However, the toxicological consequences ratio for the facility worker would be greater than 1 for SCS-CON-230 such that safety-significant classification is required.

For sludge retrieval and transfer spray release scenarios from other engineered containers, the facility worker consequences are clearly below the radiological and toxicological criteria. However, to facilitate consistent, compliant implementation, selected controls are applied to all sludge retrieval and transfers.

As documented in PRC-STP-CN-N-00947, facility worker consequences are clearly below the radiological and toxicological criteria for overfill recovery, decant, and ECRTS Sand Filter backwash spray release scenarios.

### 3.4.2.1.5 Summary of Safety-Significant SSCs, SACs and TSR Controls—ECRTS Spray Release Scenario

As discussed in Section 3.4.2.1.4, the STP has determined that safety-significant controls are warranted for facility worker protection for sludge retrieval and transfer operational spray release scenarios. The selected safety SSCs and SACs are presented in Table 3-28 and Table 3-29. Controls for slurry spray releases initiated by fires, NPH, and external events are addressed in subsequent sections of this chapter (e.g., Section 3.4.2.5, “Operational Accident—105KW Annex Fire”).

#### Table 3-28. Spray Release Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
</table>
| 1        | Prevent the spray release of slurry by maintaining integrity during sludge retrieval and transfer. | Above-water slurry transfer lines:  
- Inner pipe–slurry transfer line Ingress/Egress Assembly  
- Inner hose–slurry transfer line HIH  
- Inner pipe–slurry transfer line coaxial connector  
- Slurry transfer piping and hose within the TLSB |
Table 3-28. Spray Release Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Prevent the spray release of slurry by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer.</td>
<td>Slurry transfer line rupture disk ECRT-PSE-101</td>
</tr>
<tr>
<td>3</td>
<td>Prevent the spray release of slurry by preventing backflow into the TLSB IXM water supply lines during sludge retrieval and transfer.</td>
<td>Double-valve isolation: ECRT-AOV-104 and ECRT-CV-105, ECRT-AOV-302 and ECRT-AOV-103</td>
</tr>
<tr>
<td>4</td>
<td>Prevent the spray release of slurry by preventing backflow into overfill recovery line ECRT-SLU-300 during sludge retrieval and transfer.</td>
<td>Double-valve isolation: ECRT-AOV-302 and ECRT-V-301</td>
</tr>
<tr>
<td>5</td>
<td>Prevent the spray release of slurry by preventing backflow into decant/floculant recirculation line ECRT-H-209 during sludge retrieval and transfer.</td>
<td>Double-valve isolation: ECRT-AOV-105 and ECRT-AOV-106</td>
</tr>
<tr>
<td>6</td>
<td>Prevent a spray release of slurry by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer.</td>
<td>• Handswitch ECRT-HS-123 • Valve ECRT-SOV-123 • Valve ECRT-AOV-123</td>
</tr>
<tr>
<td>7</td>
<td>Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container.</td>
<td>Hoist Chain Stops</td>
</tr>
</tbody>
</table>

Notes:
AOV = air-operated valve

Table 3-29. Spray Release Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protect the accident analysis assumption regarding the composition of decanted STSC supernate.</td>
<td>Slurry Settling Duration</td>
</tr>
<tr>
<td>2</td>
<td>Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td>3</td>
<td>Protect the hazard analysis assumption that transfer line failures underwater in the 105KW Basin do not result in airborne releases.</td>
<td>Basin Water Level</td>
</tr>
<tr>
<td>4</td>
<td>Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container.</td>
<td>XAGO Pre-Operational Testing and Readiness Review Controls</td>
</tr>
</tbody>
</table>
The time-at-risk for a slurry spray release during sludge retrieval and transfer is relatively short. For example, based on the process flow sheet, the total slurry transfer time for the life of the facility is approximately 9 hours assuming design basis as-settled sludge is retrieved at 70 gal/min and 5 vol% solids. Even if the flow sheet parameters are not routinely achieved (e.g., if the solids content of the retrieved slurry is less than 5 vol%), the time-at-risk for a slurry spray leak is still expected to be on the order of hours-to-days versus weeks-to-months. It is noteworthy that as the slurry volume percent solids decreases, the material-at-risk for a spray release also decreases. The formation of strong cement-like layers that could impact the ability to efficiently retrieve sludge are not expected in the engineered containers based on the conclusions of PRC-STP-00579, Sludge Treatment Project Engineered Container Retrieval and Transfer System: Status Report for Long Term Monitoring of K Basin Sludge Samples.

The principal control strategy to prevent slurry spray releases during sludge retrieval and transfer is to provide safety-significant, above-water slurry transfer lines. “Above-water slurry transfer lines” includes connections between lengths of hose and pipe including gaskets and fasteners, and any in-line equipment, such as isolation valves, pump housings, and instruments, that is part of the above-water slurry transfer line pressure boundary.

The above-water slurry transfer lines are protected from over-pressurization by a safety-significant rupture disk. The rupture disk is located underwater in the 105KW Basin such that no airborne release occurs should the rupture disk open.

To prevent slurry flow into general service connected piping (e.g., IXM water supply) where a spray release could occur, safety-significant double-valve isolation was selected as a control. Safety-significant, double-valve isolation may consist of a pair of isolation valves in series, or an isolation valve followed by a check valve. The first isolation valve is a component of the safety-significant above-water slurry transfer line SSC. The second isolation valve is classified as safety-significant as it is a major contributor to defense-in-depth. Specifically, the second isolation valve increases reliability by providing a second layer of protection.

Because some of the safety-significant valves are controlled from a general service panel, a safety-significant, handswitch-controlled solenoid and associated AOV have been incorporated into the design to ensure that failure of a general service component cannot inadvertently open a safety-significant valve. The handswitch (ECRT-HS-123) is mounted on Safety Control Panel ECRT-PNL-103.

The above-water piping and hose sections that provide primary containment are engineered, passive, preventive controls. In addition, the selection of above-water slurry transfer lines is cost-effective in that the majority of the lines are also selected as safety-significant to prevent hydrogen explosions in process enclosures (see Section 3.4.2.3).

Double-valve isolation on connected piping is an engineered, active, preventive control. The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying proper system configuration (including handswitch position) prior to initiating a transfer. This key attribute requires facility equipment and system status to be controlled to ensure that facility configuration is maintained in accordance with procedure requirements. Proper system configuration will be independently verified in accordance with PRC-STP-OP-40123, Independent Verification. Check valves and the rupture disk are active controls in that they change state (based on system pressures) to perform their safety functions. The check valves and
rupture disk are procured, inspected and accepted, and verified in accordance with the requirements of PRC-MP-QA-599, Quality Assurance Program, as are all safety-significant SSCs.

To provide an additional layer of defense-in-depth for facility worker protection, an administrative control was selected to prohibit personnel entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer. Taking credit for this mitigative control, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1, respectively, should a spray release occur. This control is judged to be a major contributor to defense-in-depth and, therefore, is classified as a SAC. Facility workers may be present in the Mechanical Equipment Room, HEPA Filter Room, or Interior Stair enclosure/Personnel Change Room during sludge retrieval and transfer. Workers in these areas would not be expected to receive doses approaching 100 rem or be exposed to a PAC-3 SOF greater than 1 if an unmitigated spray leak in the Sludge Loading Bay were to occur. This judgment is based on the degree to which these areas are isolated from the Sludge Loading Bay and is not dependent upon operation of the Process/Exhaust Ventilation System.

In contrast to the Sludge Loading Bay, facility workers must be present in the 105KW Basin during slurry transfers. The safety-significant above-water slurry transfer line within the 105KW Basin includes the approximately 8-ft long inner pipe of the Ingress/Egress Assembly, and approximately 4.5 ft of HIH inner hose. In addition to the secondary confinement provided the outer pipe of the Ingress/Egress Assembly, the inner pipe is wrapped with 2 inches of a tungsten-infused silicon-based polymer for radiation shielding purposes. In addition to the secondary confinement provided by the outer hose of the HIH, the HIH is located with the In-Basin Horizontal Shielded Hose Chase. Combined, these measures adequately protect the facility worker.

As stated in Section 3.4.2.1.4, facility worker consequences are clearly below the radiological and toxicological criteria for overfill recovery, decant, and ECRTS Sand Filter backwash spray releases scenarios. The MAR values used in consequence calculations for a spray release of supernate and ECRTS Sand Filter backwash are based on a supernate solids volume fraction that assumes a 2-hour settling time. Therefore, to protect the accident analysis assumption, a SAC was selected to verify a settling duration of greater than or equal to 2 hours prior to decanting an STSC.

The hazard analysis identified the drop of an In-Basin Shielded Hose Chase shield plate onto a HIH assembly as an initiating event for a slurry spray release. As a preventive control, the Management, Organization, and Institutional Safety Provisions SMP was selected. As described in HNF-11724, CH2M Hill Plateau Remediation Company Safety Management Programs, the Management, Organization, and Institutional Safety Provisions SMP ensures that abnormal events are investigated, analyzed, and that appropriate corrective actions are established and completed.

The hazard analysis identified non-ECRTS work activities inside or outside of the 105KW Basin with the potential to physically impact the slurry transfer line as possible initiators of a spray release. To protect against such initiators, the Operational Safety SMP was selected. HNF-11724, Chapter 11, Key Activity 11-1, “Conduct of Operations,” includes multiple elements to ensure that such activities are evaluated and controlled relative to ECRTS operations.
The hazard analysis assumed that slurry transfer line failures between Booster Pump ECRT-P-101A/B and the Ingress/Egress Assembly during sludge retrieval and transfer do not result in airborne spray releases because the associated transfer line is located underwater. To protect this assumption, a SAC was selected to ensure that a minimum water level is maintained in the 105KW Basin.

The consequences of a spray release during pre-operational testing have been estimated in PRC-STP-CN-N-00947. The consequences are low to all receptors based on the assumption that the MAR is limited to basin water and a small amount of sludge. To protect the assumption that sludge will not be retrieved from an engineered container prior to completion of the Operational Readiness Review (ORR), a safety-significant chain stop is installed on each of the chain hoists used raise and lower a XAGO tool. The chain stops will be relocated to the end of the chain after the ORR is complete. To provide an additional layer of defense-in-depth, RL has directed that administrative controls be established controlling the XAGO location and Basin water motive force (letter 17-NSD-0037_RL). These controls ensure that sludge will not be transferred should too much chain be deployed and the chain stop fail.

Crediting the above identified preventive controls, the frequency of an operational spray release is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E-2/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

3.4.2.2 Operational Accident–STSC Hydrogen Explosion

The sludge stored in the engineered containers in the 105KW Basin contains uranium metal that can react exothermally with water to produce uranium oxide and hydrogen. Sludge characteristics that affect hydrogen gas retention and release for sludge stored in engineered containers is documented in PRC-STP-CN-N-00858, Sludge Treatment Project – Hydrogen Gas Storage in KW Basin Engineered Containers. Based on a review of PRC-STP-CN-N-00858, for an STSC in the Sludge Loading Bay:

- The expected gas release mechanism is a slow, steady-state release over time equal to the generation rate.
- A cascade bubble release (wherein the disturbance caused by one bubble frees nearby bubbles in the surrounding sludge) is credible following a sludge transfer as the shear strength of the sludge will initially be low. However, it takes several days for the sludge to generate and retain a significant quantity of gas, during which time the shear strength increases. Accordingly, significant cascade bubble releases are not anticipated.
- Buoyant displacement gas release events can be excluded except for SCS-CON-210 based on the critical gas fraction required for buoyancy. Based on observations of SCS-CON-210, the volume of gas for a periodic release from buoyancy events is small.
- The yield stress in shear of the sludge in SCS-CON-240, -250, and -260 is sufficiently high that a vessel spanning bubble is credible during long-term storage at T Plant.

The hazards in the hydrogen explosion category can be grouped as follows.

- **Hydrogen explosion in the STSC.** This event occurs if there is a hydrogen buildup in the headspace of the STSC upon loss of ventilation. Hydrogen accumulates in the
air-filled volume above the liquid until a flammable concentration is reached. Alternately, air could diffuse into an inerted STSC resulting in a flammable concentration in the headspace. It is noted that small amounts of entrained hydrogen gas maybe transferred into the STSC along with the slurry during sludge retrieval and transfers. As documented in PRC-STP-00687, the quantity of gas does not represent a hazard.

- **Hydrogen explosion in STSC Process/Exhaust Ventilation System.** This event occurs if there is a hydrogen buildup in the headspace of the STSC upon loss of ventilation. Hydrogen accumulates in the air-filled volume above the liquid and a flammable hydrogen concentration and migrates into the Process/Exhaust Ventilation System via the connected ventilation system hoses and ignites. The radiological and toxicological consequences of such an event are bounded by an explosion in an STSC as there is no significant MAR within the ventilation system, and both events have the same potential for facility worker impacts from the fragmentation of process equipment.

- **Hydrogen explosion in the STSC Cask.** This event could occur if hydrogen generated within the STSC mixes with air in the STSC headspace and is ignited. The radiological and toxicological consequences of a hydrogen explosion in the STSC Cask are bounded by an explosion in the STSC as there is no additional MAR in the cask, and both events have the same potential for facility worker impacts from the fragmentation of process equipment.

- **T Plant hydrogen explosion in the STSC from a vessel-spanning bubble.** The storage of sludge in an STSC over an extended period of time potentially lead to the formation of a stable sludge plug. A stable sludge plug could arise if the sludge shear strength allowed the creation of a sludge layer that hinders the release of evolved gases (e.g., hydrogen). This retention of gas then leads to the formation of a vessel-spanning bubble with the sludge plug above the bubble remaining stable until obstructed. Disturbing the sludge layer could lead to a rapid release of a significant fraction of the stored hydrogen gas. Although this event occurs at T Plant, the selected control is a design feature of the STSC (i.e., an internal, sloped fin) and as such is addressed within this DSA.

Table 3-30 provides a summary of the operational STSC and STS Cask hydrogen explosion accident scenario, consequences, frequencies, and controls.

### 3.4.2.2.1 Scenario Development–STSC Hydrogen Explosion

The hazard evaluated in this bounding unmitigated accident arises when a STSC contains enough hydrogen to make the headspace flammable. For this case, the STSC is filled with slurry, decanted, and then left isolated. Because the STSC headspace is assumed not to be inerted or ventilated, the initial headspace atmosphere is air. Hydrogen accumulates the headspace increasing the hydrogen concentration in the STSC until the headspace mixture is flammable. Ignition of this mixture is presumed. A flammable mixture of gases with 4 percent or more hydrogen and sufficient oxygen will support combustion. For this analysis, the bounding gas concentration is assumed to be a stoichiometric mixture of hydrogen and air. Evaluating with a stoichiometric mixture means that all the potential hydrogen releases are bounded by the analyzed event.
For an unmitigated scenario, no credit is taken for the ability of the STSC, its appurtenances, or interconnected enclosures to withstand the pressure generated by the explosion. Therefore, the STSC or an appurtenance is assumed to fail with the potential of causing facility worker serious injury or death.

For an unmitigated scenario, a single equipment failure or human error can initiate a hydrogen explosion. Therefore, the unmitigated frequency of an operational hydrogen explosion is qualitatively estimated to be anticipated (i.e., greater than $1E^{-2}/yr$).
Table 3-30. Operational STSC and STS Cask Hydrogen Explosion

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STSC</strong> Hydrogen gas generated by the sludge accumulates in the STSC headspace, reaches a flammable concentration, and ignites resulting in a hydrogen explosion. Causes include:</td>
<td>A Y L L (II) (III)</td>
<td>Auxiliary Ventilation System</td>
<td>Procedures</td>
<td>EU Y L L (II) (III)</td>
<td>“Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby</td>
</tr>
<tr>
<td>• Loss of Process/Exhaust Ventilation due to equipment failure (e.g., fan failure, loss of power) or operator error (e.g., STSC inlet air valve closed)</td>
<td></td>
<td>Valve position indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Failure to inert STSC due to equipment failure (e.g., leak/rupture of nitrogen supply piping/hoses) or operator error (e.g., normally-opened valve closed)</td>
<td></td>
<td>STSC pressure indication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Loss of inert atmosphere due to failure of STSC boundary (e.g., cask lid drop onto STSC, operator error in establishing boundary)</td>
<td></td>
<td>STSC inlet HEPA filter dp instrumentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sludge inadvertently transferred into STSC during pre-operational testing or operation readiness activities</td>
<td></td>
<td>Exhaust HEPA filter dp instrumentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>STS Cask</strong> Hydrogen gas generated by the sludge in the STSC is released (by design) into the STS Cask via the Transport Vent Assembly check valves. The hydrogen accumulates in the cask headspace, reaches a flammable concentration, and ignites resulting in a hydrogen explosion. Causes include:</td>
<td>A Y L L (II) (III)</td>
<td>Oxygen concentration instrumentation</td>
<td>Procedures</td>
<td>EU Y L L (II) (III)</td>
<td>“Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby</td>
</tr>
<tr>
<td>• Failure to inert cask due to equipment failure (e.g., leak/rupture of nitrogen supply piping/hoses) or operator error (e.g., normally-opened valve closed)</td>
<td></td>
<td>Valve position indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Loss of inert atmosphere due to failure of STS Cask pressure boundary (e.g., failure to properly torque lid, cask lid seal failure)</td>
<td></td>
<td>Inert gas specific cylinder connection fittings</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3-30. Operational STSC and STS Cask Hydrogen Explosion

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FW</td>
<td>CL</td>
<td>MOI</td>
<td>Engineered</td>
<td>Administrative</td>
</tr>
<tr>
<td>STSC: Hydrogen gas generated by the sludge reaches a flammable concentration in the STSC headspace during long-term storage at T Plant and ignites resulting in a hydrogen explosion. Causes include: • Formation of vessel-spanning hydrogen bubble with subsequent release to the STSC headspace • Loss of STSC passive ventilation due to sludge expansion that blocks the vent path</td>
<td>U</td>
<td>Y</td>
<td>L</td>
<td>(I)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y</td>
<td>L</td>
<td>(II)</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>EU</td>
<td>Y</td>
<td>L</td>
<td>(II)</td>
<td>L</td>
</tr>
</tbody>
</table>
3.4.2.2 Radiological Source Term—STSC Hydrogen Explosion

Table 3-31 provides references for the parameter values used to determine the radiological source term for a hydrogen explosion in an STSC.

Table 3-31. Known Quantities—Hydrogen Explosion in the STSC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Justification for Selection of Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detonation energy of TNT</td>
<td>4612 kJ/kg</td>
<td>Reference value</td>
<td>DOE-HDBK-3010-94</td>
</tr>
<tr>
<td>Combustion energy of hydrogen</td>
<td>242 kJ/mole</td>
<td>Reference value</td>
<td>Cengel, Y.A. and M.A. Boles, <em>Thermodynamics</em></td>
</tr>
</tbody>
</table>

Notes:
TNT  trinitrotoluene

Assumptions specific to the analysis of the hydrogen deflagration or detonation are summarized in the following paragraphs.

**Hydrogen-Air Mixture:** The hydrogen-air mixture is assumed to have ideal stoichiometric proportions and to be ideally mixed. The air is assumed to be 20 percent oxygen and 80 percent nitrogen. The presence of water vapor, which could be approximately 3 percent of the volume of the headspace and would act as a diluent, is conservatively ignored.

This conservative assumption maximizes the energy release and peak pressure. It is assumed that hydrogen, although buoyant in air, is not preferentially vented out of the volume. To add conservatism, the pressure in the STSC is based on a closed STSC with the addition of the hydrogen increasing the headspace pressure. A stoichiometric mix of air and hydrogen of 29.2 liters of hydrogen per 100 liters of headspace atmosphere is reached when the accumulated hydrogen increases the pressure by about 40 percent up to 1.42 atm (PRC-STP-CN-N-00947).

**Design Pressure:** The STSC design pressure of 150 psig is approximately equal to the pressure generated from the deflagration in vessel headspace at an initial pressure 1.42 atm absolute.

The over-pressure generated by the combustion of hydrogen is limited to the maximum pressure associated with an adiabatic isochoric complete combustion for a chemical reaction that proceeds to completion with no heat transfer, in a constant-volume region. Figure 2-10 of NUREG/CR-2726, *Light Water Reactor Hydrogen Manual*, shows a ratio of final pressure (after burn) to initial pressure of less than 8 for a stoichiometric mixture of hydrogen and air.

Given this stoichiometric mixture at a pressure of 1.42 atm and a temperature of 15°C, the combustion under adiabatic conditions leads to a temperature of 2700 K and a pressure of about 11.2 atm. Design pressure for an STSC is 150 psig (11.2 atm absolute) (H-1-92301, *STP ECRTS Process System P&ID*). As stated above in the scenario description, for the unmitigated analysis, the STSC or an appurtenance is assumed to fail with the potential of causing facility worker serious injury or death.
**STSC Headspace Volume:** The maximum gas volume for a decanted STSC containing STS-CON-230 sludge is 3.45 m$^3$.

The STSC has a maximum operating volume of approximately 3.5 m$^3$ excluding the upper semi-elliptical head. Including the semi-elliptical volume of 0.42 m$^3$, the total operating volume is 3.92 m$^3$. When an STSC containing 0.4 m$^3$ of Settler Tank sludge is maximally decanted (minimum heel) to 0.47 m$^3$, the maximum gas volume is approximately 3.45 m$^3$. With a full STSC prior to decanting, the headsapce gas volume would be limited to the volume of the 0.42 m$^3$ semi-elliptical head volume.

**Explosion Mechanism:** The hydrogen is assumed to burn as a deflagration.

An evaluation of the potential for a detonation has been performed and is documented in PRC-STP-00937, *Potential for a Detonation in the Sludge Transport and Storage Container and Piping*. The evaluation concludes that detonations due to a deflagration-to-detonation transition, jet initiation, or direct initiation cannot occur.

It should be recognized that the method used in this analysis for calculating the deflagration consequences is equally applicable to a detonation. The following is from DOE-HDBK-3010-94, in the summary section on liquids:

> “For detonations in or immediately contiguous to a pool of liquid, a bounding respirable release is assessed to be the mass of inert material equal to the calculated TNT equivalent.”

**Respirable Fraction:** An RF of 0.1 is applied to the release.

The mass ratio (i.e., the mass MAR and any inert material ratio to the equivalent TNT mass) is approximately 350 for a maximally-decanted STSC containing 0.4 m$^3$ of Settler Tank sludge. DOE-HDBK-3010-94, in summarizing the effects of explosive stress on liquids, states:

> “At low mass ratios, the respirable release is comparable to the total material release. As mass ratios increase, the respirable fraction becomes significantly less than the total amount of material released, which decreases with increasing mass ratio as well.”

DOE-HDBK-3010-94 addresses the expected reduction in respirable fraction by referencing “A Method for Estimating the Challenge to an Air Cleaning System Resulting from an Accidental Explosive Event” (Steindler and Seefeldt 1980) as its basis. DOE-HDBK-3010-94 describes the Steindler and Seefeldt model as conservative.

Figure 4 of the Steindler and Seefeldt paper illustrates the dramatic decrease in the weight of airborne material at smaller particle sizes as the mass ratio increases. Steindler and Seefeldt, in discussing this figure, state,

> “As an example, the absolute weight of material with particle diameters of 10 µm or less is seen to decrease from about $10^{-2}$ g/g of explosive at a mass ratio of ten to less than $10^{-5}$ g/g of explosive at a mass ratio of 400.”

This result would support the selection of an RF of 0.01, which would be equivalent to using the $10^{-2}$ g/g predicted for a mass ratio of 10 while the actual mass ratio is greater than 500.
Section 3.3.1.3 of NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*, also presents an evaluation derived from the Steindler and Seefeldt data. At a mass ratio of only 24, the limit for the data presented in Table 3-6 of NUREG/CR-6410, the ARF×RF product has a value of 9E-5 compared to the ARF×RF value of 1.9E-4 used in STSC analysis for an RF of 0.1.

Given the length of time required for a flammable concentration of hydrogen to accumulate in the STSC headspace, the slurry is expected to segregate within the STSC, with the heavier sludge solids settling to the bottom such that it is separated from the headspace by a layer of liquid supernate. Also, a new STSC is used for each transfer, so little buildup of sludge is expected in the STSC headspace. The STSC analysis RF value of 0.1 is seen to be a reasonable departure from the DOE-HDBK-3010-94 methodology.

**Time to Lower Flammability Limit (LFL) and Stoichiometric Concentration:** The time to flammable varies with the sludge temperature. A temperature of 25°C is a reasonable average sludge temperature during processing and can be used to illustrate a typical hydrogen generation rate for Settler Tank sludge (see Equation 3-15).

The ratio of sludge volume to headspace volume can be used to estimate the minimum time for the headspace volume to become flammable, assuming a starting atmosphere that has not been inerted, and no functional ventilation for the STSC headspace. For Settler Tank sludge at the safety basis isotopic composition, the hydrogen generation rate at 25°C is approximately 8.65 × 10⁻³ liters of hydrogen per hour per liter of sludge (PRC-STP-CN-N-00947). For a mixture of 20 percent Settler Tank sludge and 80 percent KE sludge the hydrogen generation rate at 25°C is approximately 1.9 × 10⁻³ liters of hydrogen per hour per liter of the sludge mixture (PRC-STP-CN-N-00947).

Therefore, for the headspace to reach the LFL of hydrogen of 4 percent volume fraction requires between 4.4 and 20 hours for an STSC containing 0.4 m³ of Settler Tank sludge and 1.6 m³ of KE sludge with headspace volumes of 0.42 m³ and 1.92 m³ respectively (PRC-STP-CN-N-00947).

\[
\text{Time to LFL} = \frac{4\%}{1.9 \times 10^{-3} \left( \frac{L_{\text{hydrogen}}}{L_{\text{sludge}} \times \text{hr}} \right)} \times \frac{0.42 \text{ m}^3}{2.0 \text{ m}^3} \quad (\text{Eq. 3-15})
\]

\[= 4.4 \text{ hr} \]

This estimate ignores any potential effect of diffusion or density-driven convection in the STSC as the hydrogen concentration is building. Both these effects would lengthen the time required to reach a flammable condition. Given similar temperature and headspace volume assumptions, the hydrogen generation rate in an STSC loaded with 0.4 m³ of sludge from SCS-CON-230 layered with 1.6 m³ of KE sludge is greater than the generation rate for other STSC loading configurations (e.g., 1.0 m³ of SCS-CON-220).

The time to a stoichiometric concentration of hydrogen and air (i.e., 29.2 liter of hydrogen per 100 liters of STSC headspace) is approximately 32 hours for a 0.42 m³ STSC headspace, and approximately 6 days for a 1.92 m³ STSC headspace.
**TNT-Equivalent Method:** The hydrogen deflagration is modeled using TNT-equivalence with an assumed and conservative efficiency of 100 percent.

The TNT-equivalent method provides a simplistic and conservative way to model the hydrogen burn. This method involves comparing the effects of a given compound with a known amount of TNT, a compound that has been extensively studied in explosion literature. The TNT-equivalent method is based on the comparison of the heat of combustion of a given material with TNT and involves calculating a TNT-equivalent weight.

For STP, the TNT-equivalent method involves estimating the generation of the aerosol source term for a hydrogen deflagration in the STSC by relating the mass of TNT with an equivalent amount of energy in the volume of the flammable mixture of hydrogen in the headspace based on DOE-HDBK-3010-94. The available combustion energy in a headspace is converted into an equivalent weight of TNT with Equation 3-16:

\[
Q_{\text{TNT}} = \eta \times \frac{Q_{H_2} \times E_{m\text{H}_2}}{E_{m\text{TNT}}} \quad \text{(Eq. 3-16)}
\]

where:

- \(\eta\) = TNT damage equivalency based on energy (100 percent)
- \(E_{m\text{H}_2}\) = combustion energy of hydrogen, 242 kJ/(mole \(H_2\)) (Table 3-31)
- \(E_{m\text{TNT}}\) = TNT equivalent is 4612 kJ/(kg TNT) (Table 3-31)
- \(Q_{H_2}\) = mass of hydrogen involved, kg
- \(Q_{\text{TNT}}\) = equivalent mass of TNT, kg.

Values for the TNT-equivalency for unconfined vapor cloud explosions, \(\eta\), have been deduced by statistical analysis from the damage observed in a limited number of major vapor cloud explosion incidents. For the wide range of explosions observed, characteristic values for TNT damage equivalency energy of average (4 percent) and an approximate upper limit (10 percent) were recommended to be used for predictive purposes for vapor cloud explosions. Use of 100 percent, even for the confined deflagration, is recognized as conservative.

Conservatism with the TNT-equivalent method also includes the concept of comparing explosive materials with very different densities and source geometries. This includes effects such as the reduced local energy density of a gaseous combustion compared with the condensed state of a detonation of solid explosives. In fact, the experiments used to determine the effects of TNT explosions were done with TNT within the affected material rather than above the material as it would be for the hydrogen explosion in the headspace of the STSC.

Therefore, the conservative nature of this estimate should be recognized. The energy released or the damage resulting from a deflagration is not expected to exceed 10 percent of the explosive yield of a TNT detonation with a similar configuration (*Chemical Process Safety: Fundamentals with Application* [Crowl and Louvar 1990]). This reduction is caused by several factors, including incomplete combustion of hydrogen; lower energy density for a gaseous mixture rather than a solid; and the position of the explosion relative to the material affected by the explosion.
Regarding the position of the explosion relative to the material affected by the explosion, within the STSC the majority of the sludge will be settled at the bottom with an overlaying layer of supernate. In addition, it is recognized that a small quantity of sludge will be adhered to the STSC walls and internal components within the STSC headspace. This material is accounted for in the 0.095 kg U source term calculated in Equation 3-21 below.

3.4.2.2.3 Radiological Consequences—STSC Hydrogen Explosion

With an STSC headspace volume of 3.45 m³ (maximum volume after decanting) and assuming a stoichiometric ratio of hydrogen and oxygen at a pressure of 1.42 atm, a temperature of 15°C, and a humidity of 100 percent, the STSC headspace would contain 60.5 moles of hydrogen for an STSC with SCS-CON-230 sludge. A lower assumed temperature gives a greater mass of hydrogen in the headspace and is therefore conservative. The heat of combustion of hydrogen is 242 kJ/mole when the energy required to vaporize the water is taken into account (Cengel and Boles 1994).

\[
\begin{align*}
    n_{H_2} & = \frac{[P \times V]}{[R_{\text{gas}} \times T]} \\
    & = \frac{3.45 \text{ m}^3 \times 1000 \frac{\text{L}}{\text{m}^3} \times 29.2 \text{ vol}\% \text{ H}_2 \times 1.42 \text{ atm}}{8.21 \times 10^{-2} \frac{\text{atm L}}{\text{mole K}} \times 288.15 \text{ K}} \\
    & = 60.5 \text{ moles of hydrogen}
\end{align*}
\]

where:

- \( n_{H_2} \) = number of moles of hydrogen in the STSC headspace
- \( P \) = initial pressure (1.42 atm)
- \( V \) = headspace volume (3.45 m³)
- \( R \) = universal gas constant (8.21×10⁻² atm L/mole /K)
- \( T \) = temperature (15°C = 288.15 K).

The energy liberated by the complete combustion of 60.5 moles of hydrogen is 14,600 kJ.

\[
    \begin{align*}
        60.5 \text{ moles of hydrogen} \times 241.82 \frac{\text{kJ}}{\text{mole}} & = 14,600 \text{ kJ}
    \end{align*}
\]

\[ \text{(Eq. 3-18)} \]

With 100 percent efficiency and at a standard conversion of 4612 kJ per kg of TNT, this corresponds to a TNT equivalent mass of 3.17 kg.

\[
    \begin{align*}
        \text{TNT}_{\text{EQ}} & = 3.17 \text{ kg} = \frac{100\% \times 14,600\text{kJ}}{4612 \frac{\text{kJ}}{\text{kg of TNT}}}.
    \end{align*}
\]

\[ \text{(Eq. 3-19)} \]
The quantity of as-settled sludge at risk in the STSC is $1.13 \times 10^{-4} \text{ m}^3$.

$$Q_{val} = \frac{(\text{TNT}_\text{EQ} \times RF)}{\rho_{\text{sludge}}} = \frac{(3.17 \text{ kg} \times 0.1)}{2800} \frac{\text{kg}}{\text{m}^3} = 1.13 \times 10^{-4} \text{ m}^3$$

(Eq. 3-20)

where:

\begin{align*}
RF &= \text{respirable fraction} \\
&= 0.1.
\end{align*}

The source term, as the kg of uranium at risk, is 0.095 kgU.

$$Q_{\text{con}} = C_{U_{\text{resp}}} \times Q_{\text{val}} = 840 \frac{\text{kg}}{\text{m}^3} \times 1.13 \times 10^{-4} \text{ m}^3 = 0.095 \text{ kgU}$$

(Eq. 3-21)

where:

\begin{align*}
C_{U_{\text{resp}}} &= \text{total uranium density in sludge kg/m}^3 \\
&= 840 \text{ kg/m}^3 \text{ (for Settler Tank sludge).}
\end{align*}

The results are shown in Table 3-32. These calculations are repeated for all the sludge types in PRC-STP-CN-N-00947 based on the STSC dimensions and sludge loadings for the sludge from each of the engineered containers. Using the values from the previous calculations, the radiological dose consequences received by onsite individuals (i.e., MOI at the Hanford Site boundary; or collocated worker at 100 m) is calculated using equations described in Equation 3-2 applied to the Settler Tank sludge from SCS-CON-230.

$$D_{\text{onsite}} = Q_{\text{con}} \times \frac{X}{Q'} \times BR \times DCF$$

$$= 0.095 \text{ kgU} \times 3.5 \times 10^{-3} \text{ s m}^3 \times 3.35 \times 10^{-4} \text{ m}^3 \text{s} \times 3.44 \times 10^7 \text{ rem kgU}$$

$$= 3.8 \text{ rem}$$

(Eq. 3-22)

where:

\begin{align*}
D_{\text{onsite}} &= \text{respirable fraction of uranium} \\
DCF &= \text{unit dose factor for collocated worker} \\
BR &= \text{breathing rate for collocated worker} \\
X/Q' &= \text{atmospheric dispersion factor for collocated from DOE-STD-1189-2008.}
\end{align*}
3.4.2.2.4 Comparison to Evaluation Guidelines–STSC Hydrogen Explosion

Dose consequences for each of the sludge types have been calculated in a similar manner to that shown above and are documented in PRC-STP-CN-N-00947. The results for the bounding sludge from SCS-CON-230 are summarized in Table 3-32.

Table 3-32. Summary of Unmitigated Dose Consequences for Hydrogen Explosion Inside an STSC

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Unmitigated rem (TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes.
*Facility worker consequences are qualitatively estimated.

For all sludge types:
- The offsite public radiological consequence does not exceed the 5 rem evaluation guideline for the consideration of safety-class controls.
- The offsite public toxicological consequence does not exceed the AEGL-2/ERPG-2/TEEL-2 evaluation guideline for the consideration of safety-significant controls.
- The collocated worker radiological dose consequence does not exceed the 100 rem evaluation criteria for safety-significant controls.
- The collocated worker toxicological consequence does not exceed the AEGL-3/ERPG-3/TEEL-3 evaluation guideline for the consideration of safety-significant controls.
- The facility worker radiological dose is clearly below 100 rem and thus does not require consideration of safety-significant controls.
- The facility worker toxicological consequence is clearly below AEGL-3/ERPG-3/TEEL-3 and thus does not require consideration of safety-significant controls.

A hydrogen deflagration or detonation in the STSC does not represent a significant radiological or hazardous material exposure to the facility worker. However, the event of concern is an explosion. Although the STSC is situated within the STS Cask, in an unmitigated scenario, an explosion has the potential to result in facility worker serious injury or death caused by failure of connected piping, hoses, or instrumentation. Therefore, safety-significant controls are required to protect the facility worker.

3.4.2.2.5 Summary of Safety-Significant SSCs, SACs and TSR Controls–STSC Hydrogen Explosion

A hydrogen explosion in an STSC or STS Cask requires safety-significant controls because of the potential for facility worker serious injury or death. The safety SSCs and SACs selected to
prevent operational hydrogen explosions are presented in Table 3-33 and Table 3-34, respectively. Safety SSCs and SACs to prevent and mitigate hydrogen explosions due to fires, NPH, and external events are identified in subsequent sections (e.g., Section 3.4.2.5, “Operational Accident–105KW Annex Fire”).

There is no hydrogen explosion hazard in an STSC or STS Cask if there is no sludge present. To ensure that sludge is not inadvertently transferred into an STSC during pre-operational testing and operational readiness activities, a safety-significant chain stop is installed on each of the chain hoists used raise and lower a XAGO tool. To provide an additional layer of defense-in-depth, RL has directed that administrative controls be established controlling the XAGO location and Basin water motive force (letter 17-NSD-0037_RL). These administrative controls ensure that sludge will not be transferred should too much chain be deployed and the chain stop fail.

During sludge retrieval and transfer, the control strategy for the STSC is to prevent an explosion by maintaining the hydrogen concentration in the STSC headspace below 25 percent of the LFL in air. Under normal operating conditions, the general service Process/Exhaust Ventilation System performs this function by providing sufficient airflow through the STSC to control the hydrogen concentration. If the general service Process/Exhaust Ventilation System fails to maintain a minimum air flow rate through the STSC (as indicated by safety-significant flow meters FE/FIT-760-651 and FE/FIT-760-652 indicating a flow of less than 1 standard cubic foot per minute [scfm]), the safety-significant Auxiliary Ventilation System will automatically actuate. The Auxiliary Ventilation System uses pressurized nitrogen gas to provide a flow rate through the STSC to maintain the hydrogen concentration below 25 percent of the LFL in air. The Auxiliary Ventilation System is an engineered, active, preventive control.

The Auxiliary Ventilation System is designed with two trains, each of which provides a minimum flow rate of 0.5 scfm. As documented in calculation PRC-STP-CN-N-00935, given a hydrogen generation rate of 175 L per day, a flow rate of 0.5 scfm will maintain the hydrogen concentration in an STSC below 25 percent of the LFL for greater than 96 hours, and below the LFL indefinitely. With each train providing a flow rate of 0.5 scfm (i.e., 1 scfm total), the hydrogen concentration in an STSC is maintained below 25 percent of LFL indefinitely. Higher hydrogen generation rates can be calculated. However, the 175 L/day value is judged to be reasonably conservative given the conservative nature of the assumptions used in the analysis.”

The Auxiliary Ventilation System has a 48-hour installed nitrogen capacity and a 48-hour reserve nitrogen capacity. Based on 100K Area operational history with loss of power events and ventilation system equipment failures, 96 hours is judged to be an adequate time period to detect actuation of the Auxiliary Ventilation System and to restore normal process ventilation. The 48-hour values for the installed and reserve nitrogen capacities are minimums protected by the Auxiliary Ventilation System TSR. The available capacity may be significantly higher as discussed in Section 4.4.6, “Auxiliary Ventilation System.”

A SAC requires the Auxiliary Ventilation System be surveilled daily for actuation when an STSC containing sludge is connected to the Process/Exhaust Ventilation System. Actuation is indicated by STSC Normal Ventilation indicator lights ECRT-IL-651 and -652 located outside of the 105KW Annex adjacent to Nitrogen Supply Panel ECRT-ME-602. These indicator lights are normally “on.” If the flow rate drops below 1.0 scfm, the Auxiliary Ventilation System automatically actuates, and the lights are de-energized such that they are “off.” Surveillances are
performed by a Stationary Operating Engineer. Stationary Operating Engineers are present in the 100K Area every day of the year. A minimum staffing level TSR supports this surveillance. If the Auxiliary Ventilation System is actuated, the Stationary Operating Engineer will contact the Shift Operating Manager (SOM) or on-call SOM who will ensure the timely switchover from the installed to the reserve nitrogen capacity such that the Auxiliary Ventilation System has a minimum 96-hour nitrogen supply, and initiate actions to restore normal process ventilation.

Hydrogen generation rates and the Auxiliary Ventilation System flow rate required to keep the STSC below 25 percent of the LFL are documented in PRC-STP-CN-N-00935, *Sludge Treatment Project – Thermal and Gas Analyses of the Process/Exhaust and Auxiliary Ventilation Systems for the Sludge Transport and Storage Container (STSC) in the 105-KW Annex Building*. Initial conditions assumed in PRC-STP-CN-N-00935 that require protection are the STSC dimensions, and the quantity and composition of sludge in an STSC. The STSC dimensions are design features of the safety-significant STSC. The quantity and composition of sludge in an STSC are controlled through a combination of engineered and administrative controls. The engineered controls are a safety-significant divider plate in SCS-CON-230 that protects assumptions regarding the mass of uranium metal retrieved from the container, and safety-significant STSC level and weight instrumentation used to determine the buoyant weight of the sludge in an STSC. The administrative controls are a Sludge Source Verification SAC and a Sludge Buoyant Weight Limit SAC. These controls verify the engineered container from which the sludge is being retrieved and that the applicable sludge buoyant weight limit is not exceeded. The sludge limit SSCs and SACs also function to protect assumptions in PRC-STP-00241, *Sludge Treatment Project-Engineered Container Retrieval and Transfer System – Thermal and Gas Analyses for Sludge Transport and Storage Container (STSC) Storage at T Plant*, and PRC-STP-CN-N-00989, *Thermal and Gas Analyses for a Sludge Transport and Storage Container (STSC) During Transportation to T Plant with KW Annex Staging*.

**Table 3-33. Hydrogen Explosion in the STSC and STS Cask Engineered Controls**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td>2</td>
<td>Measure and indicate the oxygen concentration in the STSC headspace so Operations can verify that an inert atmosphere has been established, thereby preventing a hydrogen explosion.</td>
<td>Oxygen Analyzer ECRT-CAB-601 [Note: Oxygen Analyzer ECRT-CAB-601 is a support SSC to the STSC Inerting Limit SAC and the STS Cask Inerting and Pressurization Limits SAC (see Table 3-34, Items 4 and 5)]</td>
</tr>
<tr>
<td>3</td>
<td>Measure and indicate the oxygen concentration in the STS Cask so Operations can verify that an inert atmosphere has been established, thereby preventing a hydrogen explosion.</td>
<td></td>
</tr>
</tbody>
</table>
| 4        | Prevent a hydrogen explosion in the STSC by maintaining an inert atmosphere in the STSC once established. | STSC:  
- Boundary |
### Table 3-33. Hydrogen Explosion in the STSC and STS Cask Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
</table>
| 5        | Measure and indicate the STS Cask pressure so Operations can verify that it is within limits, thereby preventing a hydrogen explosion. | Pressure indicator ECRT-PI-760-606  
[Note: Pressure Indicator ECRT-PI-760-606 is a support SSC to the STS Cask Inerting and Pressurization Limits SAC (see Table 3-34, Item 5)] |
| 6        | Prevent a hydrogen explosion in the STSC during long-term storage at T Plant by limiting the volume of a vessel-spanning bubble. | STSC:  
• Sloped fin |
| 7        | Prevent a hydrogen explosion in the STS Cask by maintaining an inert atmosphere in the STS Cask once established. | STS Cask pressure boundary |
| 8        | Measure and indicate the STS Cask leak rate so Operations can verify that it is within limits, thereby preventing a hydrogen explosion. | STS Cask Leak Tester  
[Note: The STS Cask Leak Tester is a support SSC to the STS Cask Leak Rate Limit SAC (see Table 3-34, Item 9)] |
| 9        | Protect initial conditions assumed in the STSC thermal and gas analyses regarding the quantity of sludge present in an STSC. | • STSC liquid level instrumentation  
• Truck Scale instrumentation  
[Note: STSC liquid level and truck scale instrumentation are support SSCs to the Sludge Buoyant Weight Limits SAC and the STSC Final Liquid Level Limits SAC (see Table 3-34, Items 3 and 8)] |
| 10       | Measure and indicate the liquid level in an STSC so Operations can verify that the final fill level is within limits, thereby preventing a hydrogen explosion at T Plant. | STSC liquid level instrumentation |
| 11       | Protect initial conditions assumed in the STSC thermal and gas analysis regarding the STSC dimensions. | STSC:  
• Key dimensions |
| 12       | Protect initial conditions assumed in the safety basis analyses regarding the quantity of uranium metal in an STSC containing Settler Tank sludge. | SCS-CON-230 divider plate ECRT-ME-230 |
| 13       | Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container. | Hoist Chain Stops |
Table 3-34. Hydrogen Explosion in the STSC and STS Cask Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a hydrogen explosion in an STSC or STS Cask by verifying that the Auxiliary Ventilation System and Inert Gas System are supplied with nitrogen.</td>
<td>Gas Composition Verification</td>
</tr>
<tr>
<td>3</td>
<td>Protect initial conditions assumed in the STSC thermal and gas analyses regarding the type and quantity of sludge in an STSC.</td>
<td>• Sludge Source Verification</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sludge Buoyant Weight Limits</td>
</tr>
<tr>
<td>4</td>
<td>Prevent a hydrogen explosion in an STSC by verifying that an inert atmosphere has been established in the STSC headspace.</td>
<td>STSC Inerting Limit</td>
</tr>
<tr>
<td>5</td>
<td>Prevent a hydrogen explosion in an STS Cask by verifying that an inert atmosphere has been established in the STS Cask headspace</td>
<td>STS Cask Inerting and Pressurization Limits</td>
</tr>
<tr>
<td></td>
<td>[Note that this SAC requires inerting and pressurizing the cask within 24 hr of terminating the STSC nitrogen purge. The hydrogen concentration in the STS Cask headspace after 24 hr is less than 25 percent of the LFL such that, if required, the STS Cask Lid can be safely removed and corrective actions taken.]</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Prevent a hydrogen explosion in an STS Cask by verifying the STS Cask is properly pressurized thereby preventing oxygen ingress.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Protect initial conditions assumed in the thermal and gas analyses for transportation regarding the initial STS Cask pressure.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Prevent a hydrogen explosion in an STSC during long-term storage at T Plant by limiting the liquid level in an STSC.</td>
<td>STSC Final Liquid Level Limits</td>
</tr>
<tr>
<td>9</td>
<td>Prevent a hydrogen explosion in an STS Cask by verifying the cask leak rate is less than or equal to 9.0E-4 standard cm$^3$/s air.</td>
<td>STS Cask Leak Rate Limit</td>
</tr>
<tr>
<td>10</td>
<td>Prevent hydrogen explosion in an STSC by preventing an STS Cask Lid drop.</td>
<td>STS Cask Lid Critical Lift</td>
</tr>
<tr>
<td>11</td>
<td>Protect initial conditions assumed in staging and transportation analyses regarding STSC temperatures and pressures.</td>
<td>STS Cask Staging Limit</td>
</tr>
<tr>
<td>12</td>
<td>Prevent a hydrogen explosion by limiting the rate at which hydrogen would be released should an STS Cask need to be vented in the Sludge Loading Bay.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container</td>
<td>XAGO Pre-Operational Testing and Readiness Review Controls</td>
</tr>
</tbody>
</table>
Upon completion of sludge retrieval and transfer, the control strategy for the STSC and STS Cask is to prevent a hydrogen explosion by oxidant concentration reduction using nitrogen as the inerting agent. In accordance with NFPA 69, the oxygen concentration must be limited to less than 40 percent of the limiting oxidant concentration, because continuous monitoring will not be provided. As shown in NFPA 69, Table C-1, the limiting oxidant concentration for hydrogen gas in a mixture of nitrogen and air is 3 percent, thus the oxygen concentration must be less than 1.2 percent.

The STSC is inerted using the Inert Gas System, which is designed, operated, and maintained in accordance with NFPA 69 requirements for an explosion prevention system. Nitrogen from the system is flowed through the STSC to reduce the oxygen concentration to less than 0.5 percent as measured by safety-significant Oxygen Analyzer ECRT-CAB-601. Reducing the oxygen concentration to less than 0.5 percent protects against exceeding the NFPA 69 limit of 1.2 percent due to potential air in-leakage during STSC process disconnects.

A SAC requires operators to verify that the STSC has been properly inerted. In addition, there is a SAC to verify that both the Auxiliary Ventilation System and Inert Gas System nitrogen supply cylinders contain nitrogen versus a flammable gas or a gas that is an oxidizer (e.g., chlorine). During STSC inerting, the Auxiliary Ventilation System remains connected to the STSC and is operable. If an Inert Gas System failure occurred such that no nitrogen was being provided by the system to the STSC, the Auxiliary Ventilation System would provide a flow rate through the STSC sufficient to maintain the headspace less than 25 percent of the LFL. Therefore, the Inert Gas System is classified as general service.

After the STSC has been inerted and prior to completion of STS Cask inerting, the potential exists for air in-leakage into the STSC. To prevent significant in-leakage, the STSC boundary is credited. The boundary is composed of:

- The STSC
- The man-way flange on Nozzle F
- The cap on Nozzle F1
- The flange and associated Camlock fitting and cap on Nozzle S1
- The Overfill Recovery Tool on Nozzle D
- The radar level element/transmitter connected at Nozzle C
- LSH-740-402 connected at Nozzle E
- Self-sealing Stäubli® quick disconnects, Transport Vent Assembly check valves, and associated Camlocks connected at Nozzles S2 and F2
- Sludge and decant connector interface spool assemblies, leak detectors, and flush and drain lines connected at Nozzles A and B

PRC-STP-CN-M-00774, *Analysis of Oxygen Ingress into Inerted STSC Headspace*, shows that if the STSC is inerted to 0.5 vol% oxygen and the Transport Vent Assemblies are installed, then it

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18 Stäubli is a registered trademark of Stäubli International, Pfäffikon, Switzerland.
would take at least 18 days before the concentration of oxygen in the STSC reaches 1.2 vol% if the STS Cask Lid is not installed and the cask inerted.

Once an inert atmosphere is established in the STSC, the Inert Gas System and the Process/Exhaust Ventilation System are disconnected and Transport Vent Assemblies are placed on Nozzles F2 and S2. The STS Cask Lid is then lifted from its storage location using the overhead bridge crane and lowered onto the STS Cask. As identified in the What-if hazard analysis (PRC-STP-00697), if the STS Cask Lid were dropped, nozzles on the STSC could be damaged resulting in air ingress and a loss of the inert atmosphere. As a preventive control, a SAC is used to require the installation of the STS Cask Lid at the 105KW Annex to be performed as a critical lift meeting the requirements of DOE/RL-92-36, *Hanford Site Hoisting and Rigging Manual*, Chapter 3.0, “Critical, Special, and Engineered Lifts.”

Hydrogen generated within the STSC will periodically be released via the Transport Vent Assembly check valves and poses a hazard in the STS Cask once the lid is in place. The control strategy to prevent a hydrogen explosion in the STS Cask is to use the Inert Gas System to lower the oxygen concentration to less than 1.2 vol% in accordance with NFPA 69 requirements. If the STS Cask inerting flow path is not properly configured, it is possible for the Inert Gas System to pressurize the STS Cask thereby forcing air into the STSC via the Transport Vent Assemblies resulting in a loss of the previously-established inert atmosphere. A loss of the inert atmosphere in the STSC could result in the formation of a flammable concentration of hydrogen and a subsequent deflagration. To prevent this from occurring, the Conduct of Operations key attribute of the Operational Safety SMP is credited. This key attribute requires facility equipment and system status to be controlled to ensure that facility configuration is maintained in accordance with procedure requirements. Proper configuration of the STS Cask inerting flow path will be independently verified in accordance with PRC-STP-OP-40123, *Independent Verification*.

The STS Cask Inerting and Pressurization Limits SAC (see Section 4.5.11) is used to ensure the cask is inerted to less than 1.2 vol% and pressurized to between 3 and 15 psig within 24 hours of terminating the STSC nitrogen purge. Verification that the oxygen concentration is less than 1.2 vol% is performed by reading the concentration as indicated by safety-significant Oxygen Analyzer ECRT-CAB-601. The 24-hour time limit is based on calculations in PRC-STP-CN-N-00989, which show that the hydrogen concentration in the STS Cask headspace after 24 hours is less than 25 percent of the LFL such that the STS Cask Lid can be safely removed and corrective actions taken. The 24-hour time limit also effectively protects against the previously-discussed 18-day time period for STSC air inleakage.

Once an inert atmosphere is established in the STS Cask, it must be maintained until the cask is received at T Plant. Accordingly, the STS Cask pressure boundary is a safety-significant SSC. The pressure boundary includes the STS Cask, STS Cask Lid, STS Cask Lid metal O-ring seals, and port seals. In order to prevent air inleakage during transport, the Inert Gas System is used to pressurize the STS Cask between 3 psig and 15 psig, as discussed above, and the pressure boundary is leak tested. Proper pressurization is verified by the STS Cask Inerting and Pressurization Limits SAC using safety-significant pressure indicator ECRT-PI-760-606.

After the STS Cask has been pressurized, the cask leak rate is measured using the safety-significant STS Cask Leak Tester. The STS Cask Leak Rate SAC is used to verify that the leak rate is within the allowable limit of 9.0E-4 cm³/s air per CHPRC-03111, *One-Time Request for Shipment for Sludge Transport from K West Basin to T Plant*.
PRC-STP-CN-N-00989 calculates hydrogen generation rates and STS Cask pressures for various sludge loading scenarios and staging periods in the 105KW Annex to determine an allowable shipping window for shipment to T Plant. Staging periods of 1, 4, 10, and 30 days are analyzed assuming an initial pressure of 15 psig. For all staging periods, the maximum hydrogen generation rate and STS Cask pressure are such that the STS Cask can be safely processed at T Plant given a 5-day transportation time.

PRC-STP-CN-N-00989 also analyzes the venting of an STS Cask and STSC at the 105KW Annex. Such venting is not a part of normal operations but could be required if it were not possible to ship to T Plant. The analysis, which assumes the cask is vented using the STS Pressurization Check Tool after a 10-day staging period, shows that the cask is reduced from approximately 25 psig to atmospheric pressure in approximately 1 hour. During that time the hydrogen release rate varies from an initial value of 0.25 scfm to a final value of approximately 5E-3 scfm. The maximum release rate during venting is 0.5 scfm, which occurs after 0.45 hour. If the lid is removed after the STS Cask has been vented and purged, hydrogen will continue to be released from the STSC via the two Transport Vent Assemblies at a maximum rate of 3E-3 scfm. At this low release rate, the hydrogen does not pose an explosion hazard. Accordingly, the STS Staging Limit SAC requires venting the cask within 240 hours of completing STS Cask pressurization. This limit ensures that the STSC can be safely transported to and processed at T Plant, and ensures that the STS Cask can be safely vented in the Sludge Loading Bay if transport to T Plant is significantly delayed.

A hydrogen explosion in an STSC during long-term storage at T Plant is prevented, in part, by passive ventilation. At T Plant, a 2-ft vent pipe is installed on Nozzle F2, and Nozzle S2 is left open to the storage cell atmosphere. Given that the density of the gas in the STSC headspace is lower than the density of the air in the storage cell, the difference in elevation between the top of the vent pipe and Nozzle S2 establishes a passive ventilation flow rate through the STSC adequate to control the hydrogen hazard. Sludge expansion during long-term storage at T Plant has the potential to raise the supernate level in an STSC to the point it blocks the ventilation flow path at Nozzle S2. As documented in HNF-15280, *Technical Safety Requirements for the Solid Waste Operations Complex*, a TSR has been established at T Plant to limit the maximum STSC fill volumes. Compliance with these limits ensures that the level of supernate and expanded sludge is approximately 1.5 in. below the S2 vent. Therefore, a SAC has been selected to verify that STSCs comply with the T Plant TSR requirements prior to shipping.

As discussed in HNF-41051, the storage of sludge in an STSC over an extended period of time could potentially lead to the formation of a stable sludge plug. The STSC includes a safety-significant engineered, passive, preventive design feature that creates flow paths in a sludge plug to limit the volume of hydrogen in a vessel-spanning bubble. The design feature is a sloped fin attached to the inside of the STSC. The fin is 4 in. wide and extends out at the base of the STSC tapering 5 degrees from vertical until it meets the STSC sidewall. This design is based on testing documented in PNNL-19345, *The Disruption of Vessel-Spanning Bubbles with Sloped Fins in Flat-Bottom and 2:1 Elliptical-Bottom Vessels*. This design feature provides major defense-in-depth in preventing a flammable concentration within the STSC headspace during long-term storage at T Plant.
Crediting the above identified preventive controls, the frequency of an operational hydrogen explosion in an STSC or STS Cask that results in facility worker serious injury or death is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr).

3.4.2.3 Operational Accident–Process Enclosure Explosion

The various ECRTS process enclosures do not normally contain sludge; therefore, are not considered to have the potential to contain a flammable concentration of hydrogen. However, a release of slurry into the TLSB is possible for a primary containment piping failure within the TLSB during a slurry transfer. If spilled slurry is not removed in a timely manner and the normal TLSB ventilation is not maintained, hydrogen generation within the enclosure could result in the potential for the hydrogen concentration to reach levels that can support combustion.

Table 3-35 provides a summary of the operational process enclosure hydrogen explosion accident scenario, consequences, frequencies, and controls.
Failure of a transfer line results in a spill of slurry within the Transfer Line Service Box (TLSB) or In-Basin Shielded Hose Chase. Given a concurrent loss of ventilation, hydrogen gas generated by the slurry accumulates in the process enclosure headspace, reaches a flammable concentration, and ignites resulting in a hydrogen explosion.

Causes of transfer line failure include:
- Transfer line failure due to over-pressurization (e.g., pump over-speed, normally-open valve closed)
- Loss of integrity due to equipment failure (e.g., erosion/corrosion, manufacturing flaw) or operator error (e.g., failure to properly mate connectors)

Causes of loss of ventilation include:
- Loss of Process/Exhaust Ventilation due to equipment failure (e.g., fan failure, loss of power) or operator error (e.g., air inlet or outlet valve closed)

Lost pressure in the TLSB develops over time as follows:

- Time to stoichiometric concentration = 3.7 days

Failure of a transfer line results in a spill of slurry within the Decant Pump Box. Given a concurrent loss of ventilation, hydrogen gas generated by the slurry accumulates in the process enclosure headspace, reaches a flammable concentration, and ignites resulting in a hydrogen explosion.

Causes of transfer line failure include:
- Misdirected transfer into decant line due to valve failure or valve positioning error with subsequent over-pressurization
- Causes of loss of ventilation include:
  - Loss of Process/Exhaust Ventilation due to equipment failure (e.g., fan failure, loss of power) or operator error (e.g., air inlet or outlet valve closed)

Lost pressure in the TLSB develops over time as follows:

- Time to stoichiometric concentration = 3.7 days

### Table 3-35. Operational Process Enclosure Hydrogen Explosion

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure of transfer line</td>
<td>Y (I) L (III) L (II)</td>
<td>Primary containment with leak detection</td>
<td>Procedures</td>
<td>EU Y L L (IV)</td>
<td>&quot;Yes&quot; facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/ confinement failure with facility worker nearby</td>
</tr>
<tr>
<td>Loss of integrity (equipment failure)</td>
<td>L (II)</td>
<td>TLSB active ventilation</td>
<td>Valve position indicators</td>
<td>None</td>
<td>The TLSB hydrogen explosion hazard develops over time as follows:</td>
</tr>
<tr>
<td>Causes of loss of ventilation</td>
<td>L (II)</td>
<td>TLSB active ventilation</td>
<td>Pressure instrumentation</td>
<td>None</td>
<td>- Time to LFL = 12 hr</td>
</tr>
<tr>
<td>Causes of loss of ventilation</td>
<td>L (II)</td>
<td>TLSB active ventilation</td>
<td>Pressure instrumentation</td>
<td>None</td>
<td>- Time to stoichiometric concentration = 3.7 days</td>
</tr>
<tr>
<td>Mislbed transfer into decant</td>
<td>Y (I) L (III) L (II)</td>
<td>Secondary containment with leak detection</td>
<td>Valve position indicators</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Mislbed transfer into decant</td>
<td>Y (I) L (III) L (II)</td>
<td>Secondary containment with leak detection</td>
<td>Valve position indicators</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Mislbed transfer into decant</td>
<td>Y (I) L (III) L (II)</td>
<td>Secondary containment with leak detection</td>
<td>Valve position indicators</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Mislbed transfer into decant</td>
<td>Y (I) L (III) L (II)</td>
<td>Secondary containment with leak detection</td>
<td>Valve position indicators</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Mislbed transfer into decant</td>
<td>Y (I) L (III) L (II)</td>
<td>Secondary containment with leak detection</td>
<td>Valve position indicators</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
### 3.4.2.3.1 Scenario Development–Hydrogen Explosion in a Process Enclosure

For a hydrogen explosion in a process enclosure to occur, two independent, concurrent failures must occur, i.e., a spill of slurry within the enclosure and a loss of ventilation. Therefore, the unmitigated frequency of an operational hydrogen explosion in a process enclosure is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E 2/yr).

Assumptions specific to the analysis of the hydrogen explosion are discussed in the following paragraphs.

**Process Enclosures:** Hydrogen deflagrations in the In-Basin/Horizontal Shielded Hose Chase, Decant Pump Box and Sand Filter Skid are bounded by the deflagration in the TLSB. Hydrogen generated from a spill in the In-Basin/Horizontal Shielded Hose Chase would migrate to the 105KW Annex Sludge Loading Bay via the opening at the end of the chase. In addition, the chase has been designed to drain back to a discharge point below the surface of the basin water with little sludge accumulation. The smaller sludge volume and headspace volume of the chase as compared to the TLSB justifies this bounding assumption for the leak. Therefore, the In-Basin/Horizontal Hose Chase was not evaluated for a time to flammable.

Table 3-36 provides the dimensions and volume of the evaluated process enclosures.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Sand Filter Skid&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Transfer Line Service Box&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Decant Pump Box&lt;sup&gt;c&lt;/sup&gt;</th>
<th>IWTS Filter Vessel&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Volume</td>
<td>m³</td>
<td>1.0</td>
<td>1.2</td>
<td>0.86</td>
<td>0.07</td>
</tr>
<tr>
<td>Headspace Volume</td>
<td>m³</td>
<td>9.9</td>
<td>3.12</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Uranium Metal Concentration&lt;sup&gt;e&lt;/sup&gt;</td>
<td>kg/m³</td>
<td>Negligible</td>
<td>163</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td>Time to Flammable&lt;sup&gt;f&lt;/sup&gt;</td>
<td>—</td>
<td>136 days</td>
<td>12.3 hr</td>
<td>102 days</td>
<td>234 days</td>
</tr>
</tbody>
</table>

Notes:
- a. H-1-92756, STP ECRTS Decant/Filter System Sand Filter Upper Frame WLD.
- d. HNF-1777, K West Basin Integrated Water Treatment System Annular Filter Vessel Accident Calculations and Derivation of Leak Path Factors.
- e. HNF-41051, Appendix D.
- f. PRC-STP-CN-N-00947.

Even though the Sand Filter Skid has a larger headspace volume, the TLSB consequences are bounding due to the difference in the radionuclide inventory between the transferred slurry and the decant liquid.

The analysis specifically addresses a condition in the TLSB with enough air and hydrogen to make the gas volume of the transfer box flammable. A hydrogen mixture is considered flammable with 4 percent hydrogen or greater and sufficient oxygen to support the combustion. For this evaluation, a stoichiometric mixture of hydrogen is assumed.
Table 3-36 shows that the slurries in the Decant Pump Box, ECRTS Sand Filter, and IWTS Filter Vessel contain no uranium metal. Without the uranium metal oxidation, the only source of hydrogen generation is radiolysis. With the low decay heat, the production rate of hydrogen by radiolysis has a lower hydrogen generation rate than the uranium oxidation reaction. In addition, the solid fractions of these slurries are significantly lower than the sludge retrieval and transfer slurry which is assumed to leak into the TLSB. Consequently, hydrogen deflagrations from the Decant Pump Box, Sand Filter Skid, and IWTS Filter Vessel represent a significantly lower hydrogen hazard than a release of sludge with uranium metal into the TLSB.

The rate of hydrogen generation from radiolysis is estimated in Appendix F of calculation PRC-STP-CN-N-00947. The times to LFL for the Decant Pump Box, Sand Filter Skid, and IWTS Filter Vessel are shown in Table 3-36.

Initial Pressure: The pressure in the process enclosures is 1 atm (14.7 psi).

Process enclosures have multiple flow paths to prevent a pressure increase (e.g., filtered vents, and multiple HIH connections). The addition of hydrogen is, therefore, assumed to displace the air with no loss of hydrogen.

Hydrogen-Air Mixture: The hydrogen-air mixture is assumed to have ideal stoichiometric proportions and to be ideally mixed.

This conservative assumption maximizes the energy release and peak pressure. The addition of hydrogen is, therefore, assumed to displace the air with no loss of hydrogen. It is assumed that hydrogen, although buoyant in air, is not preferentially vented out of the volumes.

Ignition Source: Ignition of the hydrogen is assumed to occur with the hydrogen in the TLSB with the hydrogen burning as a deflagration.

There are few ignition sources in the TLSB. However, because the minimum ignition energy for hydrogen is low, an ignition source with sufficient energy to ignite the hydrogen-air mixture is simply assumed to exist.

Given the geometry of the TLSB and the lack of unique or highly energetic ignition sources available, a detonation is not expected. Nevertheless, the consequence model was chosen to bound either deflagration or detonation from a radiological release perspective.

Process Enclosure Dimensions: The headspace and sludge volumes used in the analysis are derived from the dimensions and volumes of the TLSB and are shown in Table 3-36.

The headspace volume and the accumulated quantity of sludge are calculated from the dimensions of the TLSB (PRC-STP-CN-N-00947) and are shown in Table 3-36. The sludge height in the TLSB is based on the height of the centerline of the lowest HIH connection. Slurry spilled into the TLSB will drain from the outer region of the connected HIH, therefore limiting the height of slurry accumulated in the box. The slurry is assumed to collect and reach the as-settled sludge volume fraction of 45 percent.

Transfer Line Service Box Time to Flammable: For Settler Tank sludge from SCS-CON-230 at a temperature of 25°C, the time to reach the LFL (4 percent H₂ in air) in the headspace of the TLSB is approximately 12 hours. Assuming no operable ventilation for the TLSB, the ratio of
sludge volume to headspace volume can be used to estimate the minimum time for the headspace volume to become flammable.

For Settler Tank sludge from SCS-CON-230, the hydrogen generation rate at 25°C is approximately $8.7 \times 10^{-3}$ L of hydrogen per liter of SCS-CON-230 sludge per hour at standard temperature and pressure. For the TLSB headspace to reach 4 percent volume fraction of hydrogen therefore requires 12.3 hours for a leak volume of 1.2 m$^3$ of Settler Tank sludge with the TLSB headspace volume of 3.1 m$^3$.

$$Time\ to\ LFL = \frac{4\%}{\left(8.7 \times 10^{-3} \frac{L_{hydrogen}}{L_{sludge} \times hr}\right)} \times \frac{3.1\ m^3}{1.2\ m^3} \quad (Eq. \ 3-23)$$

$$= 12.3\ hr.$$

### 3.4.2.3.2 Source Term Analysis

The generation of the source term for the hydrogen explosion in the TLSB follows the same logic as described in a previous section for the hydrogen explosion in the STSC. With a TLSB gas volume of 3.1 m$^3$, a stoichiometric ratio of hydrogen and oxygen, a temperature of 15°C, and a humidity of 100 percent, the TLSB headspace could contain 38.6 moles of hydrogen. The temperature is associated with the 105KW Basin water temperature and is about 5 degrees lower than the 105KW Annex and ventilation system temperature. A lower temperature will increase the mass of hydrogen in the headspace.

$$n_{H_2} = \frac{[V_{H_2} \times P]}{[R_{gy} \times T]} = \frac{(3.1\ m^3 \times 29.2\ vol\%\ H_2) \times 1\ atm}{8.21\ \frac{atm\ m^3}{mole\ K} \times 288.15\ K} \quad (Eq. \ 3-24)$$

$$= 38.6\ moles\ of\ hydrogen.$$

The energy liberated by the complete combustion of 38.5 moles of hydrogen is 9328 kJ.

$$38.6\ moles\ of\ hydrogen \times 241.82\ kJ/mole = 9328\ kJ. \quad (Eq. \ 3-25)$$

With 100 percent efficiency and at a standard conversion of 4612 kJ per kg of TNT, this corresponds to a TNT equivalent mass of 2.0 kg.

$$TNT_{EQ} = 100\% \times 9328\ kJ \ / \ 4612\ kJ/kg\ of\ TNT \approx 2.0\ kg. \quad (Eq. \ 3-26)$$

The quantity of as-settled sludge at risk in the STSC is $7.2 \times 10^{-5}$ m$^3$.

$$Q_{vol}= (TNT_{EQ} \times RF) / \rho_{sludge} = (2.0\ kg \times 0.1) / 2800 \frac{kg}{m^3} \quad (Eq. \ 3-27)$$

$$= 7.2 \times 10^{-5} m^3$$
where:

\[ RF = 0.1. \]

The source term as mass of uranium at risk is 0.061 kg.

\[ Q_{con} = C_{U_{resp}} \times Q_{vol} = 840 \frac{kg}{m^3} \times 7.2 \times 10^{-5} m^3 = 0.061 \text{ kgU} \quad \text{(Eq. 3-28)} \]

where:

\[ C_{U_{resp}} = \text{total uranium density is sludge kg/m}^3 \]
\[ = 840 \text{ kg/m}^3 \text{ (Settler Tank sludge).} \]

3.4.2.3.3 Radiological Consequence Analysis–Hydrogen Explosion in a Process Enclosure

Dose consequences for each of the sludge types have been calculated in a similar manner in PRC-STP-CN-N-00947. The results for the bounding sludge from SCS-CON-230 are summarized in Table 3-37.

Table 3-37. Summary of Unmitigated Hydrogen Explosion Release in the Transfer Line Service Box

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Sludge Type by Engineered Container</th>
<th>Unmitigated rem (TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Worker*</td>
<td>SCS-CON-230</td>
<td>&lt; 10</td>
<td>Safety-significant controls not required to be considered (clearly &lt; 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>SCS-CON-230</td>
<td>2.4</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>SCS-CON-230</td>
<td>5.0E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.3.4 Comparison to Evaluation Guidelines–Hydrogen Explosion in a Process Enclosure

For all sludge types:

- The offsite public radiological consequence does not exceed the 5 rem evaluation criteria for the consideration of safety-class controls.
- The offsite public toxicological consequence does not exceed the AEGL-2/ERPG-2/TEEL-2 evaluation criteria for the consideration of safety-significant controls.
The collocated worker radiological dose consequence does not exceed the 100 rem evaluation criteria for safety-significant controls.

The collocated worker toxicological consequence does not exceed the AEGL-3/ERPG-3/TEEL-3 evaluation criteria for the consideration of safety-significant controls.

The facility worker radiological dose is clearly below 100 rem and thus does not require consideration of safety-significant controls.

The facility worker toxicological consequence is clearly below AEGL-3/ERPG-3/TEEL-3 and thus does not require consideration of safety-significant controls.

A hydrogen explosion in a process enclosure does not represent a significant radiological or hazardous material exposure of the facility worker. However, in an unmitigated scenario, an explosion has the potential to result in facility worker serious injury or death caused by either failure of the enclosure, or failure of connected piping, hoses, or instrumentation. Therefore, safety-significant controls are required to protect the facility worker.

3.4.2.3.5 Summary of Safety-Significant SSCs, SACs and TSR Controls—Hydrogen Explosion in a Process Enclosure

A hydrogen explosion in a process enclosure requires safety-significant controls because of the potential for facility worker serious injury or death. The safety SSCs selected to prevent operational hydrogen explosions are presented in Table 3-38.

Table 3-38. Hydrogen Explosion in a Process Enclosure Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
</table>
| 1        | Prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by maintaining integrity during slurry transfers. | Above-water slurry transfer lines:  
- Inner pipe–slurry transfer line Ingress/Egress Assembly  
- Inner hose–slurry transfer line HIH  
- Inner pipe–slurry transfer line coaxial connector  
- Slurry transfer line hard piping and hose within TLSB |
| 2        | Prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer. | Slurry transfer line rupture disk ECRT-PSE-101 |
| 3        | Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing slurry backflow during sludge retrieval and transfer. | Double-valve isolation:  
- ECRT-AOV-105 and ECRT-AOV-106 |
| 4        | Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer. | Handswitch ECRT-HS-123  
- Valve ECRT-SOV-123  
- Valve ECRT-AOV-123 |
A hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase could occur if slurry was spilled within either process enclosure. The control strategy to prevent slurry spills within process enclosures is to provide safety-significant, above-water slurry transfer lines. “Above-water slurry transfer lines” includes connections between lengths of hose and pipe including gaskets and fasteners, and any in-line equipment, such as isolation valves, pump housings, and instruments, that is part of the above-water slurry transfer line pressure boundary.

The above-water slurry transfer lines are protected from over-pressurization by a safety-significant rupture disk. The rupture disk is located underwater in the 105KW Basin such that no airborne release occurs should the rupture disk open.

A hydrogen explosion in the Decant Pump Box, Sand Filter Skid, or IWTS Filter Vessel is conceivable. However, there is no uranium metal associated with the material processed within these enclosures such that the only source of hydrogen production is radiolysis. Consequently the times to LFL are very long. As shown in Table 3-36 above, the times to LFL for the Decant Pump Box, Sand Filter Skid, and IWTS Filter Vessel are 102 days, 136 days, and 234 days, respectively. Based on these extremely long durations, no safety-significant controls are selected.

The TLSB and Decant Pump Box are interconnected via decant/flocculant recirculation line ECRT-H-209. Within the TLSB, this line is connected to a slurry transfer line. If slurry were to be misrouted into ECRT-H-209 during sludge retrieval and transfer, then a spill of slurry in the Decant Pump Box (and eventually into the Sand Filter Skid) could occur, potentially leading to a hydrogen explosion. To prevent slurry flow into the Decant Pump Box, safety-significant double-valve isolation, provided by valves ECRT-AOV-105 and ECRT-AOV-106, was selected as a control. Because these valves are controlled from a general service panel, a safety-significant, handswitch-controlled solenoid and associated AOV have been incorporated into the design to ensure that failure of a general service component cannot inadvertently open a safety-significant valve.

The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying proper system configuration (including handswitch position) prior to initiating a transfer.

Crediting the above identified preventive controls, the frequency of an operational hydrogen explosion in a process enclosure is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr).

**3.4.2.4 Operational Accident—STSC Over-Pressurization Release**

The hazard evaluated in this unmitigated accident specifically represents a high pressure venting from the STS Cask with an STS Cask Lid in place or from the STSC while the STS Cask Lid is not in place. Over-pressurization of an isolated STSC or closed up STS Cask can potentially occur due to excessive hydrogen generation from the uranium metal-water reaction in the sludge. Other potential causes of over-pressurization leading to a release from the STSC (e.g., over-pressurization due to high pressure nitrogen during inerting), were identified in the hazard analyses as standard industrial hazards.
The hazards from the over-pressurization due to excessive hydrogen buildup can be grouped as follows.

- **Over-pressurization in the STS Cask.** This event occurs if there is a hydrogen buildup in the STS Cask after it is closed up. Hydrogen generated in the STSC accumulates and simultaneously pressurizes both the STS Cask and STSC.

- **Over-pressurization in the STSC.** This event occurs if there is a hydrogen buildup in the headspace of the STSC while it is not vented to the STS Cask. Hydrogen accumulates in the STSC headspace volume and pressurizes the STSC.

The above events can occur after completion of sludge retrieval activities as the STSC and STS Cask are being prepared for shipment to T Plant. Since the radionuclide inventory for both events is contained within the STSC, the over-pressurization of the STS Cask is considered to be bounded by the STSC over-pressurization.

Table 3-39 provides a summary of the operational over-pressurization accident scenario, consequences, frequencies, and controls.

### 3.4.2.4.1 Scenario Development–STSC Over-Pressurization Release

The over-pressurization event is intended to be conservative and to represent the hazardous material release from any sudden venting of the STSC. The major phenomenon that can cause the high pressure is the uranium metal-water reaction that produces hydrogen gas. The hydrogen gas generation rate increases with increased sludge temperature. The thermal sources heating the sludge are the decay heat of radionuclides, hot ambient conditions exterior to the STSC and STS Cask, and the exothermic metal-water reaction.

An over-pressurization could occur during either sludge retrieval or STSC and STS Cask shipping preparation. During sludge retrieval, the scenario would entail isolation of the sludge retrieval and ventilation lines. During shipping preparation, the scenario would involve not installing the vent line filters.

In this analysis, closure of the STSC vent paths during processing is assumed with the buildup of hydrogen gas and a corresponding increase in STSC headspace pressure leading to an STSC component or weld failure. This failure causes the STSC headspace to vent rapidly (de-pressurization).

The unmitigated frequency of an over-pressurization accident involving an STSC or STS Cask is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E-2/yr). This estimate takes into account the long times required to exceed the pressure rating of the vessels as discussed in Section 3.4.2.4.5.
### Table 3-39. Operational Over-Pressurization Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Failure to vent STSC results in STSC over-pressurization due to hydrogen gas generated by the sludge. Causes include:  
- Failure to install, or properly install, both Transport Vent Assemblies  
- Failure of check valves on both Transport Vent Assemblies to open at prescribed cracking pressure  
- Both Transport Vent Assembly filters plug | U  Freq  Y  L  L  MOI  | Transport Vent Assemblies  
- Differential weight switch  
- STSC level indicator  
- Truck weight indicator  
- Overfill recovery tool  
- 105KW Basin Annex HEPA-filtered ventilation  
- Continuous air monitors | Administrative  
- Procedures  
- Training  
- Quality Assurance  
- Conduct of operations verifies proper system configuration  
- STSC sludge limit verification  
- Administrative control on shipping window | Preventive Engineered  
- STS Transport Vent Assemblies  
- STSC level indication instrumentation  
- Truck scale instrumentation  
- STS-CON-230 diverter plate Preventive Administrative  
- Sludge source verification  
- Sludge buoyant weight limit  
- STS Cask staging limit  
- Operational Safety SMP (Conduct of Operations) Mitigative Engineered  
- None Mitigative Administrative  
- None | EU  Freq  Y  L  L  MOI  | “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/containment failure with facility worker nearby.  
- There are two Transport Vent Assemblies; one installed on STSC nozzle F2, and one on nozzle S2. Each Transport Vent Assembly is capable of adequately venting the STSC  
- The over-pressurization hazard develops over a long period of time; after 40 days the pressure in the STSC is only 54 psig versus the STSC pressure rating of 150 psig  
- Level and weight instrumentation, sludge source verification and buoyant weight limits, and SCS-CON-230 diverter plate protect initial conditions assumed in thermal and gas analyses |
| Failure to transport STS Cask to T Plant results in STS Cask over-pressurization due to hydrogen gas generated by the sludge. Causes include:  
- Equipment failure at 105KW Annex (e.g., roll-up door fails to open) prevents transport  
- Severe weather (e.g., heavy snow) prevents transport  
- Equipment failure (e.g., crane failure) or operational upset at T Plant such that STS trailer cannot be received | U  Freq  Y  L  L  MOI  | Cask Vent Tool  
- STS Pressurization Check Tool  
- Differential weight switch  
- STSC level indicator  
- Truck weight indicator  
- Overfill recovery tool  
- 105KW Basin Annex HEPA-filtered ventilation  
- Continuous air monitors | Administrative  
- Procedures  
- Training  
- Quality Assurance  
- Conduct of operations verifies proper system configuration  
- STSC sludge limit verification  
- Administrative control on shipping window | Preventive Engineered  
- STS Cask Vent Tool  
- STS Pressurization Check Tool  
- STSC level indication instrumentation  
- Truck scale instrumentation  
- STS-CON-230 diverter plate Preventive Administrative  
- Sludge source verification  
- Sludge buoyant weight limit  
- STS Cask staging limit Mitigative Engineered  
- None Mitigative Administrative  
- None | EU  Freq  Y  L  L  MOI  | “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/containment failure with facility worker nearby.  
- The over-pressurization hazard develops over a long period of time; it takes approximately 70 days to reach the STS Cask design pressure of 80 psig  
- Level and weight instrumentation, sludge source verification and buoyant weight limits, and SCS-CON-230 protect initial conditions assumed in thermal and gas analyses |
3.4.2.4.2 Radiological Source Term–STSC Over-Pressurization Release

When the STSC vents at high pressure, some of the sludge is entrained by the flowing gas (water vapor and hydrogen) and is carried out of the STSC at the failure location. The slurry liquid surface and, to some degree, the contamination on the inner STSC headspace walls above the water level provide potential material that could be released during venting of the headspace.

**STSC Failure:** Failure of the STSC is assumed to occur in the upper region of the STSC.

A weld failure on the bottom or side of the STSC is bounded by a weld failure on top because the STSC is always inside the STS shipping cask when at the 105KW Basin. The annular gap between the STSC and STS Cask is 0.5 to 1 in. wide. All the penetrations of the STSC occur at the top. With the most likely point of failure at the penetration welds and the not the STSC vessel body, the top of the STSC is considered to be the most likely location for a failure. The consequences of a breach through the bottom or side of the STSC would be bounded by the release from the top because of the confining effect of the cask.

**Airborne Release Fraction and Respirable Fraction:** The values of 1.0E-3 and 0.4 are used for the ARF and RF, respectively.

ARF and RF values for containment failures above the liquid surface are identified in DOE-HDBK-3010-94, Section 3.2.2.3.2. The recommended bounding values are 1.0E-3 and 0.4 for the ARF and RF, respectively, for liquids with a density greater than 1200 kg/m$^3$ and pressure above 0.35 MPa$_g$ (greater than 50 psig and less than 500 psig). Since the STSC design pressure is 150 psig, STSC boundary failure is expected to be within the range of pressures. For the unmitigated analysis, the STSC is assumed to fail with the potential of causing facility worker serious injury or death.

**Radionuclide Inventory Distribution:** The total mass of uranium from the settled sludge is uniformly distributed throughout the operating slurry volume.

The maximum volume of supernate and sludge in an STSC is limited due to sludge expansion considerations during long-term storage at T Plant. As shown in Section 5.3.9 of PRC-STP-CN-N-00947, the bounding release is for an STSC with sludge from SCS-CON-220. The analysis assumes the entire inventory of solids in the sludge is uniformly distributed throughout the 3.1 m$^3$ in the STSC. In actuality, only a small fraction of the total inventory is at risk to any surface phenomena since sludge solids are known to settle to the bottom of the STSC.

The source term for the over-pressurization is derived from the volume of sludge in the STSC and the total uranium concentration. The uranium concentration in the STSC is equal to the uranium concentration of the settled sludge maximum multiplied by the settled sludge volume in the STSC divided by the STSC operating volume for the sludge type. For example, given an STSC containing 1.0 m$^3$ of SCS-CON-220 sludge, this leads to the following equation.
Q = Vol_{STSC-Plant} \times \frac{Vol_{sludge}}{Vol_{STSC-Plant}} \times C_{U,layered} \times DR \times ARF \times RF

= 3.1 \text{ m}^3 \times \frac{1.0 \text{ m}^3}{3.1 \text{ m}^3} \times 462 \frac{\text{kg U}}{\text{m}^3} \times 1.0 \times 1.0 \times 10^{-3} \times 0.4

= 1.0 \text{ m}^3 \times 462 \frac{\text{kg U}}{\text{m}^3} \times 1.0 \times 1.0 \times 10^{-3} \times 0.4

=0.185 \text{ kg U}

where:

Q = \text{Source term, kg U}
Vol_{STSC-Plant} = \text{STSC operating volume for storage at T Plant (3.1 m}^3, \text{Table 3-5)}
Vol_{sludge} = \text{STSC sludge volume (SCS-CON-220 sludge, PRC-STP-CN-N-00947)}
C_{U,layered} = 462 \frac{\text{kg U}}{\text{m}^3} (\text{Table 3-17})
DR = \text{Damage ratio (1.0)}
ARF = \text{Airborne release fraction (1 \times 10^{-3})}
RF = \text{Respirable fraction (0.4)}.

3.4.2.4.3 Radiological Consequences–STSC Over-Pressurization Release

Using the source term from the previous calculations, the radiological dose consequences received by onsite individuals (i.e., MOI at the Hanford Site boundary; or collocated worker at 100 m) is calculated using equations described in Equation 3-2 applied to the sludge from SCS-CON-220, as shown in the example that follows:

\[ D_{\text{onsite}} = Q \times X_{Q'} \times BR \times DCF \]

\[ = 0.185 \text{kg U} \times \left(3.5 \times 10^{-3} \frac{\text{S}}{\text{m}^3}\right) \times \left(3.35 \times 10^{-4} \frac{\text{m}^3}{\text{S}}\right) \times \left(3.29 \times 10^{-7} \frac{\text{rem}}{\text{kg U}}\right) \]

\[ = 7.1 \text{ rem} \]

where:

\[ D_{\text{onsite}} = \text{respirable fraction of uranium} \]
\[ DCF = \text{unit dose factor for collocated worker} \]
\[ BR = \text{breathing rate for collocated worker} \]
\[ X_{Q'} = \text{atmospheric dispersion factor for collocated worker}. \]
Dose consequences for each of the sludge types have been calculated in a similar manner in PRC-TP-CN-N-00947. The results for the bounding sludge from SCS-CON-220 are summarized in Table 3-40.

Table 3-40. Bounding Unmitigated Dose Consequences for Over-Pressurization Inside an STSC

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Sludge Type by Engineered Container</th>
<th>Unmitigated rem (TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Worker*</td>
<td>SCS-CON-220</td>
<td>&lt; 30</td>
<td>Safety-significant controls not required to be considered (clearly &lt; 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>SCS-CON-220</td>
<td>7.1</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>SCS-CON-220</td>
<td>3.9E-4</td>
<td>Safety-class controls not required/ considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.4.4 Comparison to Evaluation Guidelines–STSC Over-Pressurization Release

For all sludge types:

- The offsite public radiological consequence does not exceed the 5 rem evaluation criteria for the consideration of safety-class controls.
- The offsite public toxicological consequence does not exceed the AEGL-2/ERPG-2/TEEL-2 evaluation criteria for the consideration of safety-significant controls.
- The collocated worker radiological dose consequence does not exceed the 100 rem evaluation criteria for safety-significant controls.
- The collocated worker toxicological consequence does not exceed the AEGL-3/ERPG-3/TEEL-3 evaluation criteria for the consideration of safety-significant controls.
- The facility worker radiological dose is clearly below 100 rem and thus does not require consideration of safety-significant controls.
- The facility worker toxicological consequence does not exceed the AEGL-3/ERPG-3/TEEL-3 evaluation guideline for the consideration of safety-significant controls.

An STSC/STS Cask over-pressurization does not represent a significant radiological or hazardous material exposure to the facility worker. However, an over-pressurization event has the potential to result in facility worker serious injury or death caused by vessel fragmentation. Therefore, safety-significant controls are required to protect the facility worker.
3.4.2.4.5 Summary of Safety-Significant SSCs, SACs and TSR Controls—STSC Over-Pressurization Release

Over-pressurization of an STSC or STS Cask requires safety-significant controls due to the potential for facility worker serious injury or death. In both cases, the source of the pressurization is hydrogen gas generated by the sludge in the STSC.

To prevent air inleakage once it has been inerted, the STSC has been designed with self-sealing Stäubli quick disconnects at Purge Out/Transport Filter Nozzle F2 and Vent In & Purge Inlet/Transport Filter Nozzle S2. While these quick disconnects effectively prevent air inleakage, they also isolate the STSC if the Transport Vent Assemblies are not installed. If an STSC were to remain isolated for a long period of time, then it could over-pressurize.

The STSC has a pressure rating of 150 psig. As calculated in PRC-STP-CN-N-00819, Sludge Treatment Project – Engineered Container Retrieval and Transfer System Supplemental Thermal and Gas Calculations for Engineered Container SCS-CON-230 Settler Sludge, after 40 days the pressure in the STSC is only 54 psig for the bounding STSC sludge loading (i.e., 0.4 m$^3$ of Settler Tank sludge and 1.6 m$^3$ of KE sludge).

The STSCs are designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code (ASME BPVC). As allowed by subsection UG-140, “Over-pressure Protection by System Design,” protection is not provided by the installation of over-pressure protection during manufacturing, but instead is provided during operations following the completion of STSC inerting activities. Specifically, STSC Transport Vent Assemblies are installed on Nozzles F2 and S2 immediately following disconnect of STSC/STS purge gas outlet hose ECRT-H-659 and purge inlet hose ECRT-H-604. The assemblies are designed with check valves that open at a specific cracking pressure and vent the STSC through a HEPA filter. The assemblies are, therefore, classified as safety-significant. The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying installation of the Transport Vent Assemblies. This key attribute requires facility equipment and system status to be controlled to ensure that facility configuration is maintained in accordance with procedure requirements. Installation of the Transport Vent Assemblies will be independently verified in accordance with PRC-STP-OP-40123.

In preparation for shipment to T Plant, the STS Cask is inerted and pressurized to between 3 and 15 psig with nitrogen. If an STS Cask were to remain isolated, it could eventually over-pressurize.

The STS Cask has a pressure rating of 80 psig. As calculated in PRC-STP-CN-N-00819, it takes greater than 70 days to reach the STS Cask pressure rating for the bounding STSC sludge loading. The STS Cask Staging Limit SAC is used to ensure the STS Cask is vented prior to reaching 80 psig with an appropriate design margin. The STS Cask Vent Tool and STS Pressurization Check Tool that would be used to vent the cask are classified as safety-significant.

Similar to the hydrogen explosion hazard, controls on the quantity and composition of sludge in an STSC are required to protect analysis assumptions regarding the time to reach 150 and 80 psig, and to ensure proper design of the STSC Transport Vent Assemblies, STS Cask Vent Tool, and STS Pressurization Check Tool. These are protected by a combination of engineered controls and TSRs as indicated in the tables below.
Crediting the above identified preventive controls, the frequency of an operational STSC or STS Cask over-pressurization is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr).

The hazard analysis identified NPH initiators for STSC and STS Cask over-pressurization. For the over-pressurization accident, no NPH design criteria have been established for either the STS Cask Vent Tool or STS Pressurization Check Tool based on: (1) the unlikely frequency of NPH events, (2) the low number of STSCs loaded with sludge during the mission life of the facility (estimated to range from 18 to 25) such that there is a limited time-at-risk, and (3) the long time periods required to exceed the STSC and STS Cask design pressures.

The safety SSCs and TSRs selected to prevent STSC and STS Cask over-pressurization are presented in Table 3-41 and Table 3-42, respectively.

**Table 3-41. STSC and STS Cask Over-Pressurization Engineered Controls**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent STSC over-pressurization by venting pressure.</td>
<td>STSC Transport Vent Assembly</td>
</tr>
</tbody>
</table>
| 2        | Prevent STS Cask over-pressurization by venting pressure. | • STS Cask Vent Tool  
• STS Pressurization Check Tool |
| 3        | Protect initial conditions assumed in the STSC thermal and gas analyses regarding the quantity of sludge present in an STSC. | • STSC liquid level instrumentation  
• Truck Scale instrumentation  
[Note: STSC liquid level and truck scale instrumentation are support SSCs to the Sludge Buoyant Weight Limits SAC (see Table 3-42, Item 2)] |
| 4        | Protect initial conditions assumed in the safety basis analyses regarding the quantity of uranium metal in an STSC containing Settler Tank sludge. | SCS-CON-230 divider plate ECRT-ME-230 |

**Table 3-42. STSC and STS Cask Over-Pressurization Specific Administrative Controls**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent STS Cask over-pressurization by venting the cask.</td>
<td>STS Cask Staging Limit</td>
</tr>
</tbody>
</table>
| 2        | Protect initial conditions assumed in the STSC thermal and gas analyses regarding the type and quantity of sludge in an STSC. | Sludge Source Verification  
Sludge Buoyant Weight Limits |
3.4.2.5 Operational Accident—105KW Annex Fire

3.4.2.5.1 Scenario Development—105KW Annex Fire

Several fire scenarios were identified during the hazard analyses. In addition, HNF-SD-SNF-FHA-001 specifically analyzes a step-off pad fire, a process transfer line fire, an STS Trailer tire fire, a transient combustible fire, and a HEPA Filter Room fire.

The hazard analysis identified a fire in the 105KW Annex as an initiator for an uncontrolled release of slurry. Within the 105KW Annex Sludge Loading Bay, unshielded lengths of slurry transfer line run from the Horizontal Shielded Hose Chase to the TLSB, and from the TLSB to the STSC. Slurry transfer line hoses are made of ethylene propylene diene monomer. Direct flame impingement will cause the hose to burn, resulting in a splash and splatter or pool release, the consequences of which do not require safety-significant controls. However, a fire could initiate a slurry spray release if the fire occurred during sludge retrieval and transfer and resulted in structural damage to the 105KW Annex or Mezzanine that failed a slurry transfer line in a manner that resulted in a spray release (i.e., a small slit or hole) rather than a splash and splatter or pool release. This failure would have to occur during the approximate 10 to 15 minute duration associated with slurry transfers. Therefore, for an unmitigated scenario the frequency of a fire-initiated spray release is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr).

The hazard analysis also identified a fire in the 105KW Annex as an initiator for hydrogen explosion in an STSC or STS Cask. In contrast to a spray release, a fire does not necessarily need to result in structural damage to initiate a hydrogen explosion. A hydrogen explosion could occur if the fire resulted in a loss of ventilation to an STSC containing sludge (e.g., a fire in the Mechanical Equipment Room that damages the power distribution panel that supplies power to the Process/Exhaust Ventilation System fans), or damaged the STSC boundary or STS Cask pressure boundary resulting in a loss of the inert atmosphere once established. Therefore, for an unmitigated scenario the frequency of a fire-initiated hydrogen explosion is qualitatively estimated to be anticipated (i.e., greater than 1E-2/yr).

The hazard analysis did not identify fire-initiated hydrogen explosions in process enclosures because an enclosure would have to be damaged in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL would not be reached.

Facility fires initiated by lightning, vehicle impacts, and range fires are addressed in Section 3.4.2.9, “Natural Phenomenon—Lightning Strike,” Section 3.4.2.11, “External Events—Vehicle Impact,” and Section 3.4.2.12, “External Events—Range Fire.”

Table 3-43 provides a summary of the operational 105KW Annex fire accident scenario, consequences, frequencies, and controls.
### Table 3-43. Operational Fire Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release: A fire results in structural damage to the 105 KW Annex that impacts a transfer line during sludge retrieval and transfer resultin in a spray release. Causes include: • Ignition of transient combustible materials • Fuel spill within 105 KW Annex and subsequent ignition</td>
<td>EU (II)</td>
<td>Y</td>
<td>L (IV)</td>
<td>L (IV)</td>
</tr>
<tr>
<td>STSC Hydrogen Explosion: A fire results in a loss of Process/Exhaust Ventilation (e.g., loss of power, damage to exhaust fans) leading to the formation of a flammable concentration of hydrogen gas in the STSC that subsequently ignites resulting in an explosion. Causes include: • Ignition of transient combustible materials • Fuel spill within 105 KW Annex and subsequent ignition</td>
<td>A (VI)</td>
<td>Y</td>
<td>L (III)</td>
<td>L (III)</td>
</tr>
</tbody>
</table>
### Table 3-43. Operational Fire Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmit Freq</th>
<th>Unmit Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mit Freq</th>
<th>Mit Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSC/STS Cask Hydrogen Explosion: A fire damages the STSC boundary or STS Cask pressure boundary resulting in a loss of inert atmosphere leading to the formation of a flammable concentration of hydrogen gas that subsequently ignites resulting in an explosion</td>
<td>A</td>
<td>Y</td>
<td>L</td>
<td>(I)</td>
<td>E</td>
<td>(III)</td>
<td>Facility materials of construction, Fire-rated construction, Fire suppression system, Physical features to prevent tractor from entering Sludge Loading Bay, Procedures, Training, Quality Assurance Program, Limited combustible loading, Control of ignition sources, Hanford Fire Department Response, Emergency Preparedness Program, Preventive Engineered: 105KW Annex - Non-combustible construction - Truck stop/concrete platform, Trailer entrance ramp, Preventive Administrative: Combustible material control requirements, Fire Protection SMP, Mitigate Engineered: None, Mitigate Administrative: Emergency Preparedness SMP, “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confine failure with facility worker nearby, The STSC hydrogen explosion hazard depends on the headspace volume that varies during the sludge retrieval process: - Time to LFL minimum headspace volume = 4.4 hr - Time to stoichiometric concentration minimum headspace volume = 1.3 days - Time to LFL maximum headspace volume = 20 hr - Time to stoichiometric concentration maximum headspace volume = 6 days, The STS Cask hydrogen explosion hazard develops over time as follows: - Time to LFL = 3 days - Time to stoichiometric concentration &gt;30 days, The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.</td>
</tr>
</tbody>
</table>
3.4.2.5.2 Radiological Consequences–105KW Annex Fire

The bounding accidents associated with fire are the operational spray release and the hydrogen explosion. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.” The radiological dose consequences for these releases are provided in these sections, and are summarized in Table 3-44.

Table 3-44. Radiological Dose Consequences–Fire in the 105KW Annex

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spray due to Fire (ECRTS Spray Release, SCS-CON-230 Retrieval and Transfer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90 Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
<td></td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23 Safety-significant controls not required (&lt; 100 rem)</td>
<td></td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2 Safety-class controls not required/considered (&lt; 5 rem)</td>
<td></td>
</tr>
<tr>
<td><strong>Hydrogen Explosion due to Fire (Explosion in the STSC)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15 Safety-significant controls not required (clearly below 100 rem)</td>
<td></td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8 Safety-significant controls not required (&lt; 100 rem)</td>
<td></td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3 Safety-class controls not required/considered (&lt; 5 rem)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.5.3 Summary of Safety-Significant SSCS, SACs and TSR Controls–105KW Annex Fire

The safety SSCs and SACs selected to prevent operational fire-initiated spray releases and hydrogen explosions are presented in Table 3-45 and Table 3-46, respectively.

Table 3-45. Fire Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by maintaining structural integrity in a fire.</td>
<td>105KW Annex</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a fire-induced hydrogen explosion by maintaining structural integrity in a fire.</td>
<td>105KW Annex</td>
</tr>
</tbody>
</table>
| 3        | Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by preventing vehicle fuel spills from entering the 105KW Annex. | 105KW Annex  
  • Truck Stop/Concrete Platform  
  • Trailer Entrance Ramp |
Table 3-45. Fire Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Prevent a fire-induced hydrogen explosion by preventing vehicle fuel spills from entering the 105KW Annex.</td>
<td>105KW Annex&lt;br&gt;• Truck Stop/Concrete Platform&lt;br&gt;• Trailer Entrance Ramp</td>
</tr>
<tr>
<td>5</td>
<td>Prevent a fire-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inverting activities.</td>
<td>Auxiliary Ventilation System</td>
</tr>
</tbody>
</table>

Table 3-46. Fire Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a fire of sufficient size to initiate a spray release of slurry during sludge retrieval and transfer by controlling combustible materials.</td>
<td>Combustible Material Control Requirements</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a fire of sufficient size to initiate a hydrogen explosion by controlling combustible materials.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation Actuation Notification</td>
</tr>
<tr>
<td>4</td>
<td>Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.</td>
<td>Personnel Access Prohibition</td>
</tr>
</tbody>
</table>

For fire-initiated spray releases during sludge retrieval and transfer, the principal control strategy is to prevent the occurrence of a fire of sufficient magnitude to result in structural damage to the 105KW Annex. This is accomplished by: (1) establishing a SAC to control the quantity and location of combustible materials in the Sludge Loading Bay, (2) crediting the Fire Protection Program-mandated combustible material program in other areas of the 105KW Annex, and (3) crediting the control of hot work as a key element of the Fire Protection Program.

As a secondary control strategy, a 105KW Annex structure with noncombustible construction was selected as a safety-significant SSC. As discussed in HNF-SD-SNF-FHA-001, the 105KW Annex is classified as Type IIB in accordance with the International Building Code (IBC). By definition, this type of construction includes building elements of noncombustible construction.

The Mezzanine is located approximately 20 ft above the Sludge Loading Bay floor. The Mezzanine consists of steel grating and plate supported by I-beams. The I-beams are connected to the 105KW Annex walls at the 20-ft level using either embedded plates or pocket design. Analyses in HNF-SD-SNF-FHA-001 demonstrate that direct flame impingement of the Mezzanine does not occur for postulated fires occurring on the floor of the Sludge Loading Bay.
STS Trailer tongue, or the STSC work platform. To protect the Mezzanine from structurally endangering fires, the Combustible Material Control Requirements SAC will limit the quantity of transient combustibles in the Sludge Loading Bay to those analyzed in HNF-SD-SNF-FHA-001. HNF-SD-SNF-FHA-001 states that a process transfer line fire could result in localized exposure of a single structural column and the Mezzanine structural steel, but that such an exposure is not expected to result in collapse of any part of the structure because: (1) the structural steel is not of lightweight construction and, (2) the exposure area is small.

The 16 tires on the STS Trailer represent a quantity of combustible material that may be sufficient to result in facility structural damage if they were all ignited and burned. The most likely way to ignite all 16 trailer tires would be to engulf them in a gasoline or diesel fuel pool fire. Accordingly, safety-significant design features have been selected to prevent fuel pool fires within the 105KW Annex Sludge Loading Bay. First, a truck stop/concrete platform physically limits how far the STS Trailer can be backed into the Sludge Loading Bay. It is positioned such that the tractor fuel tanks are always located outside the 105KW Annex. Second, the trailer entrance ramp is sloped away from the 105KW Annex such that a fuel spill, if it occurred, would flow away from the facility. In addition, the Combustible Material Control Requirements SAC will require that no vehicles are parked adjacent to the 105KW Annex. HNF-SD-SNF-FHA-001 specifically analyzes a fire involving eight STS Trailer tires in the Sludge Loading Bay and concludes that it will not cause flashover or structural failure of unprotected structural steel.

The controls identified above for the prevention of fire-initiated spray releases, also function to prevent fire-initiated hydrogen explosions. In addition, the Auxiliary Ventilation System is credited with preventing hydrogen explosions for fires that result in a loss of STSC ventilation.

To provide an additional layer of defense-in-depth, the Personnel Access Prohibition SAC is credited for fire-initiated spray releases, and the Emergency Preparedness Program SMP is credited for fire-initiated hydrogen explosions. The Personnel Access Prohibition SAC prohibits personnel entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer. The Emergency Preparedness Program SMP requires the development of an emergency response procedure that will direct the Building Emergency Director to evaluate the potential for a post-fire hydrogen explosion and to restrict access to the Sludge Loading Bay until controls, if required, are implemented.

Crediting the above identified preventive controls, the frequency of an operational fire-initiated spray release is qualitatively estimated to be beyond extremely unlikely (i.e., below 1E-6/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

Crediting the above identified preventive controls, the frequency of an operational fire-initiated hydrogen explosion is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E-2/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

As discussed in Section 2.7.4.1, “Fire Sprinkler System,” an automatic sprinkler system is required for the 105KW Annex. Consideration was given to the selection of the sprinkler system.
as both a primary control and a secondary control. The sprinkler system was not selected as a safety-significant SSC for the following reasons:

- The Combustible Material Control Requirements SAC prevents a fire of sufficient magnitude to result in structural damage, whereas the automatic fire suppression system would have to activate to suppress such a fire in order to prevent structural damage.

- The noncombustible construction of the 105KW Annex provides a passive control, whereas the sprinkler system is an active control. The selection of a passive versus active control is consistent with the DOE-STD-3009-94 control selection order of preference.

- The frequency of a fire-induced spray release is extremely unlikely. As previously stated, the fire must result in damage that causes suspended equipment or structural members to fail and damage the slurry transfer line in a very specific manner (i.e., creating a small slit or hole), and this must occur in the 10- to 15-minute time period during which a slurry transfer is being performed. Based on nominal process flowsheet values (70 gal/min at 5 vol% solids), the total transfer time for retrieved slurry is approximately 9 hours.

Although the fire sprinkler system is classified as general service, it is compliant with applicable NFPA requirements and provides defense-in-depth against fire-initiated spray releases and hydrogen explosions.

3.4.2.6 Natural Phenomenon–Seismic Event

3.4.2.6.1 Scenario Development–Seismic Event

A seismic event has the potential to result in damage to any or all equipment associated with the ECRTS Process, including the 105KW Annex structure. Structural damage to the 105KW Annex could result in damage to any equipment located in or adjacent to the structure. If a seismic event occurred during sludge retrieval and transfer, then a transfer line could be damaged in a manner that resulted in spray release. In an unmitigated scenario, the damage could be caused by seismic-induced movement of the transfer line itself (e.g., differential movement of the hoses or piping which torques a coupling resulting in a spray release) or by structural failure of the 105KW Annex that results in impact forces sufficient to damage the hoses or piping.

For an unmitigated scenario, the frequency of a seismic-induced spray release during sludge retrieval and transfer is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr). Specifically, portions of the above-water slurry transfer lines are located within the 105KW Basin. The 105KW Basin superstructure meets PC-2 requirements for an existing facility, which is equal to a seismic event with a 1250-year return period (i.e., twice the annual probability of exceedance for a new facility per DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities). Using this annual probability of exceedance as a limiting value, and considering that the total slurry transfer time for the life of the facility is approximately 9 hours, the probability of a seismic-induced slurry spray release of any sludge type is on the order of 1.0E-6.

A seismic event could lead to a hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase if it occurred during sludge retrieval and transfer or overfill recovery activities, and
resulted in a spill of slurry inside the process enclosure. For an unmitigated scenario, hydrogen gas generated by the reaction between uranium metal and water in the slurry could reach a flammable concentration in the process enclosure headspace. The frequency of this event is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr) for the same reasons cited above.

A seismic event could also lead to a hydrogen explosion in the Decant Pump Box or Sand Filter Skid if it occurred during decanting or sand filter backwash operations. For an unmitigated scenario, hydrogen gas generated in the supernate/sand filter backwash via radiolysis could reach a flammable concentration in the process enclosure headspace. The frequency of this event is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr) based on seismic event with a 2500-year return period and a total supernate/sand filter backwash transfer time of approximately 50 hours.

A seismic event could lead to a hydrogen explosion in an STSC or STS Cask. If the seismic event damaged or otherwise resulted in a loss of operability of the Process/Exhaust Ventilation System, then a hydrogen explosion could occur in an STSC. If the seismic event damaged an STSC or STS Cask after inerting, then the inert atmosphere could be lost and a hydrogen explosion could occur. The unmitigated frequency of a seismic-induced hydrogen explosion in an STSC or STS Cask is qualitatively estimated to be unlikely (i.e., 1E-4 to 1E-2/yr) based on an annual probability of exceedance of 4E-4 for SDC-1 structures.

Table 3-47 provides a summary of the seismic event accident scenario, consequences, frequencies, and controls.

### 3.4.2.6.2 Radiological Source Term–Seismic Event

The bounding accidents associated with a seismic event are a seismic-induced spray release during sludge retrieval and transfer from SCS-CON-230, and a hydrogen explosion in an STSC. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.”

The divider plate in SCS-CON-230 could be dislodged in a seismic event. Therefore, in contrast to the operational spray release analyzed in Section 3.4.2.1, the seismic spray release is assumed to involve the entire mass of SCS-CON-230 Settler Tank sludge above the level of the container egg crate sections, plus one egg crate section (i.e., the section containing the XAGO). This results in a slurry transfer volume of 15.9 m³ (at 7.5 vol% solids) versus 6.7 m³ (at 7.5 vol% solids) for the operational spray release. This conservative assumption accounts for any seismic-induced movement of the sludge above the level of the egg crate sections towards the section containing the XAGO.

The source term and consequences of the seismic spray release increase proportionally with increased slurry transfer volume. For example, the Collocated Worker seismic spray release dose increases operational spray release dose by a factor of 2.4 (i.e., 15.9 m³/6.7 m³) from 23 to 56 rem, respectively.

Although the increased transfer volume results in increased radiological consequences, the toxicological consequences are the same as for the operational spray release. Toxicological consequences are based on a 15-minute time-weighted exposure versus an integrated exposure
over the duration of the release. Therefore, the larger MAR associated with the seismic versus
non-seismic initiated spray release does not increase the consequences.
### Table 3-47. Natural Phenomenon Hazard–Seismic Event Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Mit Freq</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Spray Release                     | EU Y (II) M (III) L (IV)               | • Procedures       | Preventive Engineered:  
• Seismic qualification of structures  
• Seismic qualification of transfer lines  
• Seismic shutdown switch  
• Pump operating timer  
|                                  |                                        | Administrative      | Preventive Engineered:  
• Seismic qualification of transfer lines  
• Seismic shutdown switch  
• Pump operating timer  
|                                  |                                        | Selected Controls   | Preventive Engineered:  
• Seismic shutdown switches  
• Safety Shutdown Interlock I-1  
|                                  |                                        |                     | Preventive Administrative:  
• None  
|                                  |                                        |                     | Mitigative Administrative:  
• None  
|                                  |                                        |                     | Emergency Preparedness SMP  
|                                  |                                        |                     |                                                            |
| Process Enclosure Hydrogen Explosion | EU Y (II) L (IV) L (IV)               | • Procedures       | Preventive Engineered:  
• Seismic qualification of structures  
• Seismic qualification of transfer lines  
• Seismic shutdown switch  
• Pump operating timer  
|                                  |                                        | Administrative      | Preventive Engineered:  
• Seismic qualification of transfer lines  
• Seismic shutdown switch  
• Pump operating timer  
|                                  |                                        | Selected Controls   | Preventive Engineered:  
• Seismic shutdown switches  
• Safety Shutdown Interlock I-1  
|                                  |                                        |                     | Preventive Administrative:  
• None  
|                                  |                                        |                     | Mitigative Administrative:  
• None  
|                                  |                                        |                     | Emergency Preparedness SMP  
|                                  |                                        |                     |                                                            |
|                                  |                                        |                     | “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment failure with facility worker nearby.  
|                                  |                                        |                     | EU unmitigated frequency based on a seismic event occurring concurrent with a spray release; based on process flow sheet values, the total slurry transfer time for the life of the facility is approximately 9 hr.  
|                                  |                                        |                     | A seismic event is a potential common-cause failure of both the transfer line and process enclosure ventilation.  
|                                  |                                        |                     | The TLSB hydrogen explosion hazard develops over time as follows:  
• Time to LFL = 12 hr  
• Time to stoichiometric concentration = 3.7 days  
|                                  |                                        |                     | The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.  

**Remarks:**
- EU: EU unmitigated frequency based on a seismic event occurring concurrent with a spray release, based on process flow sheet values, the total slurry transfer time for the life of the facility is approximately 9 hr.
- BEU: “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment failure with facility worker nearby.
## STSC Hydrogen Explosion

A seismic event occurs resulting in a loss of Process/Exhaust Ventilation (e.g., loss of power, damage to exhaust fans) leading to the formation of a flammable concentration of hydrogen gas in the STSC that subsequently ignites resulting in an explosion.

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>UniMit Frequencies</th>
<th>Candidates Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSC Hydrogen Explosion</td>
<td>U</td>
<td>Y</td>
<td>L</td>
</tr>
</tbody>
</table>

### Unmitigated Consequences and Risk Rank
- Loss of Process/Exhaust Ventilation System
- Seismic qualification of Auxiliary Ventilation System

### Candidate Controls
- Procedures
- Training
- Quality Assurance
- Emergency Response

### Selected Controls
- Preventive Engineered
  - Auxiliary Ventilation System
  - STSC Seismic Wedges
  - STS Trailer Seismic Dampener Shoes
- Preventive Administrative
  - Auxiliary Ventilation System actuation notification
- Mitigative Engineered
- Mitigative Administrative
  - Emergency Preparedness SMP

### Mitigated Consequences and Risk Rank
- EU
- N
- L
- L

### Remarks
- “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby.
- Upon loss of ventilation, STSC hydrogen explosion hazard develops over time and depends on the headspace volume that varies during the sludge retrieval process:
  - Time to LFL minimum headspace volume = 4.4 hr
  - Time to stoichiometric concentration minimum headspace volume = 1.3 days
  - Time to LFL maximum headspace volume = 20 hr
  - Time to stoichiometric concentration maximum headspace volume = 6 days
- The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.
Table 3-47. Natural Phenomenon Hazard–Seismic Event Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmit Freq</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitig Freq</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>STS/STS Cask Hydrogen Explosion</td>
<td>U</td>
<td>Y (I) L (III) L (III)</td>
<td>• Procedures</td>
<td>Professional</td>
<td>EU</td>
<td>N (IV) L (IV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Quality Assurance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Administrative control for installation of seismic wedges and dampener shoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Emergency Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmitigated</td>
<td></td>
<td></td>
<td>STS boundary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences and Risk Rank</td>
<td></td>
<td></td>
<td>STS Seismic Wedges</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>STS Cask pressure boundary</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>105KW Annex including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Mezzanine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Bridge crane and associated supports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Exhaust stack</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Fire protection sprinkler system supports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– HVAC duct supports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Cable tray supports</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– Hose cradles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– South tool tray</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmitigated</td>
<td></td>
<td></td>
<td>Operational Safety SMP (Conduct of Operations)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consequences and Risk Rank</td>
<td></td>
<td></td>
<td>Mitigative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mitigative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Emergency Preparedness SMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Upon completion of slurry transfers and after the STSC and STS Cask have been inerted, a seismic event occurs resulting in damage to either the STSC boundary or the STS Cask pressure boundary. Damage to the boundary results in a loss of inert atmosphere leading to the formation of a flammable concentration of hydrogen gas that subsequently ignites resulting in an explosion.

Upon loss of an inert atmosphere, the STSC hydrogen explosion hazard develops over time as follows:

- Time to LFL = 4.4 hr
- Time to stoichiometric concentration = 1.3 days

Upon loss of an inert atmosphere, the STS Cask hydrogen explosion hazard develops over time as follows:

- Time to LFL = 3 days
- Time to stoichiometric concentration > 30 days

The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.
The radiological dose consequences for the seismic-induced releases are summarized in Table 3-48.

Table 3-48. Radiological Dose Consequences—Seismic Event

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TET)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release due to Seismic Event (ECRTS Spray Release, SCS-CON-230 Retrieval and Transfer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker</td>
<td>&gt; 100 rem</td>
<td>Safety-significant controls required (clearly &gt; 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>56</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>1.2E-1</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td>Hydrogen Explosion due to Seismic Event (Explosion in the STSC)b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
a. Facility worker consequences are qualitatively estimated.
b. The consequences of a hydrogen explosion in an STSC bound the consequences of an explosion in a process enclosure.

3.4.2.6.3 Summary of Safety-Significant SSCs, SACs and TSR Controls—Seismic Event

A seismic-induced spray release during sludge retrieval and transfer results in a facility worker consequence that is clearly above 100 rem and clearly above a PAC-3 SOF of 1 and thus requires safety-significant controls. A seismic-initiated hydrogen explosion in an STSC, STS Cask, or process enclosure does not represent a significant radiological or hazardous material exposure to the facility worker. However, an explosion has the potential to result in facility worker serious injury or death. Therefore, safety-significant controls are required to protect the facility worker.

The safety SSCs and SACs selected to prevent seismic-induced slurry spray releases and hydrogen explosions are presented in Table 3-49 and Table 3-50, respectively.

Table 3-49. Seismic Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
<th>SDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a seismic-induced spray release of slurry by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.</td>
<td>• Seismic shutdown switches • Safety Shutdown Interlock I-1</td>
<td>SDC-2</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a seismic-induced hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.</td>
<td>• Seismic shutdown switches • Safety Shutdown Interlock I-1</td>
<td>SDC-1</td>
</tr>
</tbody>
</table>
### Table 3-49. Seismic Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
<th>SDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Prevent a seismic-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and STSC inerting activities.</td>
<td>Auxiliary Ventilation System</td>
<td>SDC-1</td>
</tr>
<tr>
<td>4</td>
<td>Prevent a hydrogen explosion by maintaining structural integrity during a seismic event following STSC inerting.</td>
<td>STSC boundary</td>
<td>SDC-1</td>
</tr>
<tr>
<td>5</td>
<td>Protect initial conditions assumed in the development of seismic response spectra for the top of the STSC.</td>
<td>STSC Seismic Wedges, STS Trailer Seismic Dampener Shoes</td>
<td>SDC-1</td>
</tr>
<tr>
<td>6</td>
<td>Prevent a hydrogen explosion by maintaining structural integrity during a seismic event following STS Cask inerting.</td>
<td>STS Cask pressure boundary</td>
<td>SDC-1</td>
</tr>
<tr>
<td>7</td>
<td>Prevent a hydrogen explosion by maintaining structural integrity during a seismic event thereby preventing damage to the safety-significant auxiliary ventilation, STSC Boundary, and STS Cask Pressure Boundary.</td>
<td>105KW Annex, 105KW Annex Mezzanine, Bridge crane and associated supports, 105KW Annex Exhaust Stack, Fire protection sprinkler system supports, HVAC duct supports, Cable tray supports, Hose cradles, South tool tray, Nitrogen cylinder storage awning</td>
<td>SDC-1</td>
</tr>
</tbody>
</table>

### Table 3-50. Seismic Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
</tbody>
</table>

The control strategy for seismic-induced slurry spray releases during sludge retrieval and transfer is a pair of seismic shutdown switches interlocked to remove power from Booster Pump ECRTP-101A/B via Safety Shutdown Interlock I-1. The seismic shutdown switches and Safety Shutdown Interlock I-1 are an engineered, active, preventive control for slurry spray releases.
The seismic shutdown switches and Interlock I-1 components will actuate Interlock I-1 within approximately 2 seconds of a switch setpoint being exceeded. Given the peristaltic design of the booster pumps, the slurry transfer stops very shortly after the removal of power. Testing performed in support of Integrated Process Optimization Demonstration (PRC-STP-TR-00903, Report for the Integrated Process Optimization Demonstration for the Sludge Treatment Project Engineered Container Retrieval and Transfer System) shows that the pump delivers approximately 2.5 rotations following de-energization, with an integrated flow during pump coast-down of approximately 6 gal. Subsequent failure of the transfer line, should it occur, would result in a spill of limited volume versus a spray release.

Referring to Table 3-23, “Guidance for Seismic Design Category Based on Unmitigated Consequences of SSC Failures in a Seismic Event,” because the collocated worker dose consequence for a spray release falls in the range of 5 to 100 rem, the seismic shutdown switches and associated interlock circuitry for removing power from Booster Pump ECRT-P-101A/B are required to meet, at a minimum, SDC-2 requirements. For conservatism, the seismic shutdown switches will activate Safety Shutdown Interlock I-1 at a ground motion less than 0.2 g, which is less than the SDC-1 peak acceleration value of 0.46 g. By terminating the transfer at this low ground motion, no spray release would occur if the transfer lines were to subsequently fail due to seismic forces.

Selecting seismic shutdown switches meeting SDC-2 requirements rather than selecting above-water slurry transfer lines designed to SDC-2 requirements varies from the DOE-STD-3009-94 order of preference for control selection in that passive SSCs are preferred over active SSCs. The seismic shutdown switches were selected taking into account the time-at-risk for a seismic-induced spray release during sludge retrieval and transfer. As discussed above in Section 3.4.2.6.1, the unmitigated frequency of a seismic-induced spray release is on the order of 1E-6 for the life of the facility. Given the very low probability of a seismic-induced spray release, the selection of an active versus a passive SSC is judged to be acceptable.

The seismic shutdown switches initiate Safety Shutdown Interlock I-1 located on Safety Control Panel ECRT-PNL-103, which is located inside the Fuel Transfer System (FTS) Annex. As discussed in PRC-STP-00454, Sludge Treatment Project Engineered Container Retrieval and Transfer System Seismic Interactions, there are no seismic interactions that could prevent Interlock I-1 from performing its safety function, with the possible exception of the 105-K West Reactor (105KW Reactor) Exhaust Stack.

The 105KW Reactor Exhaust Stack, located adjacent to the 105KW Basin, is 175 ft tall. As discussed in PRC-STP-00454, if the stack were to overturn in an earthquake, it could impact Safety Control Panel ECRT-PNL-103 given its location in the FTS Annex. Even if it did not directly impact the panel, the stack could impact a portion of the FTS Annex and potentially cause indirect damage to the panel.

As documented in WHC-SD-NR-DA-025, 105 K Stack Seismic Qualification Report, Final Report, Phase III, the 105KW Reactor Exhaust Stack will withstand a 2.0E-3 events/yr seismic event with a zero period acceleration of 0.2 g. As this is less than the SDC-1 peak acceleration of 0.46 g to which the 105KW Annex has been designed, it establishes the bounding setting for the seismic shutdown switches. Assuming the seismic shutdown switches and Safety Shutdown Interlock I-1 perform their safety functions, the slurry transfer would be stopped prior to stack
failure. Once Interlock I-1 is activated, Booster Pump ECRT-P-101A/B is de-energized and can only be restarted manually. Although Safety Control Panel ECRT-PNL-103 could conceivably be damaged, no additional protection against stack failure has been incorporated into the design given: (1) that the probability of a 2.0E-3/yr seismic event occurring coincident with SCS-CON-230 sludge retrieval and transfer is very low, and (2) that the stack must topple in a specific direction and impact the FTS Annex, which must in turn damage the panel in a manner that re-energizes Booster Pump ECRT-P-101A/B.

As previously discussed in 3.4.2.1.5, “Summary of Safety-Class and Safety-Significant SSCs, SACs and TSR Controls–Operational Spray Releases,” to mitigate potential worker exposure to radiological and toxicological hazards, including those associated with a spray release, the ECRTS has been designed for remote operation such that the 105KW Annex Sludge Loading Bay is normally unmanned during sludge retrieval and transfer, decant, ECRTS Sand Filter backwash, overfill recovery, and associated line-flush operations. The previously selected SAC to prohibit personnel entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer also provides major defense-in-depth by protecting facility workers from seismic-induced spray releases.

Crediting the above identified preventive controls, the frequency of a seismic-initiated spray release is qualitatively estimated to be beyond extremely unlikely (i.e., below 1E-6/yr).

Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

As previously stated, a hydrogen explosion in an STSC, STS Cask, or process enclosure does not represent a significant radiological or hazardous material exposure to the facility worker. However, an explosion has the potential to result in facility worker serious injury or death. Therefore, safety-significant controls are required to protect the facility worker.

During sludge retrieval activities, the control strategy for the STSC is to prevent a seismic-induced explosion by crediting the safety-significant Auxiliary Ventilation System with maintaining the hydrogen concentration in the STSC headspace below 25 percent of the LFL. Because a seismic-induced hydrogen explosion results in a collocated worker dose of less than 5 rem, the Auxiliary Ventilation System, including the flowpath into and out of the STSC, is required to meet SDC-1 requirements.

Upon completion of sludge retrieval activities, the control strategy for the STSC and STS Cask is to prevent a hydrogen explosion by: (1) using Oxygen Analyzer ECRT-CAB-601 to verify that the STSC and STS Cask are properly inerted, (2) crediting the STSC boundary and STS Cask Pressure Boundary with maintaining the inert atmosphere, and (3) using pressure indicator ECRT-PI-760-606 to verify that the STS Cask has been properly pressurized.

The Auxiliary Ventilation System remains connected to the STSC when it is being inerted, and would function in a seismic event to maintain the hydrogen concentration within the STSC headspace below 25 percent of the LFL. If the seismic event occurred during STS Cask inerting or pressurization activities, the STSC boundary would function to maintain an inert atmosphere in the STSC. Therefore, Oxygen Analyzer ECRT-CAB-601 and pressure indicator ECRT-PI-760-606 do not have a seismic-related safety function.
The model used to calculate the seismic response spectra assumes that the STSC and STS Cask move together as a single assembly. The STSC Seismic Wedges are devices designed to limit independent motion of the STSC and STS Cask. The STSC Seismic Wedges are therefore safety-significant devices required for meeting SDC-1 requirements for the STSC boundary. The model also assumes that STS Trailer Seismic Damper Shoes will be placed under each landing gear footing. They are credited with dampening the impact of the landing gear during seismic events. The STS Trailer Seismic Damper Shoes are, therefore, also safety-significant devices required for meeting SDC-1 requirements for the STSC boundary.

The following SSCs are classified as safety-significant due to the potential for their failure to prevent the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary from performing their safety functions given a seismic event:

- 105KW Annex
- 105KW Annex Mezzanine steel framing
- Bridge crane and associated supports
- 105KW Annex Exhaust Stack
- Fire protection sprinkler system supports
- HVAC duct supports
- Cable tray supports
- Hose cradles
- South Tool Tray
- Nitrogen cylinder storage awning

Crediting the above identified preventive controls, the frequency of a seismic-initiated hydrogen explosion in an STSC or STSC is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

For the TLSB and In-Basin/Horizontal Shielded Hose Chase, the control strategy is to prevent seismic-induced hydrogen explosions by minimizing the volume of slurry leaks within the enclosures. Identical to a seismic-induced spray release, the control strategy is to credit the seismic shutdown switches interlocked to remove power from Booster Pump ECRT-P-101A/B during sludge retrieval and transfer. By terminating the transfer, only a small volume of slurry would accumulate in the enclosures if the transfer lines were to subsequently fail due to seismic forces. Because the hydrogen explosion collocated worker dose consequence is less than 5 rem, the seismic shutdown switch and associated interlock circuitry for removing power from Booster Pump ECRT-P-101A/B would be required to meet, at a minimum, SDC-1 requirements. However, these same SSCs are required to meet SDC-2 requirements to prevent seismic-induced spray releases. To mitigate the consequences of an explosion were one to occur, the previously selected Emergency Preparedness Program SMP is credited as it provides major defense-in-depth by protecting facility workers.

Crediting the above identified preventive controls, the frequency of a seismic-initiated hydrogen explosion in the TLSB or In-Basin Horizontal Shielded Hose Chase is qualitatively estimated to
be beyond extremely unlikely (i.e., below 1E-6/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

For seismic-induced hydrogen deflagrations in the TLSB and In-Basin/Horizontal Shielded Hose Chase, Safety Shutdown Interlock I-1 is not credited with terminating the air supply to Overfill Recovery Pump ECRT-P-301. The ECRTS final design includes an overfill recovery capability in the event that a SAC-controlled STSC sludge loading limit is exceeded. The likelihood of a seismic event occurring coincident with recovering sludge from an overfilled STSC is qualitatively estimated to be sufficiently low that controls are not warranted.

As discussed in Section 3.4.2.3.5, “Summary of Safety-Class and Safety-Significant SSCs, SACs and TSR Controls—Hydrogen Explosion in a Process Enclosure,” no controls are selected for the Decant Pump Box and Sand Filter Skid based on the long times required to reach the LFL.

### 3.4.2.7 Natural Phenomenon—High Winds

#### 3.4.2.7.1 Scenario Development—High Winds

The impact of high winds, or a wind-driven missile, could cause damage to the 105KW Annex. Structural damage to the 105KW Annex could result in damage to any equipment located inside or adjacent to the structure from the impact of falling or flying debris.

If the high winds occurred during sludge retrieval and transfer, then a transfer line could be damaged in a manner that resulted in a spray release. For an unmitigated scenario, the frequency of a high wind-induced spray release during sludge retrieval and transfer is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr) based on a PC-2 wind annual probability of exceedance of 1E-2 and a total slurry transfer time for the life of the facility of approximately 9 hours.

High winds could initiate a hydrogen explosion in an STSC if sludge was present in the STSC and the high winds damaged the Process/Exhaust Ventilation System, resulted in a loss of power to the Process/Exhaust Ventilation System, or resulted in damage to the Inert Gas system during STSC/STS Cask inerting. A hydrogen explosion could also occur if structural damage from the high winds resulted in a loss of the inert atmosphere, once established, in an STSC or STS Cask. The unmitigated frequency of a high wind-induced hydrogen explosion in an STSC or STS Cask is qualitatively estimated to be unlikely (i.e., 1E-4 to 1E-2/yr) based on an annual probability of exceedance of 1E-2 for PC-2 structures.

The hazard analysis process did not identify wind-induced hydrogen explosions in process enclosures, because an enclosure would have to be damaged in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL could not be reached.

Table 3-51 provides a summary of the high wind accident scenario, consequences, frequencies, and controls.
### Table 3-51. Natural Phenomenon Hazard—High Wind Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Mitigative Administrative</th>
<th>Mitigative Engineered</th>
<th>Preventive Engineered</th>
<th>Preventive Administrative</th>
<th>Selected Controls</th>
<th>Other Candidate Controls</th>
<th>Candidate Controls</th>
<th>Mitigative Administrative</th>
<th>Mitigative Engineered</th>
<th>Preventive Engineered</th>
<th>Preventive Administrative</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STSC Hydrogen Explosion</strong></td>
<td>U (IV)</td>
<td>L (III)</td>
<td>L (III)</td>
<td>Procedures</td>
<td>105KW Annex designed for wind loads</td>
<td>Procedures</td>
<td>105KW Annex</td>
<td>Auxiliary Ventilation System</td>
<td>Emergency Preparedness SMP</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
</tr>
<tr>
<td><strong>STSC/STS Cask Hydrogen Explosion</strong></td>
<td>U (IV)</td>
<td>L (III)</td>
<td>L (III)</td>
<td>Procedures</td>
<td>105KW Annex designed for wind loads</td>
<td>Procedures</td>
<td>105KW Annex</td>
<td>Auxiliary Ventilation System</td>
<td>Emergency Preparedness SMP</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
</tr>
<tr>
<td><strong>Spray Release</strong></td>
<td>EU (IV)</td>
<td>L (IV)</td>
<td>L (IV)</td>
<td>Procedures</td>
<td>105KW Annex designed for wind loads</td>
<td>Procedures</td>
<td>105KW Annex</td>
<td>Auxiliary Ventilation System</td>
<td>Emergency Preparedness SMP</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
<td>Preventive Engineered</td>
<td>Preventive Administrative</td>
</tr>
</tbody>
</table>

**Unmitigated Scenario Description**
- **STSC Hydrogen Explosion**: High wind results in a loss of Process/Exhaust Ventilation (e.g., loss of power, structural damage to Mechanical Equipment Room/HEPA Filter Room) leading to the formation of a flammable concentration of hydrogen gas in the STSC that subsequently ignites resulting in an explosion.
- **STSC/STS Cask Hydrogen Explosion**: Upon completion of slurry transfer and after the STSC and STS Cask have been inerted, high wind results in structural damage to the 105KW Annex Sludge Loading Bay that in turn damages the STSC pressure boundary. Damage to the boundary results in a loss of inert atmosphere leading to the formation of a flammable concentration of hydrogen gas that subsequently ignites resulting in an explosion.
- **Spray Release**: High wind results in structural damage to the 105KW Annex Sludge Loading Bay or In-Basin Horizontal shielded hose chase that in turn damages a slurry transfer line supporting sludge retrieval and transfer resulting in a spray release.
3.4.2.7.2 Radiological Source Term–High Winds

The bounding accidents associated with high winds are the operational spray release and the hydrogen explosion. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.”

Analysis of the hydrogen explosion remains as presented in Section 3.4.2.2, since the hydrogen explosion is not coincident with impact to the Process/Exhaust Ventilation System, but rather occurs after significant delay. The analysis of the spray release is modified to provide a meteorology corresponding to high wind conditions. A reasonable approach to calculating the consequences of a wind-induced accident is to use the atmospheric dispersions associated with the higher wind speeds. The design-basis wind gust is 111 mph for PC-3. While a wind gust of this magnitude could be responsible for the damage to the facility, a lower sustained wind speed (60 mph) is assumed to calculate the atmospheric dispersion factor. Based on this wind speed and a Pasquill Stability Class D, revised atmospheric factors were calculated for this scenario, as shown in Table 3-52.

Table 3-52. Atmospheric Dispersion Factors ($\chi/Q'$) for the High Winds Spray Release

<table>
<thead>
<tr>
<th>Receptor</th>
<th>$\chi/Q'$ (Stability Class D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collocated Worker</td>
<td>2.77E-4</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>1.12E-7</td>
</tr>
</tbody>
</table>

The bounding accidents concluded to be initiated by high winds (i.e., spray release and hydrogen explosion) are summarized in Table 3-53.

Table 3-53. Radiological Dose Consequences–High Winds

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TE D)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release due to High Winds (ECRTS Spray Release, SCS-CON-230 Retrieval and Transfer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 5</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.2E-1</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>1.2E-4</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td>Hydrogen Explosion due to High Winds (STSC Hydrogen Explosion)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
</tbody>
</table>

3-109
Table 3-53. Radiological Dose Consequences–High Winds

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

### 3.4.2.7.3 Summary of Safety-Significant SSCs, SACs and TSR Controls–High Winds

The offsite public, collocated worker, and facility worker radiological and toxicological consequences of a high wind-induced spray release and hydrogen explosion are below guidelines for the selection safety SSCs and SACs. However, controls are required for a high wind-induced hydrogen explosion due to the potential for facility worker serious injury or death.

DOE-STD-3009-94 does not provide specific guidance that correlates design criteria for winds to unmitigated accident consequences. This issue has been addressed, in part, in Owendoff (2009). Specifically, Owendoff (2009) states that safety-significant SSCs credited in non-seismic NPH events that could result in a dose greater than or equal to 100 rem to the collocated worker are to be designed to PC-3. This approach provides a similar level of protection for both seismic and non-seismic NPH events. The collocated worker radiological consequence resulting from a high wind-induced hydrogen explosion is significantly below 100 rem. Therefore, credited SSCs are designed to PC-2 wind loads in accordance with PRC-PRO-EN-097, *Engineering Design and Evaluation (Natural Phenomena Hazard)*.

Table 3-54 and Table 3-55 present the credited controls.

Table 3-54. High Wind-Initiated Hydrogen Explosion Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSC</th>
<th>Wind Design Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a wind-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Auxiliary Ventilation System</td>
<td>PC-2</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a wind induced-induced hydrogen explosion in the STSC or STS Cask by withstanding applicable wind loads thereby preventing damage to the Auxiliary Ventilation System, STSC boundary, and STS Cask Pressure Boundary.</td>
<td>105KW Annex</td>
<td>PC-2</td>
</tr>
</tbody>
</table>
Table 3-55. High Wind-Initiated Hydrogen Explosion Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
</tbody>
</table>

During sludge retrieval and transfer, the control strategy for the STSC is to prevent a high wind-induced explosion by crediting the safety-significant Auxiliary Ventilation System with maintaining the hydrogen concentration in the STSC headspace below 25 percent of the LFL. Therefore, the Auxiliary Ventilation System must be designed to perform its safety function during and after a high wind event. Accordingly, vulnerable portions of the system (i.e., those outdoor components of the system exposed to wind loads), must be designed to PC-2 requirements.

Upon completion of sludge retrieval activities, the control strategy for the STSC and STS Cask is to prevent a hydrogen explosion by using Oxygen Analyzer ECRT-CAB-601 to verify that the STSC and STS Cask are properly inerted, and by using pressure indicator ECRT-PI-760-606 to verify that the STS Cask has been properly pressurized. The Auxiliary Ventilation System remains connected to the STSC when it is being inerted, and would function in high winds to maintain the hydrogen concentration within the STSC headspace below 25 percent of the LFL. If the high winds occurred during STS Cask inerting or pressurization activities, the STSC boundary would function to maintain an inert atmosphere in the STSC. Therefore, Oxygen Analyzer ECRT-CAB-601 and pressure indicator ECRT-PI-760-606 do not have a high wind-related event safety function.

The 105KW Annex is classified as safety-significant and is designed to PC-2 wind loads due to the potential interaction with the Auxiliary Ventilation System, the STSC boundary (after inerting) and the STS Cask Pressure Boundary (after inerting).

In addition, the previously selected Emergency Preparedness Program SMP is credited as it provides major defense-in-depth by protecting facility workers from a wind-induced hydrogen explosion.

Crediting the above identified preventive controls, the frequency of a high wind-initiated hydrogen explosion in an STSC or STSC is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

3.4.2.8 Natural Phenomenon–Snow and Ashfall

3.4.2.8.1 Scenario Development–Snow and Ashfall

Snow and ashfall loading could damage to the 105KW Annex, or damage equipment located outside the 105KW Annex. Structural damage to the 105KW Annex could result in damage to equipment located inside or adjacent to the structure from the impact of falling debris on components of the Transfer System, Process/Exhaust Ventilation System, or the Auxiliary Ventilation System.
Snow and ashfall were identified as an initiator for a slurry spray release during sludge retrieval and transfer. Snow and ashfall could initiate a slurry spray release if: (1) the snow and ashfall load was sufficiently high to damage facilities during sludge retrieval and transfer, and (2) it resulted in damage to the slurry transfer line that resulted in a spray release (i.e., a small slit or hole) versus a splash and splatter or pool release. For an unmitigated scenario wherein no credit is taken for safety features, the frequency of a snow and ashfall-induced spray release during sludge retrieval and transfer is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr) based on a PC-2 ashfall annual probability of exceedance of 5E-4/yr and a total slurry transfer time for the life of the facility of approximately 9 hours.

Snow and ashfall could also lead to a hydrogen explosion in an STSC if: (1) sludge was present in the STSC, and (2) the snow and ashfall damaged the Process/Exhaust Ventilation System or resulted in a loss of power to the Process/Exhaust Ventilation System. A hydrogen explosion could also occur if structural damage from the snow and ashfall resulted in a loss of the inert atmosphere in an STSC or STS Cask. For an unmitigated scenario wherein no credit is taken for safety features, the frequency of a snow and ashfall-induced hydrogen explosion is qualitatively estimated to be unlikely (i.e., 1E-4 to 1E-2/yr) based on a PC-2 ashfall annual probability of exceedance of 5E-4/yr.

The hazard analysis process did not identify snow or ashfall-induced hydrogen explosions in process enclosures because an enclosure would have to be damaged in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL could not be reached.

Table 3-56 provides a summary of the snow and ashfall accident scenario, consequences, frequencies, and controls.
### Table 3-56. Natural Phenomenon Hazard—Snow and Ashfall Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Snowfall</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Procedures</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
<tr>
<td><strong>STSC Boundary</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Auxiliary Ventilation System</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
<tr>
<td><strong>STSC/STS Cask</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Procedures</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
<tr>
<td><strong>STSC/STS Cask Boundary</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Procedures</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
<tr>
<td><strong>STSC/STS Cask Hydrogen Explosion</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Procedures</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
<tr>
<td><strong>STSC/STS Cask Boundary</strong></td>
<td>EU Y (II) L (III) L (IV)</td>
<td>105KW Annex designed for snow/ashfall loads</td>
<td>Procedures</td>
<td>Preventive Administrative</td>
<td>EU N (IV) L (IV) L (IV)</td>
</tr>
</tbody>
</table>

### Table 3-113

<table>
<thead>
<tr>
<th>Natural Phenomenon Hazard—Snow and Ashfall Summary</th>
<th>Time to LFL = 4.4 hr</th>
<th>Time to stoichiometric concentration minimum headspace volume = 3.3 days</th>
<th>Time to LFL minimum headspace volume = 20 hr</th>
<th>Time to stoichiometric concentration maximum headspace volume = 6 days</th>
<th>Time to stoichiometric concentration maximum headspace volume = 9 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upon loss of ventilation, STSC hydrogen explosion hazard develops over time and depends on the headspace volume that varies during the sludge retrieval process:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to LFL minimum headspace volume = 4.4 hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to stoichometric concentration minimum headspace volume = 3.3 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to LFL maximum headspace volume = 20 hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to stoichometric concentration maximum headspace volume = 6 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Yes&quot; facility worker unmitigated consequences based on serious injury or death resulting from fragmentation of process equipment or containment/confine failure with facility worker nearby</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The unlikely unmitigated frequency is based on the failure of the STSC boundary is extremely unlikely based on short time the STSC is at risk prior to the STS Cask lid being put in place and the cask inerted.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upon loss of an inert atmosphere, the STSC by hydrogen explosion hazard develops over time as follows:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to LFL = 4.4 hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to stoichometric concentration = 1.3 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upon loss of an inert atmosphere, the STS Cask by hydrogen explosion hazard develops over time as follows:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to LFL = 3 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Time to stoichometric concentration &gt;30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.8.2 Radiological Source Term–Snow or Ashfall

The bounding accidents associated with snow or ashfall are the operational spray release and the hydrogen explosion. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.” The radiological dose consequences for these releases are provided in these sections, and the radiological dose consequences are summarized in Table 3-57.

### Table 3-57. Radiological Dose Consequences–Snow or Ashfall

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TID)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spray Release due to Snow or Ashfall Event (SCS-CON-230 Retrieval and Transfer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td><strong>Hydrogen Explosion due to Snow or Ashfall (Explosion in the STSC)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.8.3 Design Requirements–Snow or Ashfall

In accordance with Owendoff (2009), PC-3 design requirements are not applicable because the collocated worker radiological dose consequences is less than 100 rem. The control selection discussed in the following section identifies the 105KW Annex structure as a safety-significant SSC designed to PC-2 snow and ashfall loadings.

3.4.2.8.4 Summary of Safety-Significant SSCs, SACs and TSR Controls–Snow and Ashfall

As was the case for operational spray releases, the ECRTS Subproject has determined that safety-significant controls are warranted for facility worker protection for spray release scenarios caused a snow and ashfall event.

A snow and ashfall-induced hydrogen explosion in an STSC, STS Cask, or process enclosure does not represent a significant radiological or hazardous material exposure to the facility worker. However, an explosion has the potential to result in facility worker serious injury or death. Therefore, safety-significant controls are required to protect the facility worker.

The controls selected for the prevention and mitigation of snow and ashfall-induced spray releases and hydrogen explosions are presented in Table 3-58 and Table 3-59.
Table 3-58. Snow and Ashfall Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
<th>Snow and Ashfall Design Criteria</th>
</tr>
</thead>
</table>
| 1       | Prevent a spray release of slurry during sludge retrieval and transfer by maintaining structural integrity during a snow and ashfall event. | • 105KW Annex  
• Horizontal Shielded Hose Chase | PC-2                             |
| 2       | Prevent a snow and ashfall-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities. | Auxiliary Ventilation System | PC-2                             |
| 3       | Prevent a hydrogen explosion by maintaining structural integrity during a snow and ashfall event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC Boundary, and STS Cask Pressure Boundary. | 105KW Annex | PC-2                             |

Table 3-59. Snow and Ashfall Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
</tbody>
</table>

The control strategy for snow and ashfall induced slurry spray releases during sludge retrieval and transfer is to prevent structural damage to the 105KW Annex and Horizontal Shielded Hose Chase that could in turn damage slurry transfer lines. Because the collocated worker consequences of a spray release are less than 100 rem, the 105KW Annex and Horizontal Shielded Hose Chase are designed for PC-2 snow and ashfall load in accordance with PRC-PRO-EN-097.

In addition, the previously selected SAC to prohibit manned entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer also provides major defense-in-depth by protecting facility workers from snow and ashfall-induced spray releases.

Crediting the above identified preventive controls, the frequency of a snow and ashfall-initiated spray release is qualitatively estimated to be beyond extremely unlikely (i.e., below 1E-6/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

During sludge retrieval and transfer activities, the control strategy to prevent a snow and ashfall-induced hydrogen explosion in an STSC is to credit the safety-significant Auxiliary
Ventilation System with maintaining the hydrogen concentration in the STSC headspace below 25 percent of the LFL. Therefore, the Auxiliary Ventilation System must be designed to perform its safety function during and after a snow and ashfall event. Accordingly, vulnerable portions of the system (i.e., those components exposed to snow and ashfall loads) are designed to PC-2 snow and ashfall loads in accordance with PRC-PRO-EN-097.

Upon completion of sludge retrieval and transfer activities, the control strategy for both the STSC and STS Cask is to prevent a hydrogen explosion by using nitrogen to reduce the oxidant concentration. Oxygen Analyzer ECRT-CAB-601 is used to verify that the oxygen concentration in the STSC and STS Cask is less 1.2 vol% per NFPA 69, Annex C, “Limiting Oxidant Concentrations.” Therefore, ECRT-CAB-601 is classified as safety-significant. For the snow and ashfall event, the Auxiliary Ventilation System remains connected to the STSC while the STSC is being inerted to maintain the hydrogen concentration within the STSC headspace below 25 percent of the LFL. If the snow and ashfall event occurred during STS Cask inverting activities, the STSC boundary would function to maintain an inert atmosphere in the STSC.

Due to the potential interaction with the Auxiliary Ventilation System, the STSC boundary (after inverting) and the STS Cask Pressure Boundary (after inverting), the 105KW Annex is classified as safety-significant and is designed to PC-2 snow and ashfall loads in accordance with PRC-PRO-EN-097.

The previously selected Emergency Preparedness Program SMP is also credited as it provides major defense-in-depth by protecting facility workers from a snow and ashfall-induced hydrogen explosion.

Last, in addition to being designed to withstand ashfall loads, the design of active safety components required to operate during and after an ashfall event must account for suspended ash. Given the 2-hour time period between an eruption and the arrival of ash on the Hanford Site (see Chapter 1, Section 1.4.5, “Ashfall Loads,”) the only active safety system required to be operable is the Auxiliary Ventilation System. As discussed above, this system is credited with preventing hydrogen explosions during sludge retrieval and transfer activities, i.e., when a non-inerted STSC containing sludge is present in the 105KW Annex.

Crediting the above identified preventive controls, the frequency of a snow and ashfall-initiated hydrogen explosion in an STSC or STSC is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

### 3.4.2.9 Natural Phenomenon—Lightning Strike

#### 3.4.2.9.1 Scenario Development—Lightning Strike

The impact of a lightning strike could damage the 105KW Annex, equipment located outside the 105KW Annex, or equipment located inside the 105KW Annex. Heating or arcing associated with the uncontrolled discharge of electrical potential from a direct lightning strike can result in fire or significant localized structural damage (e.g., spalling of concrete).

Lightning was identified in the hazard analysis as an initiator for a slurry spray release. Lightning could initiate a spray release if a lightning strike on the building occurred during a slurry transfer and caused a fire that resulted in structural damage to the 105KW Annex that, in turn, failed the slurry transfer line in a manner that resulted in a spray release. For an unmitigated scenario the
frequency of a lightning-induced spray release during sludge retrieval and transfer is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr). Specifically, as documented in PRC-STP-CN-E-00655, *Lightning Risk Assessment for the KW Annex*, the lightning strike frequency for the 105KW Annex is 1.6E-3/yr. Based on the process flowsheet, the total transfer time for retrieved sludge is approximately 9 hours. Thus, the frequency of a lightning strike on the facility during a transfer is on the order of 1.6E-6/yr. Given this very low probability of a lightning strike during a transfer, and the likelihood that the lightning strike would cause a fire resulting in a spray release, no controls to prevent or mitigate a lightning-induced spray release are warranted.

Lightning was also identified in the hazard analysis as an initiator for a hydrogen explosion. A lightning strike could act as an ignition source for a hydrogen explosion if a flammable hydrogen concentration existed in the 105KW Annex at the time of the strike. However, safety-significant SSCs and SACs have been selected to prevent flammable concentrations. The coincident failure of the Process/Exhaust Ventilation System, failure of the safety SSCs and SACs, the formation of a flammable concentration, and a lightning strike is estimated to be beyond extremely unlikely (i.e., below 1E-6/yr).

Although a lightning strike on the 105KW Annex does not directly result in a hydrogen explosion, a hydrogen explosion could eventually occur if a lightning strike caused a loss of STSC ventilation. This could occur if the lightning resulted in a loss of power to the Process/Exhaust Ventilation System or if it caused a fire that damaged the ventilation system or damaged the 105KW Annex structure that, in turn, resulted in damage to the ventilation system. Lightning could also cause an explosion in an STSC or STS Cask if a fire directly or indirectly damaged components of the STSC boundary or STS Cask pressure boundary after inerting. For an unmitigated scenario the frequency of a lightning-induced hydrogen explosion is qualitatively estimated to be unlikely (i.e., 1E-4 to 1E-2/yr) based on a lightning strike frequency of 1.6E-3/yr.

A lightning strike could also occur when either an STSC or STS Cask was being purged with nitrogen. The strike could cause equipment damage that prevented establishing an inert atmosphere. The unmitigated frequency of this scenario is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr) based on a lightning strike occurring concurrently with STSC/STS Cask nitrogen purging activities.

The hazard analysis did not identify lightning-induced hydrogen explosions in process enclosures because an enclosure would have to be damaged (e.g., structural collapse due to lightning-induced fire) in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL could not be reached.

Table 3-60 provides a summary of the lightning strike accident scenario, consequences, frequencies, and controls.
STSC/STS Cask Hydrogen Explosion: A lightning strike initiates a fire that damages the STSC boundary or STS Cask pressure boundary resulting in a loss of inert atmosphere leading to the formation of a flammable concentration of hydrogen gas that subsequently ignites resulting in an explosion.

Causes include:
- Lightning strike results in loss of power
- Lightning strike initiates a fire that results in loss of power or damage to the Process/Exhaust Ventilation System

Unmitigated Consequences
- Fire suppression system
- Fire suppression system

Candidate Controls
- Procedures
- Training
- Quality Assurance Program
- Limited combustible loading
- Hanford Fire Department Response
- Emergency Preparedness Program

Selected Controls
- Prevention Engineered:
  - Auxiliary Ventilation System
  - J05KW Annex
    - Non-combustible construction
  - Preventive Administrative:
    - Auxiliary Ventilation System activation notification
    - Combustible material control requirements

Mitigated Consequences
- EU
  - N
  - L
  - L

Remarks
- “Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby
- The STSC hydrogen explosion hazard develops over time and depends on the headspace volume that varies during the sludge retrieval process:
  - Time to LFL minimum headspace volume = 4.4 hr
  - Time to stoichiometric concentration minimum headspace volume = 1.3 days
  - Time to LFL maximum headspace volume = 20 hr
  - Time to stoichiometric concentration maximum headspace volume = 6 days
- Because a lightning-initiated fire is a potential common-cause failure of both the Process/Exhaust Ventilation System and the Auxiliary Ventilation System, only be credited with performing a preventive safety function for localized fires that result in a loss of Process/Exhaust Ventilation service to the STSC
- The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.
**Table 3-60. Natural Phenomenon Hazard-Lightning Summary**

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmit Freq</th>
<th>Unmitigated Consequences</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mit Freq</th>
<th>Mitigated Consequences</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STSC/STS Cask Hydrogen Explosion:</strong> A lightning strike occurs during STSC or STS Cask inerting and prevents establishing an inert atmosphere leading to the formation of a flammable concentration of hydrogen gas that subsequently ignites resulting in an explosion. Causes include:</td>
<td>EU</td>
<td>Y (II)</td>
<td>L (IV)</td>
<td><strong>Preventive Engineered:</strong></td>
<td>BEU</td>
<td>N (IV)</td>
<td>L (IV)</td>
</tr>
<tr>
<td>- Lightning strike results in loss of power</td>
<td></td>
<td></td>
<td></td>
<td>- Lightning protection system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Lightning strike initiates a fire that results in loss of power or damage to the Inert Gas System or oxygen reduction system</td>
<td></td>
<td></td>
<td></td>
<td>- Auxiliary Ventilation System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Facility materials of construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Fire suppression system</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.9.2 Radiological Source Term–Lightning Strike

The bounding accidents associated with a lightning strike are the operational spray release and the hydrogen deflagration. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” for the spray release and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion,” for the hydrogen deflagration. The radiological dose consequences for these releases are provided in these sections, and are summarized in Table 3-61.

Table 3-61. Radiological Dose Consequences–Lightning

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spray Release due to a Lightning Strike (SCS-CON-230 Retrieval and Transfer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td><strong>Hydrogen Explosion due to a Lightning Strike (Explosion in the STSC)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.9.3 Summary Safety-Significant SSCs, SACs and TSR Controls–Lightning Strike

A hydrogen explosion in an STSC or STS Cask requires safety-significant controls because of the potential for facility worker serious injury or death. Table 3-62 and Table 3-63 present previously selected controls that function to prevent a lightning-initiated hydrogen explosion.

For lightning-initiated fires, the Combustible Material Control Requirements SAC, noncombustible construction of the 105KW Annex, and the Emergency Preparedness Program SMP are credited with preventing and mitigating hydrogen explosions. For a lightning-initiated loss of power, the Auxiliary Ventilation System is credited. The Auxiliary Ventilation System is fail-safe on loss of power and loss of signal. For the scenario wherein a lightning strike results in: (1) a loss of normal STSC process ventilation, and (2) inoperability of the Auxiliary Ventilation System, the Emergency Preparedness Program SMP is credited. For the potential hydrogen explosion in an STS Cask, the STS Cask Inerting and Pressurization Limit SAC is credited. This SAC establishes a time limit in which the cask must be inerted and pressurized and identifies required actions if inerting cannot be accomplished within the time limit.

Crediting the above identified preventive controls, the frequency of a lightning-initiated hydrogen explosion in an STSC or STS Cask during sludge retrieval and transfer or after inerting is qualitatively estimated to be extremely unlikely (i.e., 1E-6/yr to 1E-4/yr); and the frequency of a lightning-initiated hydrogen explosion during inerting is qualitatively estimated to be beyond extremely unlikely (i.e., below 1E-6/yr). The Emergency Preparedness Program SMP is
qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

Table 3-62. Lightning-Initiated Hydrogen Explosion Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a lightning-induced hydrogen explosion by maintaining structural integrity in a fire.</td>
<td>105KW Annex</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a lightning-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Auxiliary Ventilation System</td>
</tr>
</tbody>
</table>

Table 3-63. Lightning-Initiated Hydrogen Explosion Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a fire of sufficient size to initiate a hydrogen explosion by controlling combustible materials.</td>
<td>Combustible Material Control Requirements</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a hydrogen explosion in an STS Cask by verifying that an inert atmosphere has been established in the STS Cask headspace</td>
<td>STS Cask Inerting and Pressurization Limits</td>
</tr>
<tr>
<td>3</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
</tbody>
</table>

A Lightning Protection System was added to the 105KW Annex design after approval of the 105KW Annex final design. This general service system provides defense-in-depth for all lightning-initiated scenarios.

3.4.2.10 Natural Phenomenon–Low Temperatures

3.4.2.10.1 Scenario Development–Low Temperatures

The hazard analysis identified low ambient temperatures as an initiator for a slurry spray release. Specifically, low temperatures are postulated to freeze the basin water that remains in the slurry transfer lines after the performance of line flush as described in Section 2.5.2.8, “Transfer Line Flush.” When the next slurry transfer is initiated, Booster Pump ECRT-P-101A/B would deadhead against the frozen water such that the transfer line is over-pressurized and fails resulting in a spray release. Alternatively, freezing the transfer line could directly damage the line such that a spray release occurred when the liquids thawed and the line was subsequently pressurized for a transfer.

For an unmitigated scenario, the frequency of a low temperature-induced spray release is qualitatively estimated to be anticipated (i.e., greater than 1E-2/yr) based on 100K Area meteorological data.

Table 3-64 provides a summary of the low ambient temperature accident scenario, consequences, frequencies, and controls.
### Table 3-64. Natural Phenomenon Hazard–Low Ambient Temperature Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmit Freq</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mit Freq</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FW</td>
<td>CL</td>
<td>MOI</td>
<td>Engineered</td>
<td>Administrative</td>
<td></td>
</tr>
<tr>
<td>Low ambient temperatures result in freezing of residual flush water within a slurry transfer line that fails the line. A spray release occurs when the line is subsequently pressurized for a slurry transfer.</td>
<td>A</td>
<td>Y</td>
<td>L</td>
<td>L</td>
<td>Transfer line freeze protection</td>
<td>Procedures</td>
<td>Preventive Engineered: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Secondary confinement with leak detection</td>
<td>Training</td>
<td>Preventive Administrative: Initial Testing, In-Surveillance, and Maintenance SMP (Cold Weather Protection Program Plan)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Freeze damage-resistant of hose exhaust ventilation</td>
<td>Quality Assurance Program</td>
<td>Mitigative Engineered: None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Continuous air monitors</td>
<td>Administrative control to shut down transfers during extreme weather conditions</td>
<td>Mitigative Administrative: Personnel access prohibition</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105KW Annex HEPA-filtered exhaust ventilation</td>
<td>Maintenance Program cold weather protection plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105KW Annex unmanned during transfers</td>
<td>105KW Annex unmanned during transfers</td>
<td></td>
</tr>
</tbody>
</table>

*“Yes” facility worker unmitigated consequence based on radiological and toxicological consequences.*
3.4.2.10.2 Radiological Source Term–Low Temperatures

The bounding accident associated with low temperatures is the operational spray release. Analysis for this scenario, including estimated consequences to all receptors of concern, is presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases.” The radiological dose consequences for this release are also provided in Section 3.4.2.1, and are summarized in Table 3-65.

Table 3-65. Radiological Dose Consequences–Low Ambient Temperatures

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Radiological Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray Release due to Line Freezing (SCS-CON-230 Retrieval and Transfer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.10.3 Summary of Safety-Significant SSCs, SACs, and TSR Controls–Low Temperatures

Low ambient temperatures were identified as an initiator for a slurry spray release during sludge retrieval and transfer. The ECRTS Subproject has determined that TSR controls are warranted for facility worker protection for low-temperature-induced sludge retrieval and transfer spray release scenarios. The selected control is the Initial Testing, In-Service Surveillance, and Maintenance SMP. Specifically, a 105KW Facility Cold Weather Protection Program Plan has been developed in accordance with the requirements of PRC-PRO-MN-472, Cold Weather Protection. Plan elements include ensuring that:

- Heating systems in all facilities are cleaned, serviced, and functionally tested
- Operations or maintenance personnel have specific responsibility for monitoring the temperature in facilities, on and off shifts, including weekends and holidays
- Plans exist for alerting personnel and providing increased surveillance in periods of extreme, unusual, or extended cold
- Contingency plans are prepared and available for temporarily curtailing operations in those facilities likely to sustain freeze damage.

To provide an additional layer of defense-in-depth, the Personnel Access Prohibition SAC is credited.

Crediting the above identified preventive control, the frequency of a low ambient temperature-initiated spray release is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E-2/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and
toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

3.4.2.11 External Events–Vehicle Impact

3.4.2.11.1 Scenario Development–Vehicle Impact

Work activities in the vicinity of the 105KW Facility have the potential to require vehicle traffic adjacent to either the 105KW Basin or the 105KW Annex. A loading dock is located on the east side of the FTS Annex, adjacent to the Horizontal Shielded Hose Chase that contains the slurry transfer lines. Outdoor waste storage areas supporting 105KW Basin operations are located adjacent to the KW Loop Road. The equipment required to operate the 105KW Basin Ventilation System is located west of the 105KW Annex. Soil and groundwater remediation operations are scheduled and ongoing in areas adjacent to both the 105KW Annex and the 105KW Basin. Facility demolition activities have also been conducted adjacent to the 105KW Basin. While many potential work activities would involve primarily light-duty vehicles, loaded shuttle trucks used to transfer waste to the Environmental Restoration Disposal Facility could weigh over 40 tons.

A vehicle impact could result in damage to the 105KW Annex or damage to equipment located outside the 105KW Annex. Structural damage to the 105KW Annex, as could happen from the impact of a waste transport shuttle truck, could result in damage to equipment located inside or adjacent to the structure from the impact of falling debris on components of the Transfer System, Process/Exhaust Ventilation System, or Auxiliary Ventilation System. Vehicle impact also could result in fire outside the facility. In the bounding case, damage to the slurry transfer lines results in a spray release of slurry. Also, in the bounding case, damage or loss of operability of the Process/Exhaust Ventilation System results in a flammable concentration of hydrogen accumulating in the STSC, which could result in a hydrogen explosion.

The hazard analysis process did not identify vehicle impact-induced hydrogen explosions in process enclosures because an enclosure would have to be damaged in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL could not be reached.

For an unmitigated scenario, the frequency of a vehicle impact is qualitatively estimated to be anticipated (i.e., greater than 1E-2/yr) based on routine 100K Area traffic. Taking into consideration the specific damage required, the frequency of a vehicle impact-induced hydrogen explosion is qualitatively estimated to be unlikely (i.e., 1E-4 to 1E-2/yr). Taking into consideration the specific damage required and the total slurry transfer time of approximately 9 hours, the frequency of a vehicle impact-induced spray release is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr).

Table 3-66 provides a summary of the vehicle impact accident scenario, consequences, frequencies, and controls.
### Table 3-66. External Event–Vehicle Impact

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FW CL MOH</td>
<td>Engineered</td>
<td>Administrative</td>
<td>FW CL MOH</td>
<td></td>
</tr>
<tr>
<td>Spray Release: A vehicle impact to the 105KW Annex or horizontal shielded hose chase concurrent with sludge retrieval and transfer damages a slurry transfer line resulting in a spray release.</td>
<td>EU (I) Y L (IV) L (IV)</td>
<td>Vehicle barriers around structure</td>
<td>Procedures • Training • Quality Assurance • Administrative traffic restrictions • 105KW Annex unmanned during transfers Preventive Engineered: • None Preventive Administrative: • Vehicle access control Mitigative Engineered: • None Mitigative Administrative: • Personnel Access Prohibition</td>
<td>BEU (IV) N L (IV) L (IV)</td>
<td>“Yes” facility worker unmitigated consequence based on radiological and toxicological consequences.</td>
</tr>
<tr>
<td>STSC Hydrogen Explosion: A vehicle impact results in loss of power to the 105KW Annex. The associated loss of Process/Exhaust Ventilation System leads to the formation of a flammable concentration of hydrogen gas in the STSC that subsequently ignites resulting in an explosion.</td>
<td>U (I) Y L (III) L (III)</td>
<td>Vehicle barriers around structure • Auxiliary Ventilation System</td>
<td>Procedures • Training • Quality Assurance • Administrative traffic restrictions • Emergency Response Preventive Engineered: • Auxiliary Ventilation System Preventive Administrative: • Auxiliary Ventilation System • Emergency Preparedness SMP</td>
<td>EU (IV) N L (IV) L (IV)</td>
<td>“Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby. Upon loss of ventilation, STSC hydrogen explosion hazard develops over time and depends on the headspace volume that varies during the sludge retrieval process: – Time to LFL minimum headspace volume = 4.4 hr – Time to LFL minimum headspace volume = 1.3 days – Time to LFL maximum headspace volume = 20 hr – Time to LFL maximum headspace volume = 6 days. The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.</td>
</tr>
<tr>
<td>STSC Hydrogen Explosion: A vehicle impacts the sludge Loading Bay roll-up door and STS trailer resulting in a common-cause loss of both Process/Exhaust ventilation and auxiliary ventilation.</td>
<td>U (I) Y L (III) L (III)</td>
<td>Vehicle barriers around structure • Auxiliary Ventilation System</td>
<td>Procedures • Training • Quality Assurance • Administrative traffic restrictions • Emergency Response Preventive Engineered: • None Preventive Administrative: • None Mitigative Engineered: • None Mitigative Administrative: • Emergency Preparedness SMP</td>
<td>U (III) N L (III) L (III)</td>
<td>“Yes” facility worker unmitigated consequence based on serious injury or death resulting from fragmentation of process equipment or containment/confinement failure with facility worker nearby. Upon loss of ventilation, STSC hydrogen explosion hazard develops over time and depends on the headspace volume that varies during the sludge retrieval process: – Time to LFL minimum headspace volume = 4.4 hr – Time to LFL minimum headspace volume = 1.3 days – Time to LFL maximum headspace volume = 20 hr – Time to LFL maximum headspace volume = 6 days. The Emergency Preparedness SMP includes training and exercise requirements as specified in DOE/RL-94-02, Hanford Emergency Management Plan.</td>
</tr>
</tbody>
</table>
3.4.2.11.2 Radiological Source Term–Vehicle Impact

The bounding accidents associated with vehicle impacts are the operational spray release and the hydrogen explosion. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.” The radiological dose consequences for these releases are provided in these sections, and are summarized in Table 3-67.

**Table 3-67. Radiological Dose Consequences–Vehicle Impact**

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spray Release due to Vehicle Impact (SCS-CON-230 Retrieval and Transfer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td><strong>Hydrogen Explosion Caused by Vehicle Impact (Explosion in the STSC)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes.

*Facility worker consequences are qualitatively estimated.

3.4.2.11.3 Summary of Safety-Significant SSCs, SACs and TSR Controls–Vehicle Impact

Vehicle impacts to the 105KW Annex were identified as external events that could result in either a spray release or hydrogen explosion. As was the case for operational spray releases, the ECRTS Subproject has determined that safety-significant controls are warranted for facility worker protection for spray release scenarios caused by a vehicle impact based on the resultant radiological and toxicological consequences. The selected control for vehicle impact-initiated spray releases is a Vehicle Access Control SAC that will prohibit vehicular traffic in the vicinity of the 105KW Annex during sludge retrieval and transfers. To provide an additional layer of defense-in-depth, the Personnel Access Prohibition SAC is credited for vehicle impact-initiated spray releases.

Crediting the above-identified preventive control, the frequency of a vehicle impact-initiated spray release is qualitatively estimated to be Beyond Extremely Unlikely (i.e., below 1E-6/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

A hydrogen explosion requires safety-significant controls due to the potential for facility worker serious injury or death. In contrast to the short time-at-risk for spray releases, a hydrogen
explosion hazard exists whenever an STSC containing sludge is present in the Sludge Loading Bay such that it is not practical to prohibit vehicular traffic. Given the location of Process/Exhaust Ventilation System equipment relative to the road adjacent to the 105KW Annex, the most likely cause of vehicle impact-initiated loss of normal ventilation would be damage that resulted in a loss of power, e.g., a vehicle impact to Utility Transformer 300KVA (C7230P) located to the west of 105KW Annex. For such scenarios, the selected control is the Auxiliary Ventilation System. The nitrogen gas supply for the Auxiliary Ventilation System is located on the north side of the 105KW Annex adjacent to the road for ease of nitrogen Cylinder Cradle delivery. Accordingly, this portion of the system is protected from vehicle impacts by Jersey barriers.

Crediting the above-identified preventive controls, the frequency of a vehicle impact-initiated hydrogen explosion that results in facility worker serious injury or death is qualitatively estimated to be Extremely Unlikely (i.e., 1E-6 to 1E-4/yr). The Emergency Preparedness Program SMP is credited as a major contributor to defense-in-depth. This control is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

For the unlikely scenario wherein a vehicle impacts the Sludge Loading Bay roll-up door/STS Trailer causing damage to both the Process/Exhaust Ventilation System and Auxiliary Ventilation System connections to the STSC, the Emergency Preparedness Program SMP is credited. This control is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

The safety SSCs and SACs selected for control of vehicle impact-initiated accidents are summarized in Table 3-68 and Table 3-69.

### Table 3-68. Vehicle Impact-Initiated Hydrogen Explosion Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a vehicle-impact-initiated hydrogen explosion in an STSC by preventing</td>
<td>Auxiliary Ventilation System</td>
</tr>
<tr>
<td></td>
<td>flammable hydrogen concentrations during sludge retrieval and transfer and STSC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>inverting activities.</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3-69. Vehicle Impact Specific Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent the spray release of slurry during sludge retrieval and transfer by</td>
<td>Vehicle Access Control</td>
</tr>
<tr>
<td></td>
<td>prohibiting vehicular traffic in the vicinity of the 105KW Annex.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mitigate facility worker consequences in the event of a spray release by</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td></td>
<td>prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation</td>
<td>Auxiliary Ventilation System Actuation</td>
</tr>
<tr>
<td></td>
<td>System nitrogen supply.</td>
<td>Notification</td>
</tr>
</tbody>
</table>
3.4.2.12 External Events–Range Fire

3.4.2.12.1 Scenario Development–Range Fire

Range fires are an anticipated seasonal event and severe range fires have, over the years, burned hundreds of square miles on the Hanford Site. Range fires can move quickly and cause significant damage, particularly when driven by high winds.

A range fire could initiate a slurry spray release if the fire occurred during sludge retrieval and transfer and resulted in structural damage to the 105KW Annex or Mezzanine that failed a slurry transfer line in a manner that resulted in a spray release (i.e., a small slit or hole) rather than a splash and splatter or pool release. This failure would have to occur during the approximate 10 to 15 min duration associated with slurry transfers. Therefore, for an unmitigated scenario the frequency of a range fire-initiated spray release is qualitatively estimated to be extremely unlikely (i.e., 1E-6 to 1E-4/yr).

A range fire could also initiate a hydrogen explosion if it resulted in a loss of power or structural damage to the 105KW Annex that rendered the Process/Exhaust Ventilation System inoperative. For an unmitigated scenario, the frequency of a range-fire-initiated hydrogen explosion is qualitatively estimated to be anticipated (i.e., greater than 1E-2/yr) based on the anticipated frequency of Hanford Site range fires.

As was the case with lightning-induced fires, the hazard analysis process did not identify range fire-induced hydrogen explosions in process enclosures because an enclosure would have to be damaged in order for transfer lines located within to be subsequently damaged. Therefore, although a spill could occur, any hydrogen generated would be released into a very large volume such that the LFL could not be reached.

Table 3-70 provides a summary of the range fire accident scenario, consequences, frequencies, and controls.
Table 3-70. External Event—Range Fire Summary

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit Release</strong></td>
<td>EU</td>
<td>Fire</td>
<td>L</td>
<td>L</td>
<td>• Facility materials of construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fire-rated construction</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>• Fire suppression system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>STSC/STS Cask Hydrogen Explosion</strong></td>
<td>A</td>
<td>Fire</td>
<td>L</td>
<td>L</td>
<td>• Facility materials of construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fire-rated construction</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>• Fire suppression system</td>
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</tr>
</tbody>
</table>

- **Time to stoichiometric concentration**:
  - Maximum headspace volume:
    - Time to stoichiometric concentration maximum headspace volume = 20 hr
    - Time to stoichiometric concentration maximum headspace volume = 6 days
  - Minimum headspace volume:
    - Time to stoichiometric concentration minimum headspace volume = 4.4 hr
    - Time to stoichiometric concentration minimum headspace volume = 1.3 days

- **Time to LFL**:
  - Maximum headspace volume:
    - Time to LFL maximum headspace volume = 20 hr
  - Minimum headspace volume:
    - Time to LFL minimum headspace volume = 4.4 hr

- **Engineered**

<table>
<thead>
<tr>
<th>Unmitigated Scenario Description</th>
<th>Unmitigated Consequences and Risk Rank</th>
<th>Candidate Controls</th>
<th>Selected Controls</th>
<th>Mitigated Consequences and Risk Rank</th>
<th>Remarks</th>
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<tbody>
<tr>
<td><strong>Unit Release</strong></td>
<td>EU</td>
<td>Fire</td>
<td>L</td>
<td>L</td>
<td>• Facility materials of construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fire-rated construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fire suppression system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>STSC/STS Cask Hydrogen Explosion</strong></td>
<td>A</td>
<td>Fire</td>
<td>L</td>
<td>L</td>
<td>• Facility materials of construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fire-rated construction</td>
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<td>• Fire suppression system</td>
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</tbody>
</table>

- **Time to stoichiometric concentration**:
  - Maximum headspace volume:
    - Time to stoichiometric concentration maximum headspace volume = 20 hr
    - Time to stoichiometric concentration maximum headspace volume = 6 days
  - Minimum headspace volume:
    - Time to stoichiometric concentration minimum headspace volume = 4.4 hr
    - Time to stoichiometric concentration minimum headspace volume = 1.3 days

- **Time to LFL**:
  - Maximum headspace volume:
    - Time to LFL maximum headspace volume = 20 hr
  - Minimum headspace volume:
    - Time to LFL minimum headspace volume = 4.4 hr

- **Engineered**

7-129
3.4.2.12.2 Radiological Source Term–Range Fire

The bounding accidents associated with range fire are the operational spray release and the hydrogen explosion. Analyses for these scenarios, including estimated consequences to all receptors of concern, are presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” and in Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion.” The radiological dose consequences for these releases are provided in these sections, and are summarized in Table 3.71.

Table 3.71. Radiological Dose Consequences–Range Fire

<table>
<thead>
<tr>
<th>Receptor Location</th>
<th>Dose Consequence (rem TED)</th>
<th>Safety Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spray Release Caused by Range Fire (Retrieval and Transfer)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>70-90</td>
<td>Safety-significant controls to be considered (not clearly above/below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>23</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>4.8E-2</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
<tr>
<td><strong>Hydrogen Explosion Caused by Range Fire (Explosion in the STSC)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facility Worker*</td>
<td>&lt; 15</td>
<td>Safety-significant controls not required (clearly below 100 rem)</td>
</tr>
<tr>
<td>Collocated Worker</td>
<td>3.8</td>
<td>Safety-significant controls not required (&lt; 100 rem)</td>
</tr>
<tr>
<td>Offsite Public</td>
<td>7.9E-3</td>
<td>Safety-class controls not required/considered (&lt; 5 rem)</td>
</tr>
</tbody>
</table>

Notes:
*Facility worker consequences are qualitatively estimated.

3.4.2.12.3 Summary of Safety-Significant SSCs, SACs and TSR Controls–Range Fire

The following controls have been selected to prevent range fire-initiated spray releases and hydrogen explosions.

1. Combustible Material Control SAC. The Combustible Material Control SAC is used to limit the quantities of fixed and transient combustible materials external to the facility with the potential to be ignited by windblown firebrands and embers. The SAC includes the maintenance of a 30-ft defensible space; which is a requirement of 100K-PRO-FP-50757, Fire Protection Program. The 30-ft distance is consistent with NFPA 1144, Standard for Reducing Structural Ignition Hazards from Wildfire.

2. 105KW Annex constructed of noncombustible material. Noncombustible construction precludes ignition of the 105KW Annex structure by windblown firebrands and embers.

3. Auxiliary Ventilation System. The Auxiliary Ventilation System is credited with preventing hydrogen explosions for range fires that result in a loss of electrical power to the 105KW Annex (e.g., damage to substations or transmission systems).

To provide an additional layer of defense-in-depth, the Personnel Access Prohibition SAC is credited for fire-initiated spray releases, and the Emergency Preparedness Program SMP is credited for fire-initiated hydrogen explosions.
Crediting the above identified preventive controls, the frequency of a range fire-initiated spray release is qualitatively estimated to be beyond extremely unlikely (i.e., below 1E-6/yr). Crediting the Personnel Access Prohibition SAC, the facility worker radiological and toxicological consequences are qualitatively estimated to be clearly below 100 rem and a PAC-3 SOF of 1.

Crediting the above identified preventive controls, the frequency of a range fire-initiated hydrogen explosion is qualitatively estimated to be unlikely (i.e., 1E-4/yr to 1E-2/yr). The Emergency Preparedness Program SMP is qualitatively estimated to reduce consequences such that facility worker serious injury or death does not occur.

The SSCs and SACs selected for control of range fire-initiated accidents are summarized in Table 3-72 and Table 3-73.

### Table 3-72. Range Fire Engineered Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>Safety-Significant SSCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by maintaining structural integrity in a fire.</td>
<td>105KW Annex</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a fire-induced hydrogen explosion by maintaining structural integrity in a fire.</td>
<td>105KW Annex</td>
</tr>
<tr>
<td>3</td>
<td>Prevent a hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Auxiliary Ventilation System</td>
</tr>
</tbody>
</table>

### Table 3-73. Range Fire Administrative Controls

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Safety Function</th>
<th>SAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Prevent a fire of sufficient size to initiate a spray release of slurry during sludge retrieval and transfer by controlling combustible materials.</td>
<td>Combustible Material Control Requirements</td>
</tr>
<tr>
<td>2</td>
<td>Prevent a fire of sufficient size to initiate a hydrogen explosion by controlling combustible materials.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.</td>
<td>Personnel Access Prohibition</td>
</tr>
<tr>
<td>4</td>
<td>Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply.</td>
<td>Auxiliary Ventilation System Actuation Notification</td>
</tr>
</tbody>
</table>
3.4.2.13 Criticality

The hazards analysis, as documented in PRC-STP-00687, did not explicitly identify a nuclear criticality as a hazardous condition, but identified that the condition would need to be addressed. A criticality safety evaluation addressing the fissile material present in the 105KW Basin has been performed and is documented in CHPRC-02459, CSER 14-006: Criticality Safety Evaluation Report for Limited Fissile Material Operations at the K West Basin. Section 5.5 of CHPRC-02459 concludes that a criticality accident at the 105KW Facility is not credible. Section 6.0 of CHPRC-02459 states that no specific nuclear criticality safety limits or controls are required.” Additional information regarding the analyses documented in CHPRC-02459 is provided in Chapter 6.0, “Design for the Prevention of Inadvertent Criticality.”

3.4.3 Beyond Design Basis Accidents

As stated in DOE-STD-3009-94, “The rule requires consideration of the need for analysis of accidents which may be beyond the design basis of the facility to provide perspective of the residual risk associated with the operation of the facility.” Beyond design basis accidents (BDBAs) serve as the bases for cost-benefit considerations if consequences exceed the evaluation guidelines.

As discussed in the following paragraphs, considering the need for BDBA operational accidents and natural phenomena events, it has been determined that no BDBA analysis is needed (recognizing that, in accordance with DOE-STD-3009-94, BDBAs are not evaluated for man-made external events). Consequences associated with BDBAs are effectively bounded by the existing hazards analysis.

3.4.3.1 Operational Beyond Design Basis Accidents

As discussed in DOE-STD-3009-94, operational BDBAs are simply those operational accidents with more severe conditions or equipment failures than are estimated for the corresponding DBA. The unmitigated operational spray release, hydrogen explosion, over-pressurization, and fire DBAs were analyzed in accordance with DOE-STD-3009-94, Appendix A, “Evaluation Guidelines,” which stipulates that no predetermined frequency cutoff exists for excluding low-frequency operational accidents. Accordingly, the unmitigated analyses presented in Section 3.4.2.1, “Operational Accident–ECRTS Spray Releases,” Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion,” Section 3.4.2.3, “Operational Accident–Process Enclosure Explosion,” and Section 3.4.2.4, Operational Accident–105KW Annex Fire,” already assume severe conditions (e.g., safety-basis versus design-basis inventories, pressure in excess of pump capability, stoichiometric concentrations) and equipment failures (failure of process controls, failure of primary and secondary containment, failure of STSC ventilation). Therefore, there is no sharp increase in the accident consequences from the DBA to the BDBA and, thus, no sharp increase in residual risk.

3.4.3.2 Natural Phenomena Beyond Design Basis Accidents

As discussed in DOE-STD-3009-94, BDBA natural phenomenon events are defined by the initiating frequency of the event itself (i.e., frequency of occurrence less than the DBA frequency of occurrence). Thus a natural phenomenon BDBA involves a natural phenomenon force greater than the design basis of the facility.
The two dominant natural phenomena forces for the 105KW Basin and the 105KW Annex are seismic and high wind. The unmitigated seismic and high-wind analyses addressed in Section 3.4.2.6, “Natural Phenomenon–Seismic Event,” and Section 3.4.2.7, “Natural Phenomenon–High Winds,” assume worst case structural collapse (i.e., during a slurry transfer leading to spray release versus a splash and splatter release, and when sludge is present in an STSC leading to a hydrogen explosion). Therefore, there is no sharp increase in accident consequences from a natural phenomenon event of greater force; thus, no sharp increase in the residual risk.
Chapter 4.0

Safety Structures, Systems, and Components
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4.0 Safety Structures, Systems, and Components

4.1 Introduction

This chapter provides the safety functions, system descriptions, functional requirements, system evaluations, and controls for the safety-class and safety-significant structures, systems, and components (SSCs) that are necessary to ensure protection of the public, onsite workers, and the environment. Descriptions 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 (TSRs) are provided. The contents of this chapter include the following:

- Description of safety SSCs, including safety functions
- Identification of safety SSCs of the support systems that are relied on to carry out safety functions
- Identification of the functional requirements necessary for the safety SSCs to perform their safety functions and the general conditions caused by postulated accidents under which the safety SSCs must operate
- Identification of the performance criteria necessary to provide reasonable assurance that the functional requirements will be met
- Identification of analysis assumptions and other items that need TSR coverage

4.2 Requirements

The following codes, standards, U.S. Department of Energy (DOE) orders, and DOE guidance documents are applicable to this chapter.

- 10 CFR 830, “Nuclear Safety Management,” Subpart B
- DOE G 423.1-1A, Implementation Guide for Use in Developing Technical Safety Requirements
- DOE O 420.1B, Facility Safety
- DOE-STD-1066-99, Fire Protection Design Criteria

4.3 Safety-Class Systems, Structures, and Components

Guidelines for the safety classification of SSCs are established in DOE-STD-3009-94 and DOE-STD-1189-2008, Integration of Safety into the Design Process, as well as
HNF-34374, *Sludge Treatment Project Safety Design Strategy*. Safety-class controls are required where unmitigated accident consequences to the offsite public exceed 25 rem total effective dose (TED), and should be considered where unmitigated accident consequences result in radiological doses greater than or equal to 5 rem TED. As demonstrated in Chapter 3.0, unmitigated accident consequences do not challenge these criteria, therefore, no safety-class SSCs have been defined.

### 4.4 Safety-Significant Systems, Structures, and Components

The safety function, functional requirements, and performance criteria for safety-significant SSCs identified in Chapter 3.0 for the prevention and mitigation of accidents are described in the following sections. A summary list of the safety-significant SSCs is provided in Table 4-1. Safety-significant SSCs have been procured, inspected and accepted, and verified as Quality Level 2 items in accordance with the requirements of PRC-MP-QA-599, *Quality Assurance Program*.

The system descriptions provided in the following sections describe the boundaries and interface points with other SSCs. To aid in the understanding of the system, safety-significant components are shown in red on the simplified system drawings provided in this chapter.
### Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components

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<th>Safety-Significant SSC</th>
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<th>Safety Functions</th>
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<tbody>
<tr>
<td>Above-water Slurry Transfer Lines</td>
<td>Operational Accident–ECRTS Spray Releases (3.4.2.1) Operational Accident–Process Enclosure Explosion (3.4.2.3)</td>
<td>Prevent the spray release of slurry by maintaining integrity during sludge retrieval and transfer. Prevent a hydrogen explosion in the TLSB and the In-Basin/Horizontal Shielded Hose Chase by maintaining integrity during slurry transfers.</td>
<td>1. Above-water slurry transfer lines shall be designed to ensure their integrity at the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin.</td>
<td>The design pressure of the above-water slurry transfer lines shall be 220 psig</td>
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<td></td>
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<td>2. Above-water slurry transfer line isolation valves shall be provided with valve position indication.</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
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<td>3. Above-water slurry transfer lines shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry with an appropriate design margin.</td>
<td>3.1 Above-water slurry transfer lines (with the exception of the slurry HIH within the Horizontal Shielded Hose Chase) shall be designed to perform their safety function in the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand or be replaced, if necessary, for the broader range of temperatures specified for the project of -27° to 110°F.</td>
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<td>3.2 Slurry transfer line hose-in-hose within the Horizontal Shielded Hose Chase shall be designed to perform its safety function in the range of temperature of -27° to 110°F.</td>
<td>3.2 Slurry transfer line hose-in-hose within the Horizontal Shielded Hose Chase shall be designed to perform its safety function in the range of temperature of -27° to 110°F.</td>
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<td>3.3 Above-water slurry transfer lines shall be capable of withstanding a 50 mil loss of wall thickness loss due to corrosion and erosion without failure.</td>
<td>3.3 Above-water slurry transfer lines shall be capable of withstanding a radiation exposure of 1.1E+5 rad without failure.</td>
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<td>3.4 Above-water slurry transfer lines shall be capable of withstanding a radiation exposure of 1.1E+5 rad without failure.</td>
<td>3.4 Above-water slurry transfer lines shall be capable of withstanding a radiation exposure of 1.1E+5 rad without failure.</td>
</tr>
<tr>
<td>Slurry Transfer Line Rupture Disk</td>
<td>Operational Accident–ECRTS Spray Releases (3.4.2.1) Operational Accident–Process Enclosure Explosion (3.4.2.3)</td>
<td>Prevent the spray release of slurry by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer. Prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer.</td>
<td>1. Slurry transfer line rupture disk ECRT-PSE-101 shall have a nominal pressure rating no greater than the design pressure of the transfer line (i.e., 220 psig).</td>
<td>Rupture disk rating shall be 115 psig ± 5%.</td>
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<td>2. Slurry transfer line rupture disk ECRT-PSE-101 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry with an appropriate design margin.</td>
<td>Rupture disk must perform its safety function submerged in a nominal 15 ft of water.</td>
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<td>2.1 Rupture disk must perform its safety function submerged in a nominal 15 ft of water.</td>
<td>2.2 Rupture disk shall be oriented to limit the potential for accumulation of sludge that might impede performance of its safety function.</td>
</tr>
<tr>
<td>Safety- Significant SSC</td>
<td>Chapter 3 Accident Analysis Cross Reference (Section)</td>
<td>Safety Functions</td>
<td>Functional Requirements</td>
<td>Performance Criteria</td>
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</tr>
<tr>
<td>Double-Valve Isolation</td>
<td>Operational Accident - ECRTs Spray Releases (3.4.2.1)</td>
<td>Prevent the spray release of slurry by preventing backflow into the TLSB IXM water supply lines during sludge retrieval and transfer. [ECRT-AOV-104 and ECRT-CV-105, ECRT-AOV-302 and ECRT-AOV-103] Prevent the spray release of slurry by preventing backflow into overfill recovery line ECRT-SLU-300 during sludge retrieval and transfer. [ECRT-AOV-302 and ECRT-V-301] Prevent the spray release of slurry by preventing backflow into decant/boilant recirculation line ECRT-SUP-210 and hose ECRT-H-209 during sludge retrieval and transfer. [ECRT-AOV-105 and ECRT-AOV-106] Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing slurry backflow during sludge retrieval and transfer. [ECRT-AOV-105 and ECRT-AOV-106] Prevent a spray release of slurry by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer. [ECRT-HS-123, ECRT-SOV-123, and ECRT-AOV-123] Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer. [ECRT-HS-123, ECRT-SOV-123, and ECRT-AOV-123]</td>
<td>1. Valves ECRT-AOV-104, ECRT-CV-105, ECRT-AOV-302, and ECRT-AOV-103 shall prevent significant backflow of slurry into the TLSB IXM water supply line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin. 2. Valves ECRT-AOV-104, ECRT-CV-105, ECRT-AOV-302, and ECRT-AOV-103 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin. 3. Valves ECRT-AOV-104, ECRT-AOV-302, and ECRT-AOV-103 shall be provided with valve position indication. 4. Valves ECRT-AOV-302 and ECRT-V-301 shall prevent significant backflow of sludge into the overfill recovery line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101, with an appropriate design margin. 5. Valves ECRT-AOV-302 and ECRT-V-301 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin.</td>
<td>Valve seats (valve closed) shall be designed to prevent significant leakage (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig). 2.1 Valves shall be capable of performing their safety function over the range of temperatures expected in ECRTs interior spaces of 40°F to 100°F and to withstand the broader range of temperatures specified for the project of -27°C to 110°F (without slurry freezing). 2.2 With the exception of ECRT-CV-105 (which is not exposed to slurry), valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids. 2.3 Valve and check valve materials shall be capable of a total integrated dose of 1.1E+5 rad without failure.</td>
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</tbody>
</table>
### Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components

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<thead>
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<tbody>
<tr>
<td>Double-Valve Isolation (cont.)</td>
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<td>6. Valves ECRT-AOV-302 and ECRT-V-301 shall be provided with valve position indication.</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
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<td>7. Valves ECRT-AOV-105 and ECRT-AOV-106 shall prevent significant backflow of sludge into the decant/flocculant recirculation line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin.</td>
<td>Valve seats (valve closed) shall be designed to prevent significant leakage (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).</td>
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<td>8. Valves ECRT-AOV-105 and ECRT-AOV-106 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin.</td>
<td>Valves shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F (without slurry freezing).</td>
<td>8.1 Valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).</td>
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<td>9. Valves ECRT-AOV-105 and ECRT-AOV-106 shall be provided with valve position indication.</td>
<td>Valve materials shall be capable of a total integrated dose of $1.1 \times 10^5$ rad without failure.</td>
<td>8.2 Valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).</td>
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<td>10. Isolate the instrument air supply to safety-significant valves ECRT-AOV-103, -104, -105, -106, -113, and -302 during sludge retrieval and transfer.</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
<td>8.3 Valve materials shall be capable of a total integrated dose of $1.1 \times 10^5$ rad without failure.</td>
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<td>10.1 Safety-significant handswitch ECRT-HS-123 shall be mounted on the Safety Control Panel ECRT-PNL-103 and de-energize to isolate the instrument air supply to the solenoids (SOVs) for the specified valve air actuators (AOVs).</td>
<td>Safety-significant handswitch ECRT-HS-123 shall be mounted on the Safety Control Panel ECRT-PNL-103 and de-energize to isolate the instrument air supply to the solenoids (SOVs) for the specified valve air actuators (AOVs).</td>
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<td>10.2 Safety-significant solenoid ECRT-SOV-123 shall de-energize when handswitch ECRT-HS-123 is placed in the “disable” position and safety-significant instrument air valve ECRT-AOV-123 shall close and remain closed when solenoid ECRT-SOV-123 is de-energized.</td>
<td>Safety-significant solenoid ECRT-SOV-123 shall de-energize when handswitch ECRT-HS-123 is placed in the “disable” position and safety-significant instrument air valve ECRT-AOV-123 shall close and remain closed when solenoid ECRT-SOV-123 is de-energized.</td>
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<td>10.3 Closing ECRT-AOV-123 shall isolate and vent instrument air from the SOVs for the specified valves.</td>
<td>Closing ECRT-AOV-123 shall isolate and vent instrument air from the SOVs for the specified valves.</td>
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<td>10.4 Closed position indication for ECRT-AOV-123 shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
<td>Closed position indication for ECRT-AOV-123 shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
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<td>10.5 The three components above shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F.</td>
<td>The three components above shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F.</td>
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</table>
### Safety Significant SSC

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Seismic Shutdown Switches</td>
<td>Natural Phenomenon–Seismic Event (3.4.2.6)</td>
<td>Prevent a seismic-induced spray release of slurry by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion. Prevent a seismic-induced hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.</td>
<td>1. The seismic shutdown switches shall actuate Safety Shutdown Interlock I-1. Inputs from the two seismic shutdown switches shall each suffice to actuate Interlock I-1. 2. The seismic shutdown switches shall function to remove power to Booster Pump ECRT-P-101A/B before a seismic event reaches SDC-2 levels and shall not restart the pump during or after the event without manual intervention. Seismic shutdown switches shall be designed to SDC-2 requirements. 3. The seismic shutdown switches shall activate at less than an acceleration of 0.2g. 4. Seismic shutdown switches shall be fail-safe for more probable failure modes. 5. Seismic shutdown switches shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
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</tr>
<tr>
<td>Safety Shutdown Interlock I-1</td>
<td>Natural Phenomenon–Seismic Event (3.4.2.6)</td>
<td>Prevent a seismic-induced spray release of slurry by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.</td>
<td>1. Interlock I-1 shall remove power from Booster Pump ECRT-P-101A/B. When actuated, Interlock I-1 shall open redundant contactors to remove 480 VAC power from the Booster Pump ECRT-P-101A/B VFD. 2. Interlock I-1 shall be fail-safe for more probable failure modes. 3. Interlock I-1 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin. 4. Interlock I-1 shall function to remove power to Booster Pump ECRT-P-101A/B before a seismic event reaches SDC-2 levels and shall not restart the pump during or after the event without manual intervention. Interlock I-1 shall be designed and installed to perform its safety functions to include receipt of seismic trip signals and the interruption of electrical power to ECRT-P-101A/B before a seismic event reaches SDC-2 levels, and shall not restart the pump during or after the event without manual intervention.</td>
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</tbody>
</table>

Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components
<table>
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<tr>
<td>Safety Shutdown Interlock I-1 (cont.)</td>
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</tr>
<tr>
<td>Auxiliary Ventilation System</td>
<td></td>
<td>Prevent a hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Safety Control Panel ECRT-PNL-103 shall meet SDC-2 requirements.</td>
</tr>
<tr>
<td></td>
<td>Operational Accident - STSC Hydrogen Explosion (3.4.2.2)</td>
<td>Prevent a fire-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a fire-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>1. The Auxiliary Ventilation System shall automatically actuate on loss of normal STSC ventilation.</td>
</tr>
<tr>
<td></td>
<td>Operational Accident - 105KW Annex Fire (3.4.2.5)</td>
<td>Prevent a seismic-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and STSC inerting activities.</td>
<td>Prevent a seismic-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and STSC inerting activities.</td>
<td>2. The Auxiliary Ventilation System shall maintain the hydrogen concentration at or below 25% of the LFL in air for the maximum sludge quantities allowed for interim storage.</td>
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<td></td>
<td>Natural Phenomenon - Seismic Event (3.4.2.6)</td>
<td>Prevent a wind-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a wind-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>3. The Auxiliary Ventilation System shall be fail safe for more probable failure modes.</td>
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<tr>
<td></td>
<td>Natural Phenomenon - Snow and Ashfall (3.4.2.7)</td>
<td>Prevent a snow and ashfall-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a snow and ashfall-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>4. The Auxiliary Ventilation System shall be designed to maintain the combustible concentration at or below 25% of the LFL for a period of 96 hr.</td>
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<td>Natural Phenomenon - Lightning (3.4.2.9)</td>
<td>Prevent a lightning-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a lightning-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>5. The Auxiliary Ventilation System shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with an appropriate design margin.</td>
</tr>
<tr>
<td></td>
<td>External Events - Vehicle Impact (3.4.2.11)</td>
<td>Prevent a vehicle impact-initiated hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>Prevent a vehicle impact-initiated hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.</td>
<td>6. Auxiliary Ventilation System STSC inlet hose ECRT-H-604 shall be of noncombustible construction.</td>
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<td></td>
<td>External Events - Range Fire (3.4.2.12)</td>
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**Notes:**

- ECRT-SOV-612/622 shall open if the room airflow rate into the STSC ventilation intake pipe is < 1.0 scfm actual flow.
- Each train of the Auxiliary Ventilation System shall be capable of delivering a minimum of 0.5 scfm of nitrogen to the STSC when ECRT-SOV-612/622 are open.
- The Auxiliary Ventilation System shall maintain the hydrogen concentration at or below 25% of the LFL in air for the maximum sludge quantities allowed for interim storage.
- The Auxiliary Ventilation System shall be fail safe for more probable failure modes.
- The Auxiliary Ventilation System shall be designed to maintain the combustible concentration at or below 25% of the LFL for a period of 96 hr.
- The Auxiliary Ventilation System shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with an appropriate design margin.
- Auxiliary ventilation components installed indoors shall be designed to perform their safety function over the range of temperatures expected in HCRFS interior spaces of 40° to 100°F. Auxiliary ventilation components located outdoors shall be suitable for operation over an ambient temperature range of 27° to 110°F.
- Auxiliary ventilation components installed indoors shall be designed to perform their safety function over the range of temperatures expected in HCRFS interior spaces of 40° to 100°F. Auxiliary ventilation components installed indoors shall be designed to perform their safety function over the range of temperatures expected in HCRFS interior spaces of 40° to 100°F. Auxiliary ventilation components located outdoors shall be suitable for operation over an ambient temperature range of 27° to 110°F.
- Auxiliary Ventilation Control Panel ECRT-PNL-602 shall be NEMA 4X rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.
- Nitrogen Supply Panel ECRT-ME-602 shall be NEMA 3R rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.
- The maximum nitrogen flow rate shall be 0.8 scfm.
Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components

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<tr>
<td>Auxiliary Ventilation System (cont.)</td>
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<td>Vulnerable portions of the Auxiliary Ventilation System shall be protected against vehicle impact.</td>
</tr>
<tr>
<td>Oxygen Analyzer</td>
<td>Operational Accident - STSC Hydrogen Explosion (3.4.2.2)</td>
<td>Prevent a hydrogen explosion in the STSC by maintaining an inert atmosphere in the STSC once established.</td>
<td>Oxygen Analyzer ECRT-CAB-601 shall be capable of measuring an oxygen concentration of less than 0.5 vol% for the STSC and &lt; 1.2 vol% for the STS Cask.</td>
<td>The Oxygen Analyzer shall be shown, through testing and calibration, to be capable of measuring an oxygen concentration 0.5 vol% or less with sufficient accuracy for practical use during STSC inerting.</td>
</tr>
<tr>
<td>STSC Boundary and Transport Vent Assemblies</td>
<td>• Operational Accident - STSC Hydrogen Explosion (3.4.2.2) • Operational Accident - STSC Over-Pressurization Release (3.4.2.4) • Natural Phenomenon - Seismic Event (3.4.2.6)</td>
<td>Prevent a hydrogen explosion in the STSC by maintaining structural integrity during a seismic event following STSC inerting.</td>
<td>Oxygen Analyzer ECRT-CAB-601 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>Each STS transport vent assembly shall be capable of withstanding SDC-1 seismic loads while maintaining leak tightness.</td>
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<td>Prevent a hydrogen explosion by maintaining structural integrity in the STS Cask so Operations can verify that an inert atmosphere has been established, thereby preventing a hydrogen explosion.</td>
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<td>The STS trailer Seismic Dampener Shoes shall limit independent motion of the STSC and STS Cask.</td>
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<td>Prevent a hydrogen explosion in the STSC during long-term storage at T Plant by limiting the volume of a vessel-spanning bubble.</td>
<td>STSC transport vent assembly shall each have a flow capacity at the STSC design pressure of at least 400 L/day (0.01 scfm)</td>
<td>Each STS transport vent assembly shall be capable of flowing greater than 0.01 scfm with a differential pressure of 1 atmosphere (14.7 psi) or less.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protect initial conditions assumed in the STSC thermal and gas analysis regarding the STSC dimensions. (STSC Key Dimensions.)</td>
<td>STSC inside diameter of 58 in.</td>
<td>STSC Seismic Wedges shall prevent secondary impacts between the STS cask and the STSC vessel resulting from ground acceleration(s) in any horizontal direction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prevent STSC over-pressurization by venting pressure (Transport Vent Assemblies)</td>
<td>STSC overpressure of no more than 5 psig.</td>
<td>The STS trailer Seismic Dampener Shoes shall maintain the trailer landing gear in contact with the truck scale during an SDC-1 seismic event.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Static Spring Rate (Ks): 35 ≤ Ks ≤ 107 kip/ft at 18,000 lb load.</td>
</tr>
<tr>
<td>Safety- Significant SSC</td>
<td>Chapter 3 Accident Analysis Cross Reference (Section)</td>
<td>Safety Functions</td>
<td>Functional Requirements</td>
<td>Performance Criteria</td>
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<tr>
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</tr>
<tr>
<td>STS Cask Pressure Boundary</td>
<td>STS Cask Vent Tool and STS Pressurization Check Tool</td>
<td>Prevent a hydrogen explosion in the STS Cask by maintaining an inert atmosphere in the STS Cask</td>
<td>1. The STS Cask pressure boundary shall be capable of maintaining an inert atmosphere for the duration of the Shipping Window with an appropriate design margin</td>
<td>The STS Cask shall be designed for a maximum leak rate of 9.0E-4 standard cm²/s air.</td>
</tr>
<tr>
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<td>Prevent a hydrogen explosion by maintaining structural integrity during a seismic event following STS Cask marring STS Cask Pressure Boundary</td>
<td>2. The STS Cask pressure boundary shall be capable of maintaining an inert atmosphere within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin</td>
<td>The STS Cask shall be designed for temperature extremes of -27° to 110°F.</td>
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<tr>
<td></td>
<td></td>
<td>Prevent STS Cask over-pressurization by venting the cask STS Cask Vent Tool and STS Pressurization Check Tool</td>
<td>3. The STS Cask pressure boundary shall meet SDC-1 requirements</td>
<td>The STS Cask pressure boundary design shall be capable of withstand SDC-1 seismic loads while maintaining leak tightness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STSC liquid level instrumentation</td>
<td>4. The STS Cask Vent Tool and STS Pressurization Check Tool shall be shown by analysis or testing to be capable of flowing greater than 0.01 scfm with a differential pressure of 1 atmosphere (14.7 psi) or less.</td>
<td></td>
</tr>
<tr>
<td>STS Cask Leak Tester</td>
<td>Operational Accident - STSC Hydrogen Explosion (3.4.2.2)</td>
<td>Measure and indicate the STS Cask leak rate so Operations can verify that it is within limits, thereby preventing a hydrogen explosion.</td>
<td>1. Pressure indicator ECRT-PL-760-606 shall measure the STS Cask pressure.</td>
<td>The STS Cask Leak Tester shall be capable of measuring a cumulative cask leak rate of 9.0E-4 standard cm²/s air with a sensitivity of 1E-4 standard cm²/s air.</td>
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<td>2. Pressure indicator ECRT-PL-760-606 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>Pressure indicator ECRT-PL-760-606 shall be designed to operate in the environmentally controlled 105KW Annex over the allowed operating temperature range of 40° to 100°F.</td>
</tr>
<tr>
<td>Sludge Quantity Instrumentation</td>
<td>Operational Accident - STSC Hydrogen Explosion (3.4.2.2) Operational Accident - STSC Over-Pressurization Release (3.4.2.4)</td>
<td>Protect initial conditions assumed in the STSC thermal and gas analyses regarding the quantity of sludge present in an STSC STSC liquid level instrumentation and truck scale instrumentation</td>
<td>1. STSC liquid level instrumentation shall measure the liquid level in the STSC.</td>
<td>Total measurement error shall not exceed 0.2 in.</td>
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<td>2. Truck scale instrumentation shall measure the weight of the STS Trailer.</td>
<td>The truck scale shall have a minimum capacity of 75 tons, a total relative accuracy per load cell of 0.02%, and meet NTEP accuracy class III, with 10,000 divisions.</td>
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<tr>
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<td></td>
<td>3. STSC liquid level instrumentation and truck scale instrumentation shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>3.1 Truck Scale and level instruments shall be designed to perform their safety functions over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>3.2 Truck scale load cells and summation box shall be designed with appropriate protection such that they may be submerged in water to a depth which will not exceed 1 ft 10 in.</td>
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<td>3.3 The level sensor shall be fully functional in a radiation environment where the accumulated dose is 1000R or less.</td>
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<td></td>
<td>3.4 Safety Instrument Panel ECRT-PNL-401 and Instrument Bypass Panel ECRT-PNL-402 shall be NEMA 4X rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.</td>
</tr>
</tbody>
</table>
### Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components

<table>
<thead>
<tr>
<th>Safety- Significant SSC</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>105KW Annex and Other Structures and Components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Operational Accident</td>
<td>105KW Annex Fire (3.4.2.5)</td>
<td>Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by maintaining structural integrity in a fire. [105KW Annex]</td>
<td>1. The 105KW Annex structure shall be of noncombustible construction.</td>
<td>3.5 STSC Junction Box ICRT-JB-402 shall be NEMA 4 rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.</td>
</tr>
<tr>
<td>• Natural Phenomenon–Seismic Event (3.4.2.6)</td>
<td>Prevent a fire-induced hydrogen explosion by maintaining structural integrity in a fire. [105KW Annex]</td>
<td>2. The 105KW Annex structure shall be of noncombustible construction as described in the HNF-SD-SNF-FHA-001 consistent with its classification as an IBC Type IIB building.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Natural Phenomenon–Wind (3.4.2.7)</td>
<td>Prevent a fire-induced hydrogen explosion by maintaining structural integrity in a fire. [105KW Annex]</td>
<td>The truck stop shall be no more than 42 ft 7 in. from the outside face of the 105KW Annex east wall.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Natural Phenomenon–Snow and Ashfall (3.4.2.8)</td>
<td>Prevent a fire-induced hydrogen explosion by preventing vehicle fuel spills from entering the 105KW Annex. [Truck Stop/Concrete Platform, Trailer entrance]</td>
<td>The trailer entrance ramp shall be sloped at least 1 percent away from the 105KW Annex for the first 10 ft.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Natural Phenomenon–Lightning (3.4.2.9)</td>
<td>Prevent a fire-induced hydrogen explosion by preventing vehicle fuel spills from entering the 105KW Annex. [Truck Stop/Concrete Platform, Trailer entrance]</td>
<td>3. The trailer entrance shall be sloped away from the 105KW Annex such that a tractor fuel spill, should it occur, will not enter the building.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• External Events–Range Fire (3.4.2.12)</td>
<td>Prevent a fire-induced hydrogen explosion by maintaining structural integrity during a seismic event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary. [105KW Annex, Mezzanine, bridge crane and associated supports, 105KW Annex exhaust stack, fire protection sprinkler system supports, HVAC duct supports, cable tray supports, hose cradles, South Tool Tray, and the Nitrogen Cylinder Storage Awning]</td>
<td>4. The following structures shall meet SDC-1 requirements: 105KW Annex and Mezzanine, bridge crane and associated supports, 105KW Annex exhaust stack, fire protection sprinkler system supports, HVAC duct supports, cable tray supports, hose cradles, South Tool Tray, and the Nitrogen Cylinder Storage Awning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>105KW Annex</td>
<td>Prevent a wind-induced hydrogen explosion in the STSC or STS Cask by withstanding applicable wind loads thereby preventing damage to the Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary. [105KW Annex]</td>
<td>5. The 105KW Annex shall be designed for PC-2 wind loads as defined in PRC-PRO-EN-097.</td>
<td>Seismic design shall be to SDC-1 requirements as modified below: a. $S_{HA} = 0.458g$ b. $S_{EV} = 0.323g$ c. Vertical Load Effect, $E_v = 0.129 g D$ where $D$ is the dead load.</td>
</tr>
<tr>
<td></td>
<td>tool tray</td>
<td>Prevent a spray release of slurry during sludge retrieval and transfer by maintaining structural integrity during a snow and ashfall event. [105KW Annex, Horizontal Shielded Hose Chase]</td>
<td>6. The 105KW Annex and Horizontal Shielded Hose Chase shall be designed for PC-2 snow and ashfall as defined in PRC-PRO-EN-097.</td>
<td>105KW Annex and Horizontal Shielded Hose Chase shall be designed to withstand PC-2 snow and ashfall loads which are 20 psf combined (i.e., worst case).</td>
</tr>
<tr>
<td></td>
<td>105KW Annex</td>
<td>Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by maintaining structural integrity in a fire. [105KW Annex]</td>
<td></td>
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</tr>
</tbody>
</table>
## Table 4-1. Summary List of Safety-Significant Structures, Systems, and Components

<table>
<thead>
<tr>
<th>Safety-Significant SSC</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
<th>Performance Criteria</th>
</tr>
</thead>
</table>
| SCS-CON-230            | • Operational Accident - STSC Hydrogen Explosion (3.4.2.2)  
                         • Operational Accident - STSC Over-Pressurization Release (3.4.2.4) | Protect initial conditions assumed in the safety basis analyses regarding the quantity of uranium metal in an STSC containing Settler Tank sludge. | Limit the leakage of sludge from the center of the sludge mound in adjacent quadrants when retrieving sludge from a given quadrant. | The maximum uranium metal content that can be loaded into an STSC from the north half of SCS-CON-230 with the divider plate installed and layered with 105-K East sludge shall not exceed the 72.5 kg assumed in thermal and gas analyses. |
| Hoist Chain Stops      | • Operational Accident - ECRTS Spray Releases (3.4.2.1)  
                         • Operational Accident - STSC Hydrogen Explosion (3.4.2.2) | Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container. Note: To provide defense-in-depth and administrative control has been established to control the location of the XAGO and configuration of the motive water (see Section 4.5.16, “XAGO Pre-Operational Testing and Operational Readiness Controls”) | Prevent a XAGO from being lowered into an Engineered Container by physically limiting the length of chain deployed by the hoist. | The hoist chain stop shall limit the length of chain deployed by the hoist to a maximum of 92 in. |

Notes:
* The option to replace above water transfer line components as part of a planned test and recovery effort, where doing so is practical, is an acceptable alternative for damage due to unexpected freezing temperature conditions affecting components otherwise rated for the specified range of temperatures.

HNF-SD-SNF-FHA-001, Fire Hazards Analysis for the 105-KW Facility.
PNNL-19345, The Disruption of Vessel-Spanning Bubbles with Sloped Fins in Flat-Bottom and 2:1 Elliptical-Bottom Vessels.
PRC-PRO-EN-097, Engineering Design and Evaluation (Natural Phenomena Hazard)
PRC-STP-00688, Thermal and Gas Analyses for a Sludge Transport and Storage Container (STSC) During Transportation.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOV</td>
<td>air-operated valve</td>
</tr>
<tr>
<td>DOT</td>
<td>U.S. Department of Transportation</td>
</tr>
<tr>
<td>ECRTS</td>
<td>Engineered Container Retrieval and Transfer System</td>
</tr>
<tr>
<td>FM</td>
<td>Factory Mutual</td>
</tr>
<tr>
<td>HH</td>
<td>hose-in-hose</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating, ventilation, and air conditioning</td>
</tr>
<tr>
<td>IBC</td>
<td>International Building Code</td>
</tr>
<tr>
<td>IXM</td>
<td>Ion Exchange Module</td>
</tr>
<tr>
<td>LFL</td>
<td>lower flammability limit</td>
</tr>
<tr>
<td>MAR</td>
<td>material at risk</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturer’s Association</td>
</tr>
<tr>
<td>NTPE</td>
<td>National Type Evaluation Program</td>
</tr>
<tr>
<td>PC</td>
<td>Performance Category</td>
</tr>
<tr>
<td>FM</td>
<td>Factory Mutual</td>
</tr>
<tr>
<td>MAR</td>
<td>material at risk</td>
</tr>
<tr>
<td>SDC</td>
<td>Seismic Design Category</td>
</tr>
<tr>
<td>SOV</td>
<td>solenoid-operated valve</td>
</tr>
<tr>
<td>STS</td>
<td>Sludge Transport System</td>
</tr>
<tr>
<td>STSC</td>
<td>Sludge Transport and Storage Container</td>
</tr>
<tr>
<td>TLSB</td>
<td>Transfer Line Service Box</td>
</tr>
<tr>
<td>UL</td>
<td>Underwriters Laboratories</td>
</tr>
<tr>
<td>VFD</td>
<td>variable frequency drive</td>
</tr>
<tr>
<td>XAGO</td>
<td>XAGO Retrieval Tool</td>
</tr>
</tbody>
</table>
4.4.1 Above-Water Slurry Transfer Lines

4.4.1.1 Safety Function

The above-water slurry transfer lines are safety-significant because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the Protective Action Criteria (PAC)-3 sum of fraction (SOF). The safety function of the above-water slurry transfer lines is to prevent the spray release of slurry by maintaining integrity during sludge retrieval and transfer. The safety function is specific to “above-water” lines as failures below the surface of the basin water do not result in an air-borne release.

The above-water slurry transfer lines are also safety-significant because a hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase can result in facility worker serious injury or death. These process enclosures do not normally contain sludge, and therefore there is normally no hydrogen explosion hazard. However, if slurry was spilled within an enclosure then a hydrogen explosion could potentially occur. Thus above-water slurry transfer lines have the additional safety function to prevent a hydrogen explosion in the TLSB and the In-Basin/Horizontal Shielded Hose Chase by maintaining integrity during slurry transfers.

4.4.1.2 System Description

The slurry transfer lines provide the primary containment for slurry transfers. The safety-significant system includes only those system components that are above water. Above-water slurry transfer lines include: (1) the inner pipe within the slurry transfer line Ingress/Egress Assembly; (2) the inner hose of the slurry transfer line HIH; (3) the inner pipe for the slurry transfer line coaxial connector; and (4) the slurry transfer line piping and hose in the TLSB. Each is described in more detail below, and Figure 4-1 provides a simplified system drawing.

The first safety-significant component is the inner pipe (ECRT-SLU-110) of the egress portion of the Ingress/Egress Assembly, which provides primary containment at the point at which the slurry transfer line emerges from the basin water. This line, as are all other hard piping sections of the above-water slurry piping, is nominally 1.5 in. Schedule 80, stainless steel. A bulkhead plate inside the 16 in. encasement pipe of the Ingress/Egress Assembly (item 9 of H 1 92658, STP ECRTS Transfer System Ingress/Egress Assembly) forms a barrier between two regions of the confinement space around the above water slurry lines. On the basin side of this plate, the air space is common with the basin water. A leak in this area is confined to the 16 in. encasement pipe and routed back to the basin. The HIH side of the plate forms the termination for the HIH annulus which confines leaks within the encasement hose or encasement pipe. A leak in this area is directed to a drain line that carries the slurry to a leak detector assembly. Once the leak detector well fills, excess slurry material is routed to discharge point below the basin water surface.
Figure 4-1. Above-Water Slurry Transfer Lines
The second component, ECRT-H-103, is a HIH assembly that connects the Ingress/Egress Assembly to the TLSB and runs approximately 155 ft in length including an approximate 20-ft elevation gain from the Ingress/Egress Assembly to the TLSB on the 105KW Annex Mezzanine. Hose-in-hose assembly ECRT-H-103 consists of an inner primary transfer hose and a secondary encasement hose. The inner hose is 1.5 in. inside diameter and is constructed of an integral system of ethylene propylene diene monomer (EPDM) rubber, polyester fiber, and a double helix steel wire. It connects to hard piping with threaded unions. The secondary hose is 4-in. inner diameter, is of the same construction, and connects to interfacing equipment with pipe flanges. Leaks from the primary hose drain from the annulus between the primary and secondary hoses to the leak detector at the Ingress/Egress Assembly (LDE/LDK 710-101).

Spare transfer HIH assembly ECRT-H-103SA/-103SB is installed with the primary assembly to preclude the need to access the Horizontal Shielded Hose Chase to repair the primary assembly in the event of a failure. The spare assembly, consisting of two segments with a total length of 155 ft, is identical to ECRT-H-103 except for the couplers that join the two segments. Should ECRT-H-103 fail for any reason (e.g., by leaking or plugging), the installed spare can be connected after disconnecting the end connectors of the failed hose.

The above-water slurry piping within the TLSB consists of hard piping, hoses, and pipe components that provide primary containment of slurry. The IXM, Decant/Filter, and Overfill Recovery Systems interface with the slurry piping through branch connections within the TLSB. In addition, the sump pump discharge line and high point vent line interface with the slurry line within the TLSB containment boundary.

ECRT-H-107 is an HIH assembly that connects the TLSB to the STSC for slurry transfer. It consists of an inner primary slurry transfer hose and an outer encasement hose. A specialty coaxial connector, integral with the HIH assembly, interfaces with the STSC.

Above-water slurry transfer lines are defined to include connections (flanges and unions) between lengths of hose and hard pipe, gaskets and fasteners, and any in-line piping components that are part of the above-water slurry transfer line pressure boundary. This includes isolation valves at the following branch connections of the above-water slurry transfer lines within the TLSB:

- IXM Flush Water: ECRT-SLU-112 and ECRT-H-308 to valve ECRT-AOV-104
- Overfill recovery: ECRT-SLU-301, -302, and -300 to valve ECRT-AOV-302 (assuming three-way valve ECRT-V-102 is mis-positioned or leaks)
- Decant Recirculation: ECRT-SLU-109 to valve ECRT-AOV-105
- Sump Pump discharge: ECRT-H-310 and ECRT-SLU-113 to valve ECRT-AOV-118

4.4.1.3 Functional Requirements

Table 4-2 below identifies the functional requirements and associated performance criteria for the above-water slurry transfer lines.
Table 4-2. Above-Water Slurry Transfer Lines Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Above-water slurry transfer lines shall be designed to ensure their integrity at</td>
<td>The design pressure of the above-water slurry transfer lines shall be 220 psig.</td>
</tr>
<tr>
<td>the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin.</td>
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<tr>
<td>2. Above-water slurry transfer line isolation valves shall be provided with valve</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and</td>
</tr>
<tr>
<td>position indication.</td>
<td>shall be visible to an operator either by direct observation or by use of cameras.</td>
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<tr>
<td>3. Above-water slurry transfer lines shall be designed to operate within the</td>
<td>1. Above-water slurry transfer lines (with the exception of the slurry HIH within the Horizontal</td>
</tr>
<tr>
<td>environmental parameters associated with normal and off-normal operating conditions</td>
<td>Shielded Hose Chase) shall be designed to perform their safety function in the range of temperatures</td>
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<tr>
<td>associated with the transfer of slurry with an appropriate design margin.</td>
<td>expected in ECRTS interior spaces of 40° to 100°F and to withstand or be replaced,* if necessary, for</td>
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<td>the broader range of temperatures specified for the project of -27° to 110°F.</td>
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<td>2. Slurry transfer line HIH within the Horizontal Shielded Hose Chase shall be designed to perform its</td>
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<td>safety function in the range of temperature of -27° to 110°F.</td>
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<tr>
<td></td>
<td>3. Above-water slurry transfer lines shall be capable of withstanding a 50 mil loss of wall</td>
</tr>
<tr>
<td></td>
<td>thickness loss due to corrosion and erosion without failure.</td>
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<td></td>
<td>4. Above-water slurry transfer lines shall be capable of withstanding a radiation exposure of 1.1E+5</td>
</tr>
<tr>
<td></td>
<td>rad without failure.</td>
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</tbody>
</table>

Notes:
*The option to replace above water transfer line components as part of a planned test and recovery effort, where doing so is practical, is an acceptable alternative for damage due to unexpected freezing temperature conditions affecting components otherwise rated for the specified range of temperatures.

ECRTS Engineered Container Retrieval and Transfer System
HIH hose in hose

4.4.1.4 System Evaluation

The performance criteria identified above characterizes the specific operational responses and capabilities necessary for the above-water slurry transfer line to meet its functional requirements. The following sections evaluate the capabilities of the above-water slurry transfer line to meet the identified performance criteria.

Conservative Design Features—Based on MASF Pre-Operational Acceptance Testing (MPAT) of the booster pump and transfer line configuration planned for operational use, the pump discharge pressure is usually less than 100 psig, however, it did exceed 100 psig at times [see PRC-STP-TR-00960, Report for Maintenance and Storage Facility Pre-Operational Acceptance Testing for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, and PRC-STP-CN-M-00563, Slurry Transfer Hydraulic Parameter Review for the Sludge Treatment Project - Engineered Container Retrieval and Transfer System (STP-ECRTS)].
However, the pressure in above-water portions of the transfer line was less than nominal 115 psig since the rupture disk remained intact during test transfers (setpoint 115 psig plus or minus 5 percent). The maximum operating pressure expected during line flushing operations is less than 115 psig. The design pressure for the above-water slurry lines is 220 psig, as required by PRC-00132, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Process System Piping Specifications and Schedules. The hydrostatic tests for the slurry transfer line in the Ingress/Egress Assembly is found in submittal 53920-003-SUB-014 001. The hydrostatic tests for the slurry lines in the TLSB are found in submittals 53921-002-SUB-016 004 and 53921-002-SUB-016 005. Hoses were proof-tested at higher pressures depending on the hose working pressure as required by PRC-00132 and RMA IP-2, Hose Handbook. The difference between the design pressure (220 psig) and the maximum operating pressure (115 psig) affords a substantial design margin to accommodate hydraulic differences or differences between slurry and test simulants that could exist between the integrated test mock-up and the final production equipment installed in the 105-K West Basin (105KW Basin) and 105KW Annex. The higher pressure rating for the transfer HIH, backed by demonstration of the HIH assembly design by proof testing, provides a demonstrated design margin that ensures reliable operation.

Piping calculations performed to ASME B31.3 for the above-water slurry transfer lines (44577-M-CALC-026, STP-ECRTS Transfer Line Service Box Pipe Stress Evaluation and 44577-M-CALC-030, STP-ECRTS Ingress/Egress Pipe Stress Evaluation) show that resultant stresses are below allowable stresses at a design pressure of 220 psig. The design margin provided by stress analysis is at least 25 percent for piping.

The maximum, unmitigated deadhead pressure of the booster pump (354 psig per PRC-00533, Test Report for Sludge Treatment Project Engineered Container Retrieval and Transfer System Hose Pump Discharge Pressure Characterization) exceeds the transfer line design pressure; therefore, a rupture disk (ECRT-PSE-101) is required for compliance with ASME B31.3. The rupture disk is located downstream of the booster pump and has a rating of 115 psig (plus or minus 5 percent) and protects the design margins included in piping analysis (see Section 4.4.2).

The HIH transfer line ECRT-H-103, has a maximum rated working pressure of 600 psig and a test pressure of 1200 psig for the primary hose assembly. The test results for ECRT-H-103 are found in submittal 50919-000-SUB-014 001. The HIH STSC hose/connector assembly ECRT-H-107 has a maximum rated working pressure of 250 psig and a test pressure of 500 psig for the primary hose/connector assembly. The hydrostatic test results for ECRT-H-107 are found in submittal 50919-000-SUB-021 001. Therefore, the total design margins are 485 psig for the transfer HIH assembly and 135 psig for the STSC HIH assembly. Inside the TLSB, hoses ECRT-H-308 and ECRT-H-310 are the only hoses directly pressurized during a slurry transfer. These hoses have a maximum rated working pressure of 425 psig and a test pressure of 850 psig. Therefore, the total design margin is 310 psig. The test results for ECRT-H-308 and -310 are found in submittals 53921-002-SUB-016 004 and 53921-002-SUB-016 005.

The hose assemblies were proof tested using lengths of hose and end connectors from the same hose batch numbers, the same assembly connection procedures and tooling, and the same end connector configurations and materials as those supplied to the ECRTS HIH assemblies. The inner hose proof burst pressure was specified to be a minimum of 2400 psig. Actual burst pressures were in excess of 3000 psig.
The design calculations and drawings that apply to the above-water slurry transfer lines include:

- 44577-M-CALC-026
- 44577-M-CALC-030
- 44577-M-CALC-032, STP-ECRTS Pipe Support Evaluation for Process Equipment
- H-1-92653, STP-ECRTS Transfer System Xfer Line Service Box Piping
- H-1-92654, STP-ECRTS STSC HIHTL Hose Assemblies
- H-1-92655, STP-ECRTS Transfer System HIHTL Hose Assemblies
- H-1-92658, STP-ECRTS Transfer System Ingress/Egress Assembly

Loads evaluated include normal and abnormal loads. Specific load cases evaluated include hydrostatic, sustained (normal), occasional (seismic plus normal), and an expansion case evaluating expected operating temperatures of 40° to 100°F. Resultant stresses were under allowable stresses by at least 25 percent for all load cases for all calculations, another significant design margin.

**Safe Failure Modes**—For a spray release, the failure mode of concern is a failure that creates an idealized slit in a piping component under pressure. For a hydrogen explosion, the failure mode of concern is any loss of integrity that results in a spill of slurry within a process enclosure.

Features that increase the likelihood of a safe condition, assuming such failures, include:

- Above-water slurry lines are provided with general service secondary confinement consisting of stainless steel, pipe, stainless steel plate, or EPDM hose.
- Resultant piping stresses are below the allowable stresses and significantly below the yield stress of the materials.
- The rupture disk will release pressure at 115 psig.
- Above-water slurry transfer lines are designed to a minimum of 220 psig and are hydrostatically qualified to at least 330 psig.
- The inner hose of the HIH transfer line (ECRT-H-103) is rated to 600 psig.
- The inner hose of the STSC HIH assembly is rated to 250 psig.
- The hose ECRT-H-308 in the TLSB is rated to 425 psig
- The TLSB is provided with leak detection interlocked to stop slurry transfers
- The TLSB is provided with active ventilation that would function to reduce the hydrogen concentration within the enclosure.

Above-water slurry transfer line isolation valves are designed with suitable position indication to support visual verification of the required alignment (valve position) before initiating slurry transfer operations. Visual valve verification is primarily performed by viewing the manual and air operator position indicators on the top surface/lid of the TLSB, and secondarily by viewing into the box through polycarbonate panels on the box sides. Each isolation valve has design features including valve stops with contrasting colors to allow easier verification that the valve is closed. Should fatigue or other failure of the valve drive train prevent the valve from fully
closing, this deviation would be visually detectable. Fatigue analysis documented in PRC-STEP-CN-M-00660, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Analysis of the Process Valve Drive Trains, qualifies the drive train to unlimited cycles.

Environmental Design—The slurry transfer line HIH assembly within the Horizontal Shielded Hose Chase is required to perform its safety function in the range of temperature of -27° to 110°F. The HIH assemblies are suitable for use in this temperature range as specified in PRC-STEP-00133, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Hose-in-Hose Specification and as required by HNF-40475, Functional Design Criteria Sludge Treatment Project Phase 1 ECRTS. Testing performed by River Bend Systems (the HIH vendor) demonstrates that freezing does not have an adverse impact on the hose assemblies (RPP-RPT-52155, Test Report for Freeze Testing of 2” Safe-T-Chem™ Hose). Slurry freezing is not expected to occur within the 105KW Annex and 105KW Basin based on the operating temperature limits of 40° to 100°F.

The HIH lots were tested at both transient and steady-state (12-hour) tests at elevated pressure (at least 600 psig) and a temperature in the range of 170° to 180°F, ensuring design margin for over-temperature conditions. Test results are found in submittals 50919-000-SUB-007 001 and 50919-000-SUB-014 001. Temperatures above this level are precluded in the pipe chase by design: contact with the earth below, thick concrete walls, and a metal rain cover, combine to support this conclusion.

Individual pipe, pipe components, and materials of the above-water slurry transfer line are rated for the environmental extremes of -27° to 110°F as required in PRC-STEP-00132. Pipe analysis qualifies the interior piping from 40° to 100°F (see calculations 44577-M-CALC-026, 44577-M-CALC-030, and 44577-M-CALC-032).

All above-water slurry transfer lines materials have a radiation resistance rating greater than 1.1E+5 rad. The HIH, for example, can tolerate at least 1.0E+6 rad based on the limitations posed by use of EPDM material. The final radiation calculations for the above-water slurry transfer line are documented in PRC-STEP-CN-M-00562, Basis for Erosion and Corrosion Rates and Radiation Resistance of Materials for the Sludge Treatment Project - Engineered Container Retrieval and Transfer System (STP-ECRTS), which derives the 1.1E+5 requirement and demonstrates compliance. The 1.1E+5 rad requirement is conservatively based on an assumed year of exposure to contained radiological material at a dose rate of 12 rad per hour. In contrast, using the process flowsheet slurry transfer time of approximately 9 hours for the life of the facility, the dose would be approximately 110 rad.

The performance criteria for erosion and corrosion states that above-water slurry transfer lines shall be capable of withstanding a 50 mil loss of wall thickness without failure. The 50-mil value is based on calculation PRC-STEP-CN-M-00562. The calculation concludes that the corrosion is significantly bounded by erosion from slurry with a 5-year design life (i.e., 49 mil due to erosion and 1 mil due to corrosion). The 50-mil performance criteria is supported by testing with a standard pipe elbow subjected to three times the mission volume of solids, as documented in PRC-STEP-TR-00664, STP-ECRTS Test Report for Valve Cycling and Leak Rate Determination. Under this test, the erosion of a straight pipe was approximately 60 percent that of the pipe elbow. The ECRTS transfer lines utilize 5-diameter bends, not standard pipe elbows. Test report
A21C-STEP-TR-0015, *Test Report for Sludge Treatment Project Slurry Transfer Testing for Direct Hydraulic Loading (Hose Pump)*, shows erosion of a 5-diameter bend is similar to erosion of straight pipe reported in PRC-STEP-TR-00664. The margin between maximum expected erosion/corrosion based on testing (i.e., ~30 mil) and the 50 mil performance criteria is approximately 40 percent if the piping were subjected to three times the mission volume of solids. This suggests the erosion and corrosion-based design life would be more than 5 times the expected mission life.

Above-water slurry transfer lines are a preventive control, as such there are no accident environmental conditions to consider.

**Support Systems**—The above-water slurry transfer lines do not rely on support SSCs to perform their designated safety function.

**Interface Design**—The primary function of the above-water slurry transfer lines is to act as a pressure retention boundary. As such, a primary concern at points of interface between the above-water slurry transfer lines and other systems is preventing misrouting or backflow into the branch connection. A strategy of safety-significant double-valve isolation, as described in Section 4.4.3, “Double-Valve Isolation,” has been used to ensure a reliable boundary by defining a first valve as part of the boundary and a second valve as an additional layer of safety-significant protection.

Another primary interface point for the above-water slurry transfer lines is the interface between the Ingress/Egress Assembly and the general service, underwater sludge retrieval line (ECRT-H-112). A failure at this interface point would result in no airborne release because the interface point is under basin water. A SAC has been established to verify a minimum basin water level prior to energizing Booster Pump ECRT-P-101A/B (see Section 4.5.2, “Basin Water Level”).

Within the TLSB, three systems interface with the slurry transfer line as described below.

- The overfill-recovery system interfaces with the slurry transfer line at ECRT-V-102. Overfill recovery system piping is designed to the same criteria as slurry transfer line piping (e.g., 220 psig); however, Overfill Recovery Pump ECRT-P-301 is rated to only 130 psig and the associated pulsation dampener ECRT-PD-301 is limited to a 220 psig hydrostatic test. Transfer line rupture disk ECRT-PSE-101 set at 115 psig prevents operational pressures from exceeding the 130 psig pump rating. During sludge retrieval and transfer, valve ECRT-V-102 is positioned such that it protects the Overfill Recovery Pump and pulsation dampener from over-pressurization, as allowed by ASME B31.3, Paragraph 301.2.2. In addition, general service overfill recovery process connections on the suction side of pump ECRT-P-301 are protected by double isolation valves ECRT-AOV-302/-103 and ECRT-AOV-302/ECRT-V-301 (see Section 4.4.3).

- The Decant/Filter System interfaces with the slurry transfer line through double-isolation valves ECRT-AOV-105/-106 (see Section 4.4.3). This branch connection allows decanted supernate to be pumped from the STSC and through the Decant Pump Box into the TLSB and back into the STSC during a flocculation cycle. The double isolation valves and the rupture disk protect the Decant/Filter System, rated at 87 psig, from over-pressurization during slurry transfers.
• The Ion Exchange Module (IXM) water supply system interfaces with the slurry transfer line through double-isolation valves ECRT-AOV-104/-105 (see Section 4.4.3). This branch connection allows an IXM water flush at the high point of the slurry transfer line to aid in reducing radiation dose rates and the potential for a spread of contamination. The double isolation valves prevent not only over-pressurization during sludge retrieval and transfer, but also slurry migration into the IXM system outside of the TLSB to eliminate slurry spray leaks outside of a general service secondary confinement SSC.

The final interface point for the above-water slurry transfer lines is the interface between the transfer line coaxial connector and the safety-significant STSC.

Specific Criteria—The principal standards applicable to hose and piping assemblies making up the primary and secondary sludge transfer line boundary are ASME B31.3, ASCE/SEI 7-05, and RMA IP-2, Hose Handbook. These codes are applied to ensure: (1) structural integrity (pressure, seismic, thermal, and fatigue), (2) material and welding control, (3) identification of erosion and corrosion allowances, and (4) application of qualification testing. Ball valves used to isolate a general service branch connection from the above-water slurry transfer line are qualified to ASME B16.34.

4.4.1.5 Controls (Technical Safety Requirements)

The above-water slurry transfer lines are predominantly a passive engineered control. As designed, the passive components (i.e., hoses and piping) are not subject to change by Operations personnel. The passive components are therefore addressed in the TSRs as a design feature as discussed in Section 5.6.1, “Above-Water Slurry Transfer Lines.”

Isolation valves that are components of the pressure boundary are active components in that they can change state. These valves are required to be in the correct position to perform their credited safety function. This is accomplished by the Conduct of Operations key attribute of the Operational Safety SMP.

4.4.2 Slurry Transfer Line Rupture Disk

4.4.2.1 Safety Function

The slurry transfer line rupture disk is safety-significant because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The safety function of the slurry transfer line rupture disk is to prevent the spray release of slurry by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer.

The slurry transfer line rupture disk is also safety-significant because a hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase can result in facility worker serious injury or death. Thus the slurry transfer line rupture disk has a second safety function which is to prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer.

4.4.2.2 System Description

Slurry transfer line rupture disk ECRT-PSE-101 is located between Booster Pumps ERCT-P-101A/B and the Ingress/Egress Assembly ECRT-ME-104. The rupture disk is mounted
on rupture disk skid ECRT-ME-105 located on the basin floor. Both the slurry piping and rupture disk piping on the skid are nominally 1.5 in. and are stainless steel. The rupture disk skid includes two manual ball valves (ECRT-V-110A and ECRT-V-110B) upstream from the rupture disk to allow either the A or B retrieval/transfer line to be lined up for use.

The rupture disk is designed to relieve at a pressure of 115 psig, plus or minus 5 percent, to provide adequate pressure relief for the slurry transfer line. If the rupture disk relieves during a slurry transfer, slurry will be discharged into the basin water, and general service “Rupture Disk Open” indicator light ECRT-IL-103 on Retrieval/Transfer Control Panel ECRT-PNL-101 will illuminate. In response to the indicator light, operators will shut down the transfer using general service “Stop Transfer” handswitch ECRT-HS-12.

The maximum unmitigated deadhead pressure of the booster pump exceeds the design pressure of the above-water slurry transfer line; therefore, a rupture disk has been specified and provided as the chosen means to comply with ASME B31.3.

### 4.4.2.3 Functional Requirements

Table 4-3 below identifies the functional requirements and associated performance criteria for the slurry transfer line rupture disk.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Slurry transfer line rupture disk ECRT-PSE-101 shall have a nominal pressure rating no greater than the design pressure of the transfer line (i.e., 220 psig).</td>
<td>Rupture disk rating is 115 psig ± 5%</td>
</tr>
<tr>
<td>2. Slurry transfer line rupture disk ECRT-PSE-101 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry with an appropriate design margin.</td>
<td>1. Rupture disk must perform its safety function submerged in a nominal 15 ft of water 2. Rupture disk shall be oriented to limit the potential for accumulation of sludge that might impede performance of its safety function</td>
</tr>
</tbody>
</table>

**4.4.2.4 System Evaluation**

The performance criteria identified in Table 4-3 characterize the specific operational responses and capabilities necessary for the slurry transfer line rupture disk to meet functional requirements. The following subsections evaluate the capabilities of the slurry transfer line rupture disk to meet the identified performance criteria.

**Conservative Design Features**—The design pressure for the above water slurry lines is 220 psig, as required by PRC-STP-00132 and associated drawings. The hydrostatic proof pressure required by ASME B31.3 is 330 psig. The process piping and instrumentation diagram (H-1-92301, Sheet 3) specifies slurry transfer via Booster Pump ECRT-P-101A/B is at a nominal pressure of 100 psig. During previous testing and demonstrations the booster pump discharge pressures varied widely from the average. Variations in pressure occur due to the pulsing characteristics of peristaltic pumps as well as changes in percent solids of the slurry stream. The
system is designed so that normal operations should not cause the rupture disk to burst. The function of the rupture disk is to protect above-water slurry transfer lines from over-pressurizing. There is a substantial design margin of 105 psig between the rupture disk setpoint and the above-water slurry line design pressure.

The rupture disk rating is 115 psig (plus or minus 5 percent) and protects the design margins included in the piping analysis. It also protects the general service systems that interface with the slurry transfer lines within the TLSB. The effects of rupture disk submergence and of the backpressure created by discharge flow after rupture disk activation are evaluated in PRC-STP-CN-M-00563, Appendix C. Submergence does not impact required performance because both the inlet and outlet pressures are increased based on the depth of submergence, so the differential pressure from inside to outside the piping is unaffected and remains protected as required. The flow resistance upon discharge and the 5 percent uncertainty in the activation pressure are both accommodated by the allowance in ASME B31.3, Paragraph 302.2.4.

**Safe Failure Modes**—There are two rupture disk failure modes: opening before demand, and failure to open on demand. Opening before demand is a safe condition in that the resultant slurry release occurs under water as designed, although at a lower pressure than 115 psig. Failure to open on demand has not been experienced in testing and is mitigated by configuring the rupture disk in a vertical position to prevent solids from accumulating on the disk.

**Environmental Design**—The slurry transfer line rupture disk is an integral component of the slurry transfer line and will be exposed to slurry since it is mounted in a branch line of the slurry piping. The nominal solids concentration for slurry transfers is 5 to 10 vol%; however, concentrations up to 15 vol% or more can be expected for brief periods of time. A build-up of solids on the rupture disk or plugging of the pipe assembly housing the rupture disk represents a possible cause of failure where relief subsequently would not be provided on demand. To minimize solids buildup, the rupture disk is oriented vertically above the transfer line such that solids will settle out by gravity and not collect at the rupture disk or in its branch line. In addition, the slurry transfer line is flushed following each transfer. This is expected to minimize solids collection in the slurry transfer line and branch connections. Erosion and corrosion of the rupture disk is not expected; however, failure by either mechanism would not prevent the rupture disk from meeting its safety function, as relief would then be provided at a lower demand. The rupture disk design accommodates the range of basin water temperatures identified during operation.

The slurry transfer line rupture disk is a preventive control, as such there are no accident environment conditions to consider.

**Support Systems**—The slurry transfer line rupture disk does not rely on support SSCs to perform its safety function.

**Interface Design**—The slurry transfer line rupture disk interfaces with a general service relay sensor that sends a signal to the “rupture disk open” indicator light. Although a relay sensor failure could result in loss of indication, it does not prevent the rupture disk from performing its safety function. Receipt of the alarm and response to it are not required for the rupture disk safety function.

The slurry line rupture disk is mounted on a pipe spool that interfaces with the non-safety under water slurry transfer line as a branch connection. Failure of the pipe spool or rupture disk
mounts would not prevent the rupture disk from performing its safety function as relief would be provided at a lower demand.

**Specific Criteria**—Section 322.6.3 of ASME B31.3 provides the requirements for pressure relieving devices. The design configuration shown in Item 4 of drawing H-1-92697 satisfies these criteria. The set pressure (115 plus or minus 5 psig) is not greater than the design pressure of the transfer line (i.e., 220 psig).

### 4.4.2.5 Controls (Technical Safety Requirements)

The rupture disk is an active component in that it changes state to perform its safety function. However, it is an “off-the-shelf,” passive mechanical device with characteristics that are ensured through design and procurement. The rupture disk is not subject to change by Operations personnel and therefore is addressed in the TSRs as a design feature as described in Section 5.6.2, “Slurry Transfer Line Rupture Disk.”

### 4.4.3 Double-Valve Isolation

#### 4.4.3.1 Safety Function

Double-valve isolation is safety-significant because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. Double-valve isolation is also safety-significant because a hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase can result in facility worker serious injury or death.

Double-valve isolation is required at interfaces between the slurry transfer line and connecting general service lines during slurry transfers. The safety functions are as follows:

- Prevent the spray release of slurry by preventing backflow into the TLSB IXM water supply lines during sludge retrieval and transfer. [ECRT-AOV-104 and ECRT-CV-105, ECRT-AOV-302 and ECRT-AOV-103]

- Prevent the spray release of slurry by preventing backflow into overfill recovery line ECRT-SLU-300 during sludge retrieval and transfer. [ECRT-AOV-302 and ECRT-V-301]

- Prevent the spray release of slurry by preventing backflow into decant/flocculant recirculation line ECRT-SUP-210 and hose ECRT-H-209 during sludge retrieval and transfer. [ECRT-AOV-105 and ECRT-AOV-106]

  Note: preventing backflow into the decant/flocculant line prevents the possible backflow into the flocculant addition line ECRT-H-207.

- Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing slurry backflow during sludge retrieval and transfer. [ECRT-AOV-105 and ECRT-AOV-106]
The safety function of handswitch ECRT-HS-123 and valves ECRT-SOV-123 and ECRT-AOV-123 is to:

- Prevent a spray release of slurry by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer.
- Prevent a hydrogen explosion in the Decant Pump Box and Sand Filter Skid by preventing inadvertent repositioning of safety-significant AOVs during sludge retrieval and transfer.

4.4.3.2 System Description

Double-valve isolation may consist of a pair of ball valves in series or a ball valve followed by a check valve. In each case, the second valve is a major contributor to defense-in-depth.

Where double-valve isolation protects the interface between the safety-significant above-water slurry transfer line and a general service line; the primary valve also is defined as a component of the above-water slurry transfer line. Both the primary valve and the secondary valve are relied upon during sludge retrieval and transfer where integrity of the slurry transfer line primary boundary is a safety requirement. Figure 4-2 identifies the double-valve isolation pairs.

Valve pair ECRT-AOV-104/ECRT-CV-105, located inside the TLSB, consists of a ball valve followed by a check valve. These valves protect the interface between slurry transfer line ECRT-SLU-106 and IXM water line ECRT-H-708/-707, which supplies IXM water to the TLSB. Valve ECRT-AOV-104 is defined as a component of the safety-significant above-water slurry transfer line described in Section 4.4.1, “Above-Water Slurry Transfer Lines.” The primary concern for the backflow event at this interface is ECRT-H-707, which feeds the TLSB, rather than ECRT-H-708, which is the immediate interface inside the TLSB. ECRT-H-707 is a single hose and no secondary containment is provided.

The safety-significant valve pair ECRT-AOV-302/-103, located inside the TLSB, consists of two ball valves in series. These valves protect the interface between slurry transfer line ECRT-SLU-302 and IXM water line ECRT-H-708/-707, which supplies IXM water to the TLSB. Valve ECRT-AOV-302 is a defined component of the safety-significant above-water slurry transfer line described in Section 4.4.1. As previously discussed, the primary concern for the backflow event at this interface is the IXM water feed line located outside the TLSB (ECRT-H-707), rather than the short length of general service IXM water line (ECRT-H-708) provided with general service secondary confinement by the TLSB. It should be noted that this potential backflow event would be a result of the misrouting of slurry at three-way valve ECRT-V-102 and through ECRT-P-301, rather than the result of the failure of the primary isolation valve. Note that this scenario conservatively assumes that slurry backflows through the ECRT-P-301 internal check valves.

The valve pair ECRT-AOV-302/ECRT-V-301, located inside the TLSB, consists of two ball valves in series. These valves protect the interface between slurry transfer line ECRT-SLU-302 and overfill recovery line ECRT-SLU-300, which normally is capped where it enters the TLSB. As previously stated, valve ECRT-AOV-302 is defined as part of the safety-significant above-water slurry transfer line described in Section 4.4.1. As noted for the previous valve pair, this potential backflow event also is a result of the misrouting of slurry at three-way valve ECRT-V-102.
The valve pair ECRT-AOV-105/-106, located inside the TLSB, consists of two ball valves in series. These valves protect the interface between slurry transfer line ECRT-SLU-109 and decant/floculant recirculation line ECRT-H-209, which provides the decant feed to the TLSB. The primary concern for the backflow event at this interface is ECRT-H-209, which feeds the TLSB, rather than ECRT-SUP-210, which is the immediate interface. The feed line ECRT-H-209 is general service HIH. Valve ECRT-AOV-105 is defined as a component of the safety-significant slurry transfer line described in Section 4.4.1.

To protect the alignment of the air-operated ball valves of the double valve isolation pairs, air is secured to the actuators and the line vented with three-way valve ECRT-AOV-123. When handswitch ECRT-HS-123 is placed in the “disable” position from Safety Control Panel ECRT-PNL-103, ECRT-SOV-123 is de-energized which allows ECRT-AOV-123 to isolate and vent the instrument air lines to the air operators of the double-valve isolation valves.
Figure 4-2. Double-Valve Isolation Pairs
### Functional Requirements

Table 4-4 below identifies the functional requirement and associated performance criteria for double-valve isolation.

**Table 4-4. Double-Valve Isolation Functional Requirements and Performance Criteria**

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Valves ECRT-AOV-104, ECRT-CV-105, ECRT-AOV-302, and ECRT-AOV-103 shall prevent significant backflow of slurry into the TLSB IXM water supply line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin.</td>
<td>Valve seats (valve closed) shall be designed to prevent significant leakage (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).</td>
</tr>
</tbody>
</table>
| 2. Valves ECRT-AOV-104, ECRT-CV-105, ECRT-AOV-302, and ECRT-AOV-103 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin. | 1. Valves shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F (without slurry freezing).  
2. With the exception of ECRT-CV-105 (which is not exposed to slurry), valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids.  
3. Valve and check valve materials shall be capable of a total integrated dose of 1.1E+5 rad without failure. |
| 3. Valves ECRT-AOV-104, ECRT-AOV-302, and ECRT-AOV-103 shall be provided with valve position indication. | Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras. |
| 4. Valves ECRT-AOV-302 and ECRT-V-301 shall prevent significant backflow of sludge into the overfill recovery line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101, with an appropriate design margin. | Valve seats (valve closed) shall be designed to prevent significant leakage (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig). |
| 5. Valves ECRT-AOV-302 and ECRT-V-301 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin. | 1. Valves shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F (without slurry freezing).  
2. Valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).  
3. Valve and check valve materials shall be capable of a total integrated dose of 1.1E+5 rad without failure. |
<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Valves ECRT-AOV-302 and ECRT-V-301 shall be provided with valve position indication.</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
</tr>
<tr>
<td>7. Valves ECRT-AOV-105 and ECRT-AOV-106 shall prevent significant backflow of sludge into the decant/floculant recirculation line at a pressure that exceeds the burst pressure of rupture disk ECRT-PSE-101 with an appropriate design margin.</td>
<td>Valve seats (valve closed) shall be designed to prevent significant leakage (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig).</td>
</tr>
<tr>
<td>8. Valves ECRT-AOV-105 and ECRT-AOV-106 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with the transfer of slurry, with an appropriate design margin.</td>
<td>1. Valves shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F (without slurry freezing). &lt;br&gt;2. Valve seats (valve closed) shall be designed to prevent significant leakage after passing at least 1X the mission volume of slurry at 12 to 15 vol% solids (i.e., leak less than 0.1% of normal flow at a pressure difference of 220 psig). &lt;br&gt;3. Valve materials shall be capable of a total integrated dose of 1.1E+5 rad without failure.</td>
</tr>
<tr>
<td>9. Valves ECRT-AOV-105 and ECRT-AOV-106 shall be provided with valve position indication.</td>
<td>Ball valve open and closed position indication shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
</tr>
</tbody>
</table>
Table 4-4. Double-Valve Isolation Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Isolate the instrument air supply to safety- significant valves ECRT-AOV-103, -104, -105, -106, and -302 during sludge retrieval and transfer.</td>
</tr>
<tr>
<td>2.</td>
<td>Safety-significant handswitch ECRT-HS-123 shall be mounted on the Safety Control Panel ECRT-PNL-103 and de-energize to isolate the instrument air supply to the solenoids (SOVs) for the specified valve air actuators (AOVs).</td>
</tr>
<tr>
<td>3.</td>
<td>Safety-significant solenoid ECRT-SOV-123 shall de-energize when handswitch ECRT-HS-123 is placed in the “disable” position and safety-significant instrument air valve ECRT-AOV-123 shall close and remain closed when solenoid ECRT-SOV-123 is de-energized.</td>
</tr>
<tr>
<td>4.</td>
<td>Closing ECRT-AOV-123 shall isolate and vent instrument air from the SOVs for the specified valves.</td>
</tr>
<tr>
<td>5.</td>
<td>Closed position indication for ECRT-AOV-123 shall be suitable to confirm required alignment and shall be visible to an operator either by direct observation or by use of cameras.</td>
</tr>
<tr>
<td>6.</td>
<td>The three components above shall be capable of performing their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F.</td>
</tr>
</tbody>
</table>

AOV air-operated valve
SOV solenoid-operated valve

4.4.3.4 System Evaluation

The performance criteria identified in Table 4-4 characterize the specific operational responses and capabilities necessary for double-valve isolation to meet functional requirements. The following sections evaluate the capabilities of the double-valve isolation to meet the identified performance criteria.

Conservative Design Features—The design pressure for the above-water slurry transfer lines, including the first isolation valve, is 220 psig, as required by PRC-STP-00132, and the hydrostatic proof pressure required by ASME B31.3 is 330 psig. The process piping and instrumentation diagram (H-1-92301) specifies slurry transfer via Booster Pump ECRT-P-101A/B at a nominal pressure 100 psig, though a short-term peak of 135 psig was seen during MPAT. The maximum operating pressure expected during IXM line flushing operations at the TLSB is 100 psig, but the system is capable of 125 psig. This demonstrates that the normal operating pressures are significantly below the design pressure of the slurry transfer line (220 psig). To protect design margins provided by piping analysis, a rupture disk has been provided to relieve pressure at 115 psig.
The design ratings of valves and check valves providing double isolation for the above-water slurry transfer lines are, in many cases, significantly greater than the piping design rating. For example, the ball valves chosen as isolation valves for the above-water slurry transfer lines are a Flow-Tek\textsuperscript{19} Triad Series with a pressure rating of the shell of 1000 psig at 150°F and are leak tight at 580 psig. Based on the maximum operating pressure of 125 psig during IXM flushes, the design margin between the normal operating pressure and the pressure rating for leak tightness is 455 psig.

The valves seats of slurry transfer piping valves are ultra-high molecular weight polyethylene. This material is a long-chain thermoplastic that results in a material that has high impact strength, a low coefficient of friction, high chemical resistance, and a very high abrasion resistance. Valve seats of ultra-high molecular weight polyethylene are, therefore, recommended for highly abrasive chemical applications. Testing (PRC-STP-TR-00664) has shown that ball valves with these seats remain leak tight after passing 3 times the mission volume of slurry. This is judged to demonstrate that leakage in-service will not be significant per the corresponding functional requirement and performance criteria.

The double isolation valves are included in piping calculations 44577-M-CALC-026, 44577-M-CALC-030, and 44577-M-CALC-032.

Loads evaluated include normal and abnormal loads. Specific load cases evaluated include hydrostatic, sustained (normal), occasional (seismic plus normal), and an expansion case evaluating the ECRTS interior operating temperature range of 40° to 100°F. Resultant stresses were under allowable stresses by at least 25 percent for all load cases for all calculations, another significant design margin.

**Safe Failure Modes**—The isolation valves used for double-valve isolation are specified as full port ball valves with cavity fillers. With the exception of manual ball valve ECRT-V-301 and check valve, ECRT-CV-105, these valves are operated remotely, either from a control panel in the 105KW Annex Sludge Loading Bay, or from a control panel in the 105KW Basin administrative area. These valves are specified to fail in a closed position, making this the failure mode on loss of compressed air, loss of electrical power, or loss of signal. Closed is the safe position for their double-valve isolation safety function.

The valves are designed with suitable position indication to support visual verification of the required alignment (valve position) before initiating slurry transfer operations. This includes ECRT-AOV-123, which secures air (fail closed when de-energized) to the AOV actuators and vent the air in the lines to the actuators. Visual valve verification is primarily performed by viewing the air operator position indicators on the top surface/lid of the TLSB, and secondarily by viewing into the box through polycarbonate panels on the box sides. Each isolation valve has design features, including valve stops with contrasting colors, to allow verification that the valve is closed. Should fatigue or other failure of the valve drive train prevent the valve from fully closing, this deviation would be visually detectable. Fatigue analysis documented in PRC-STP-CN-M-00660 qualifies the drive train for unlimited cycles.

Check valve ECRT-CV-105 is configured to minimize the potential for slurry to adversely impact its ability to close when required. This valve is a swing check valve that is the secondary

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\textsuperscript{19} Flow-Tek is a registered trademark of Bray International, Houston, Texas.
valve for ECRT-AOV-104. To ensure its ability to perform this function, a swing check valve was tested (PRC-STP-TR-00664) in a configuration that allowed slurry to deadhead against the flapper of the valve. This extreme condition would not be anticipated, but nevertheless the check valve was leaktight at the conclusion of testing.

**Environmental Design**—The double isolation valves are qualified as a piping system in calculation 44577-M-CALC-026. The environmental extremes for the hard-piped portions of the system are specified as -27° to 110°F in PRC-STP-00132. These temperatures would have no adverse effect on the valves, provided liquids, if present, were not permitted to freeze.

With operable environmental controls, temperatures experienced inside the 105KW Basin and the 105KW Annex, where the double isolation valves are located, are expected to range from 65° to 80°F. Components used for double valve isolation are suitable for operation in the temperature range of 40° to 100°F.

Materials in the valves and check valve subject to damage from radiation within the 5-year design life include ultra-high molecular-weight polyethylene (UHMWPE) seats and EPDM seals. All materials in the piping system have a radiation resistance rating that exceeds the required capacity of 1.1E+5 rad, including 3.8E+5 rad rating for UHMWPE and a 1.0E+6 rating for EPDM. Teflon®, which is known to be more vulnerable, is not used in the double isolation valves.

The final radiation calculations for the above water slurry transfer line are documented in PRC-STP-CN-M-00562, which derives the 1.1E+5 rad requirement and demonstrates compliance. The 1.1E+5 rad requirement is conservatively based on an assumed year of exposure to contained radiological material at a dose rate of 12 rad per hour. In contrast, using the process flowsheet slurry transfer time of approximately 9 hours for the life of the facility, the dose would be approximately 110 rad.

The basis for erosion and corrosion is developed in calculation PRC-STP-CN-M-00562, and is supported with testing and K Basin operations experience. The erosion and corrosion allowance applied to above-water slurry pipe is 50 mil. The calculation concludes that the corrosion is significantly bounded by erosion from slurry within a 5-year design life. The erosion allowance is based on testing documented in PRC-STP-TR-00664, which showed the most erosion in pipe elbows and pipe tees when subjected to 3 times the mission volume of solids. The test included representative isolation valves and check valves, which showed no measurable erosion given their design-required configuration.

The first of the 2 double-valve isolation valves will be exposed to slurry. Also, for the decant/floculant line, both valves will be exposed to STSC supernate. As discussed above in, “Conservative Design Features,” the ball-valve seats are of UHMWPE, which is recommended for abrasive chemical applications. Testing of the isolation valves and check valves (PRC-STP-00664) has been performed to demonstrate that their safety function will be met for their design life cycle. The testing used 3 times the mission volume of solids, whereas the performance requirement is 1 times the mission volume. Based on the test results documented in

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20 Teflon is a registered trademark of E.I. DuPont Nemours and Company, Wilmington, Delaware.
PRC-STP-00946, Rev. 0

PRC-STP-TR-00664 and the short mission life of the facility, no in-service testing of ball valves and check valves will be performed.

Double-valve isolation is a preventive control, as such there are no accident environment conditions to consider.

Support Systems—The double-valve isolation pairs do not rely on support SSCs to perform their safety function. Although AOV operation depends on the availability of electrical power, instrument air, and the signal line to the valve, the valves are designed to fail closed should any of these support systems be interrupted. Additionally, the valves are verified to be closed and the handswitch (ECRT-HS-123) provides added assurance that the valves cannot change state during sludge retrieval and transfer. The operation of a check valve depends only on the difference in the fluid pressure on either side of the valve mechanism; this is inherently reliable in that backflow into the general service lines cannot occur unless the necessary differential is present.

Interface Design—As discussed in the Section 4.4.1.4, “System Evaluation,” double-valve isolation forms the interface between safety-significant above-water slurry transfer lines and the various general service lines that connect to them.

The interface between the air-operated double isolation ball valves and the instrument air actuation supplies and general service remote control (electrical) signals was recognized as a vulnerability and has been addressed by the provision of the safety-significant handswitch, solenoid, and instrument air isolation valve (ECRT-HS-123, ECRT-SOV-123, ECRT-AOV-123).

Specific Criteria—The double isolation valves are designed to comply with ASME B31.3. The double isolation valves are stainless steel and the materials are qualified to ASME B16.34 or API 594.

4.4.3.5 Controls (Technical Safety Requirements)

Isolation ball valves are active components in that can change state. Isolation ball valves are required to be in the correct position to perform their credited safety function. The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying the valve alignment and proper positioning of handswitch ECRT-HS-123 before initiating a slurry transfer.

Check valve ECRT-CV-105 is an active component in that it changes state to perform its safety function. However, it is an “off-the-shelf,” passive mechanical device with characteristics that are ensured through design and procurement. The check valve is not subject to change by Operations personnel and therefore is addressed in the TSRs as a design feature as described in Section 5.6.3, “Double-Valve Isolation Check Valve ECRT-CV-105.”

4.4.4 Seismic Shutdown Switches

4.4.4.1 Safety Function

The seismic shutdown switches are safety-significant because the facility worker radiological consequences of seismic-induced slurry spray release is clearly above 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The seismic shutdown switches are also safety-significant because a hydrogen explosion in the TLSB or
In-Basin/Horizontal Shielded Hose Chase can result in facility worker serious injury or death. Accordingly, the seismic shutdown switches have the following two safety functions:

1. Prevent a seismic-induced spray release of slurry by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.

2. Prevent a seismic-induced hydrogen explosion in the TLSB or In Basin/Horizontal Shielded Hose Chase by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.

The seismic shutdown switches actuate Safety Shutdown Interlock I-1 (see Section 4.4.5, “Safety Shutdown Interlock I-1”) to terminate sludge retrieval and transfer. The seismic sensors are credited with performing their safety function before and during an SDC-2 seismic event and with establishing a tripped state that requires manual reset.

4.4.4.2 System Description

Redundant seismic shutdown switches are mounted in two different locations: seismic shutdown switch VS-710-103A is floor-mounted adjacent to Safety Control Panel ECRT-PNL-103 in the Fuel Transfer System (FTS) Annex, and seismic shutdown switch VS-710-103B is floor-mounted on the north wall of the Sludge Loading Bay in the 105KW Annex. The diverse locations result in separate raceway routing between the switches and the safety control panel where Safety Shutdown Interlock I-1 receives their input.

Each switch receives three inputs from high sensitivity, triaxial piezo-electric accelerometers and activates the alarm relay when the signal from any axis exceeds the pre-set alarm level. The alarm relay will de-energize (open) to trip.

Either seismic shutdown switch in alarm will actuate Safety Shutdown Interlock I-1 to terminate slurry transfers. To provide indication of a trip condition to the Operators, a normally “on” general service seismic shutdown switch status light (ECRT-IL-133) on the safety control panel goes “off.”

The seismic shutdown switches and Safety Shutdown Interlock I-1 are designed to terminate slurry transfers at less than an acceleration of 0.2g. As discussed in Section 3.4.2.6.3, “Summary of Safety-Class and Safety-Significant SSCs, SACs and TSR Controls–Seismic Event,” the 0.2g value is based on potential seismic interactions between the 105KW Reactor stack and safety-significant components located in the 105KW Basin, FTS Annex, and Horizontal Shielded Hose Chase. The 0.2g value is more limiting than that associated with SDC-1, 2, and 3 design requirements.

4.4.4.3 Functional Requirements

Table 4-5 below identifies the functional requirements and associated performance criteria for the seismic shutdown switches.
Table 4-5. Seismic Shutdown Switches Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The seismic shutdown switches shall actuate Interlock I-1.</td>
<td>Inputs from the two seismic shutdown switches shall each suffice to actuate Interlock I-1.</td>
</tr>
<tr>
<td>2. The seismic shutdown switches shall function to remove power to Booster Pump ECRT-P-101A/B before a seismic event reaches SDC-2 levels and shall not restart the pump during or after the event without manual intervention.</td>
<td>Seismic shutdown switches shall be designed to SDC-2 requirements.</td>
</tr>
</tbody>
</table>
| 3. The seismic shutdown switch shall activate at less than an acceleration of 0.2g. | 1. Seismic shutdown switches shall be set to activate at less than an acceleration of 0.2g with allowance for applicable uncertainty.  
2. The seismic shutdown switch and Interlock I-1 components shall actuate Interlock I-1 within 2 seconds of the switch setpoint being exceeded. |
| 4. Seismic shutdown switches shall be fail-safe for more probable failure modes. | 1. The seismic shutdown switches shall actuate Interlock I-1 on loss of power, or loss of signal, or a trip/alarm is provided.  
2. Active components shall meet the single failure criterion.  
3. Switches shall be mounted in different locations with wiring separately routed. |
| 5. Seismic shutdown switches shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin. | Seismic shutdown switches shall be designed to perform their safety function in the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand the broader range of temperatures specified for the project of -27° to 110°F. |

4.4.4.4 System Evaluation

The performance criteria identified in Table 4-5 characterize the specific operational responses and capabilities necessary for the seismic shutdown switches to meet functional requirements. The following sections evaluate the capabilities of the seismic shutdown switches to meet the identified performance criteria.

Conservative Design Features—The seismic shutdown switches must be set to activate at less than an acceleration of 0.2g with allowance for applicable uncertainty. As documented in PRC-STP-00754, Sludge Treatment Project Engineered Container Retrieval and Transfer System Setpoint Determination Document, a design limit has been established at 60 percent of the 0.2g performance criteria, or 0.12g. To ensure a trip before the design limit acceleration, the seismic shutdown switch setpoint is 0.046g to allow for instrument uncertainty and to provide margin.

The seismic shutdown switch and Safety Shutdown Interlock I-1 are designed to perform their safety functions before, during, and to not repower ECRT-P-101A/B after an SDC-2 seismic event. Once a trip signal is received (switch is open), the Interlock I-1 cannot be reset without direct operator action at a reset key switch. However, the seismic shutdown switch will automatically
reset after 10 seconds if the seismic event has stopped. The setpoint, function before, during and after a seismic event were tested and the results recorded in Test Report PRO35381-TR-15, Section 7.3. The test report was further evaluated by 53921-02-RCI-CHPRC-044. These reports are part of submittal 53921-002-SUB-032 001.

The 2-second performance criterion has been established to ensure that the trip occurs prior to prolonged acceleration at levels up to the SDC-2 level. The calculated response time of less than one second ensures prompt control action when the setpoint is exceeded.

**Safe Failure Modes**—Components associated with Interlock I-1, including the seismic shutdown switches, are designed to be energized for normal operation to ensure that loss of electrical power or circuit interruption will actuate Interlock I-1.

The seismic shutdown switches are fail safe for loss of power or interruption of signal. Two redundant seismic shutdown switches are provided in compliance with the single failure criterion for Safety Instrumented Systems (SISs) established in PRC-STP-CN-CS-00776, “Failure Modes and Effects Analysis for Engineered Container Retrieval Transfer System Safety Instrumented Systems. Drawing H-1-92669, STP ECRTS Safety Control Panel ECRT-PNL-103 Wiring Diagram, depicts the two seismic shutdown switches and their connection to the interlock circuit.

Physical separation of the two switches limits the risk of other wiring damage, such as a hot short, defeating the safety function. Drawing H-1-92361, STP ECRTS I&C Plan, depicts the installation location and raceway plan for both switches.

The Interlock I-1 relays trip and remove power to the pump when either of the seismic shutdown switch contacts open during a seismic event. Once the Interlock I-1 relays trip, they cannot restore power to the pump if the seismic shutdown switch contacts reclose unless Interlock I-1 is manually reset by the operator. Therefore, once the seismic shutdown switches trip during a seismic event, they no longer have any safety function. Interlock I-1 has the safety function that it cannot restore power to the pump, after the relays have tripped, during or after a seismic event.

Postulated failure modes and causes were derived by examining technical data from published scientific literature, theory of operation, lessons learned, and manufacturer datasheets. Effects of the failures were derived by examination of piping and instrument diagrams. Analysis of the seismic shutdown switches determined that common mode failure is unlikely because the seismic sensors are installed in two diverse physical locations (in two different fire zones). The routing of the control wiring is also diverse. Use of the same seismic sensors for both trains could result in a vulnerability to common cause failure. Such a failure is not likely as the sensors are of a proven design used worldwide and will be regularly tested.

**Environmental Design**—The accelerometers and the seismic safety switches are rated to perform their safety function over a range of temperatures from -4°F to 158°F, which encompasses the project operating temperature range of 40°F to 100°F. The sensors themselves are hermetically sealed and not subject to humidity effects; the case for the switch is an outer weatherproof housing sealed to equivalent to a National Electrical Manufacturer’s Association (NEMA®) 4 rating to be splash-proof. There is no radiation identified in the

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21 NEMA is a registered trademark of the National Electrical Manufacturers Association, Rosslyn, Virginia.
installed environment although the equipment is rated to withstand 6700 rad over 40 years. The seismic shutdown switch can withstand up to a 6000g shock without damage. The ability of the equipment to meet these requirements is verified by the Syscom MRSK2002 Data Package including their Certificate of Conformance, the Technical Specification: MRSK2002 Seismic Switch and Strong Motion Recorder and Inspection Report No: CEQA-IR-15-439R1-658 (includes nonconformance report CEES-NCR-15-010). These documents are part of submittal 53921-002-SUB-032 001.

No concerns related to abnormal environmental conditions were identified for the seismic shutdown switches in PRC-STP-CN-CS-00776.

The seismic shutdown switches are a preventive control, as such there are no accident environment conditions to consider.

**Support Systems**—The seismic shutdown switches do not rely on support SSCs to perform the safety function of terminating slurry transfers. Although normal operation depends on availability of electrical power and the signaling line to the equipment, the seismic shutdown switches are fail-safe, in that loss of power to the switches, or signal from the switch, will actuate Safety Shutdown Interlock I-1 and terminate a slurry transfer. This function was verified by testing by FIT-0658, Step 40, which is included in submittal 53921-002-SUB-032 001 and by cold commissioning (MPAT) test procedure, PRC-STP-TPR-00961, *Procedure for Maintenance and Storage Facility Pre-operational Acceptance Testing for the Sludge Treatment Project Engineered Container Retrieval and Transfer System*.

**Interface Design**—The panels are powered by the general service 105KW Basin electrical distribution system. A loss of panel power will result in a loss of signal in the interlock loop, which will actuate Safety Shutdown Interlock I-1 and terminate a slurry transfer. The power supply is protected by fusing that is rated to protect the switch contacts from overcurrent. This provides adequate assurance that any fault in the general service power supply would not impair their safety function.

**Specific Criteria**—The general design requirements for the seismic shutdown switches derive primarily from NFPA 70, *National Electrical Code*, which governs its installation. The seismic shutdown switch is not required to be listed by an Occupational Safety and Health Administration approved Nationally Recognized Testing Laboratory because they use only 24 VDC.

The specific requirements pertinent to seismic design and qualification of the seismic shutdown switches are provided in IEEE 344, *Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations*.


Calibration of the seismic shutdown switches will be performed by tilting the unit either in place or on tilting table and measuring the trip angle. If the trip angle is between 2.5 and 3.7 degrees from horizontal, then it is tripping before 1.2g. The level used to measure the trip angle will be managed in accordance with the requirements of PRC-PRO-MN-490, *Calibration Management Program*. 

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4.4.4.5 Controls (Technical Safety Requirements)

The seismic shutdown switches are an active, engineered control. The switches and associated components must be operable to perform their credited safety function. An LCO/Surveillance Requirement (SR) has been established to ensure seismic shutdown switch and Safety Shutdown Interlock I-1 operability as described in Section 5.5.2.1, “Limiting Condition for Operation 3.1-Seismic Shutdown Switches and Safety Shutdown Interlock I-1.”

4.4.5 Safety Shutdown Interlock I-1

4.4.5.1 Safety Function

Safety Shutdown Interlock I-1 is safety-significant because the facility worker radiological consequences of seismic-induced slurry spray release is above 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. Interlock I-1 is also safety-significant because a hydrogen explosion in the TLSB or In-Basin/Horizontal Shielded Hose Chase can result in facility worker serious injury or death.

Safety Shutdown Interlock I-1 has the following safety functions:

- Prevent a seismic-induced spray release of slurry by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.
- Prevent a seismic-induced hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by terminating slurry transfers during sludge retrieval and transfer upon detection of seismic motion.

4.4.5.2 System Description

Safety Shutdown Interlock I-1 is actuated upon receipt of a seismic motion alarm from either redundant channel for the safety-significant seismic shutdown switches (see Section 4.4.4, “Seismic Shutdown Switches”).

Safety Shutdown Interlock I-1 is also actuated upon receipt of a leak alarm from either redundant channel of the general service leak detectors located in the STSC, TLSB and Ingress/Egress Assembly. In PRC-STP-00718, Preliminary Documented Safety Analysis for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, the TLSB and Ingress/Egress Assembly leak detectors were classified as safety-significant because they were judged to be major contributors to defense-in-depth. Accordingly, the leak detectors and associated components and wiring were procured as safety-significant. Subsequent to their approval of PRC-STP-00718, RL expressed concern that there were unnecessary controls that could have a negative impact on the conduct of operations and could result in a dilution of engineering/Design Authority/operator attention. Accordingly, meetings were held with and RL to identify where controls could be eliminated or reclassified. As a result of these meetings, it was determined that the leak detectors and associated components should be classified as general service and be credited with providing a defense-in-depth function; the primary control for the prevention of spray releases and hydrogen explosions in process enclosures being above-water slurry transfer lines as described in Section 4.4.1.

When actuated, Safety Shutdown Interlock I-1 removes electrical power from Booster Pump ECRT-P-101A/B and energizes audible and visual alarms at Safety Control Panel.
ECRT-PNL-103, located in the FTS Annex. Stopping Booster Pump ECRT-P-101A/B terminates a slurry transfer from the basin to an STSC during sludge retrieval and transfer. The Interlock I-1 actuation signal downstream of a safety-significant optical isolator (IY-701-103) also actuates the general service Decant Interlock I-2 and the Process Emergency Shutdown Interlock I-3.

Figure 4-3 summarizes the Safety Shutdown Interlock I-1 logic.

Note: All components are safety-significant with exception of IL-153, VFD, and ECRT-P-101A/B

**Figure 4-3. Safety Shutdown Interlock I-1 Logic**
Redundant contactors to interrupt 480 VAC power to the variable frequency drive (VFD) for Booster Pump ECRT-P-101A/B are mounted on the same rack as the Safety Control Panel ECRT-PNL-103. An additional redundant general service solenoid (ECRT-SOV-763) is also activated by Interlock I-3, which is triggered by Interlock I-1.

Components of Safety Shutdown Interlock I-1 are designed to be energized for normal operation. Loss of electrical power or circuit interruption will actuate Interlock I-1 and ensure its safety function.

4.4.5.3 Functional Requirements

Table 4-6 below identifies the functional requirements and associated performance criteria for Safety Shutdown Interlock I-1.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Interlock I-1 shall remove power from Booster Pump ECRT-P-101A/B</td>
<td>When actuated, Interlock I-1 shall open redundant contactors to removed 480 VAC power from the Booster Pump ECRT-P-101A/B VFD.</td>
</tr>
</tbody>
</table>
| 2. Interlock I-1 shall be fail-safe for more probable failure modes. | 1. Interlock I-1 shall be designed to be energized for normal operation so loss of electrical power or circuit interruption will actuate Interlock I-1.  
2. Active components shall meet the single failure criterion.  
3. Signal isolators shall be used to separate safety-significant functions of Interlock I-1 from inputs to general service circuitry.  
4. Safety-significant circuits shall be separated from general service circuits as appropriate to ensure that failure of a general service circuit does not cause the failure of a safety-significant circuit. |
| 3. Interlock I-1 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin. | 1. Interlock I-1 shall be designed to perform its safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F and to withstand or be replaced, if necessary, for the broader range of temperatures specified for the project of -27° to 110°F.  
2. Safety Control Panel ECRT-PNL-103 shall be NEMA 4X rated (at a minimum) to protect equipment from airborne hazards including dust, moisture and dust. |
| 4. Interlock I-1 shall function to remove power to Booster Pump ECRT-P-101A/B before a seismic event reaches SDC-2 levels and shall not restart the pump during or after the event without manual intervention. | Interlock I-1 shall be designed and installed to perform its safety functions to include receipt of seismic trip signals and the interruption of electrical power to ECRT-P-101A/B before a seismic event reaches SDC-2 levels and shall not restart the pump during or after the event without manual intervention. |
Table 4-6. Safety Shutdown Interlock I-1 Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Safety Control Panel ECRT-PNL-103 shall meet SDC-2 requirements.</td>
<td>Safety Control Panel ECRT-PNL-103 shall be designed and installed to perform its safety functions before, during, and after a seismic event in accordance with SDC-2 requirements.</td>
</tr>
</tbody>
</table>

4.4.5.4 System Evaluation

The performance criteria identified in Table 4-6 characterize the specific operational responses and capabilities necessary for Safety Shutdown Interlock I-1 to meet its functional requirements. The following sections evaluate the capabilities of Interlock I-1 to meet the identified performance criteria.

Conservative Design Features—Safety Shutdown Interlock I-1 is being implemented with rugged components chosen to be suitable for its safety function. Numerous design features for this application have been chosen to ensure reliability, including redundant active components and fail-safe features as discussed further in “Safe Failure Modes” below.

The Safety Shutdown Interlock I-1 actuation signal is transmitted through a safety-significant optical isolator (IY-710-103) to then also activate general service annunciators ECRT-ANN-101 and ECRT-ANN-201 in the basin operating area. Drawing H-1-92669 depicts the signal isolator and its connection to the interlock circuit.

When actuated, Safety Shutdown Interlock I-1 opens redundant contactors to remove 480VAC power from the Booster Pump ECRT-P-101A/B variable frequency drive. Drawing H-1-92669 depicts the redundant electrical contractors and their connection to the interlock circuit.

All these functions were verified by testing by the cold commissioning (MPAT) test procedure, PRC-TPR-00961.

Safe Failure Modes—Components of Safety Shutdown Interlock I-1 are designed to be energized for normal operation to ensure that loss of electrical power or circuit interruption will actuate Interlock I-1. Comparison of the redundant circuits from each leak detector and each seismic shutdown switch in Safety Control Panel ECRT-PNL-103 affords substantial assurance that damage to either circuit that does not open the circuit will nevertheless cause actuation of Interlock I-1. These devices are physically separated and consequently, the wiring connecting them to Safety Control Panel ECRT-PNL-103 is routed in raceways that are separated as well.

The above discussion applies for control power to Safety Shutdown Interlock I-1 and the actuating sensors, but does not apply to the 480 VAC power, for example, for ECRT-P-101A/B. The pump may be stopped and started many times either deliberately or due to failures affecting its power supply, but these events do not involve the leaks or seismic motions that warrant activation of Interlock I-1.

Safety Shutdown Interlock I-1 utilizes redundant components to ensure that a single active failure cannot defeat the safety function and thus complies with the single failure criterion for
SISs established in PRC-STP-CN-CS-00776. Key features include dual seismic shutdown switch inputs, dual outputs to ensure the required pump trip actions, and one-of-two trip logic for Interlock I-1. PRC-STP-CN-CS-00776 evaluates postulated failure modes and their effects, and demonstrates that no single failure compromises the safety functions.

All safety-significant wiring is separated from general service wiring in accordance with standard industry practices. Drawing H-1-92668, STP ECRTS Safety Control Panel ECRT-PNL-103 Assembly, depicts the safety-significant and general service wiring separation and implemented industry standard for the interlock circuit. As previously noted, the TLSB and Ingress/Egress Assembly leak detectors, formerly classified as safety-significant, have been re-classified as general service. The associated wiring and interface with Safety Shutdown Interlock I-1 were procured and installed as safety-significant and thus the separation requirement is met.

**Environmental Design**—The components of Safety Shutdown Interlock I-1 have the following vendor-rated temperature operating ranges:

- Interposing relay (PILZ® model PNOZ sigma series)
  - 14°F to 131°F
- Optical isolator (PR Electronics® model 9202)
  - -4°F to 140°F
- Electric contactor
  - -13°F to 140°F

These ranges ensure that Safety Shutdown Interlock I-1 is capable of performing its safety function over the range of temperatures encompassing the project operating temperature range of 40°F to 100°F with a significant margin in most instances. Compliance with this requirement was verified by a review of the Certificate of Conformance and product data sheets submitted as part of submittal 53920-008-SUB-020001, the Final Data Package for Safety Control Panel ECRT-PNL-103.

None of the components of Safety Shutdown Interlock I-1 are located in a significant radiation environment (PRC-STP-CN-CS-00776).

Safety Shutdown Interlock I-1 is designed to terminate slurry transfers (during sludge retrieval and transfer) before a seismic event reaches SDC-2 levels, and to not restart the pump during or after the event without manual intervention. Drawing H-1-92668 identifies the limit state and SDC-2 requirement and PRC-STP-00766, Safety Significant Control Panel Equipment Specification for the Sludge Treatment Project Engineered Container Retrieval and Transfer System flows down the verification requirements.

Components of Safety Shutdown Interlock I-1 are housed in Safety Control Panel ECRT-PNL-103. Safety Control Panel ECRT-PNL-103 is a NEMA 4X enclosure rated to protect against water ingress and entry of small, solid foreign objects (e.g., dust). The NEMA 4X rating was specified on Bill of Material H-1-92668 and verified by a review of the associated Certificate of Conformance.

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22 PILZ is a registered trademark of PILZ GMBH & Company, Germany.
23 PR Electronics is a registered trademark of PR Electronics, Denmark.
Safety Control Panel ECRT-PNL-103 is designed and installed to SDC-2 requirements both to prevent spray releases during slurry transfers and to prevent hydrogen explosions. Drawing H-1-92668 identifies the SDC-2 requirement and PRC-STM-00766 addresses verification requirements. The panels were tested according to test plans which were included in submittals 53920-008-SUB-020001, the Final Data Package for Safety Control Panel ECRT-PNL-103 and 53920-008-SUB-024001, the Final Data Package for ECRT-PNL-109A/B.

Safety Shutdown Interlock I-1 is a preventive control, as such there are no accident environment conditions to consider.

Support Systems—Safety Shutdown Interlock I-1 is supported by the general service 105KW Basin electrical power distribution system, but Interlock I-1 is actuated in the event of electrical power interruption, ensuring the safety function. The contactors, in particular, are equipped with springs to ensure a trip when they are de-energized.

Interface Design—Interfaces between Interlock I-1 circuitry and general service instrument circuits are protected with optical isolators designed to preclude feedback into the safety-significant circuits.

Non-safety components downstream of the 480 VAC electrical contactors have no separate electrical power source that might feed back to the safety-significant contactors and damage them or sustain operation of the Booster Pump, ECRT-P-101A/B, when the contactors are open. Interlock I-1 is powered by a general service electrical distribution system. A loss of power will actuate Interlock I-1 and trigger the control function. The potential for other modes of power supply failure to prevent Interlock I-1 from performing its safety function has been assessed. The maximum current through relay contacts for expected operation is approximately 1 amp, while the contacts are rated for 6-amp service. Given the limits on power output inherent in the power supply design and the use of overcurrent protection for compliance with NFPA 70, no mechanism for unsafe failure (i.e., one that defeats the Interlock I-1 function) has been identified.

Specific Criteria—The general design requirements for Safety Shutdown Interlock I-1 are derived primarily from NFPA 70. These requirements are applicable to the installation of Instrumentation and Control (I&C) systems design for general industrial use. Those components that are included as part of Interlock I-1 and that are also protected by Safety Control Panel ECRT-PNL-103 are listed and labeled to UL 508A, Industrial Control Panels, as an assembled industrial control panel.

4.4.5.5 Controls (Technical Safety Requirements)

Safety Shutdown Interlock I-1 utilizes active, engineered components. Components must be operable to perform their credited safety function when applicable. An LCO/SR has been established to ensure seismic shutdown switch and Safety Shutdown Interlock I-1 operability as described in Section 5.5.2.1, “Limiting Condition for Operation 3.1-Seismic Shutdown Switches and Safety Shutdown Interlock I-1.”

4.4.6 Auxiliary Ventilation System

4.4.6.1 Safety Function

The Auxiliary Ventilation System is safety-significant because a hydrogen explosion in an STSC can result in facility worker serious injury or death.
The safety function of the Auxiliary Ventilation System is to prevent a hydrogen explosion in an STSC by preventing flammable hydrogen concentrations during sludge retrieval and transfer and STSC inerting activities.

The Auxiliary Ventilation System is also credited with preventing a fire-induced hydrogen explosion in an STSC by preventing flammable hydrogen concentrations, including preventing damage to the STSC inlet hose that could interrupt Auxiliary Ventilation System flow.

In addition, the Auxiliary Ventilation System is credited with preventing a hydrogen explosion in an STSC induced by a seismic, wind, or snow/ashfall event, lightning strike, or vehicle impact by preventing flammable hydrogen concentrations during sludge retrieval and STSC inerting activities.

4.4.6.2 System Description

If the general service Process/Exhaust Ventilation System fails to maintain the requisite flow rate through the STSC, the Auxiliary Ventilation System is automatically actuated. The system flows nitrogen gas, supplied from high-pressure cylinders, through the STSC to maintain the hydrogen concentration in the headspace below 25 percent of the LFL. To enhance reliability, the system design provides two separate trains (Train A and Train B), either of which is capable of performing the safety function. Figure 4-4 provides a simplified system drawing of the Auxiliary Ventilation System. For presentation purposes, the figure shows a single train.

The availability of auxiliary ventilation is verified prior to initiating slurry transfer operations. While the STSC is being filled, auxiliary ventilation affords a standby means for controlling the STSC hydrogen concentration should normal ventilation for the STSC be interrupted for any reason. The system has sufficient nitrogen to ensure a minimum of 96 hours of operability. This provides an adequate time period to detect actuation of the Auxiliary Ventilation System and to restore normal process ventilation. The Auxiliary Ventilation System remains operable and available to limit the hydrogen gas concentration in an STSC until the loaded STSC is inerted prior to transfer to T Plant.

Dedicated supplies of nitrogen gas are provided from nitrogen cylinder cradles (ECRT-PURGE-602A/B) located outside along the north side of the 105KW Annex. Because this location is adjacent to the road (for ease of nitrogen cylinder cradle delivery), Jersey Barriers are used to protect the nitrogen supply from vehicle impacts.

Each cradle contains 12 cylinders, each of which has a minimum water capacity of 64.7 L (2.28 ft\(^3\)). “Water capacity” is a term commonly used in the compressed gas cylinder industry catalogs, webpages, etc. It is defined as the volume of water that could be contained by a cylinder, and is provided to differentiate between the physical volume of the cylinder and the compressed gas capacity.
Figure 4-4. Auxiliary Ventilation System
To maintain the gas inventory in the auxiliary ventilation supply cylinders (ECRT-PURGE-602A/B), nitrogen gas is preferentially supplied to the Auxiliary Ventilation System by a safety-significant portion of the inert gas supply system (ECRT-PURGE-601A). The inert gas pressure control valve (ECRT-PCV-601) is set to supply gas to a common safety-significant header at a nominal pressure of 200 psig. The auxiliary ventilation supply regulators (ECRT-PCV-611 and ECRT-PCV-621) are set at a nominal 150 psig ensuring that they will provide required nitrogen gas if the inert gas supply runs out or otherwise becomes unavailable. Backflow from the auxiliary ventilation supply into the general service portions of the Inert Gas System is prevented by safety-significant check valves for each auxiliary ventilation train (ECRT-CV-612 and ECRT-CV-622). The purpose of preferential supply from the Inert Gas System is to maintain the necessary gas inventory in the Auxiliary Ventilation System to meet the 96-hour requirement while minimizing the need to refill the Auxiliary Ventilation System gas cylinders.

Nitrogen from the cylinder cradles is directed through stainless steel-lined, braided, and armored hoses to the exterior wall of the 105KW Annex where it connects to stainless steel tubing. The nitrogen is then routed through the stainless steel tubing (supported by 3/8 in. thick 4 in. by 6 in. stainless steel angle) to Nitrogen Supply Panel ECRT-ME-602, which is mounted on the exterior west wall of the Sludge Loading Bay.

Nitrogen Supply Panel ECRT-ME-602 contains the Auxiliary Ventilation System pressure reduction and flow control equipment for both Trains A and B. For Train A, the nitrogen pressure supplied from ECRT-PURGE-602A is displayed on PI-760-611, and a safety-significant pressure gauge mounted on the ECRT-PURGE-602A gas cylinder supply manifold. The nitrogen cylinder pressure is reduced to 150 psig by pressure control valve ECRT-PCV-611. Nitrogen is then directed to a second pressure control valve (ECRT-PCV-614) with a nominal set pressure of approximately 40 psig. After ECRT-PCV-614 is an 80 psig outlet pressure safety valve (ECRT-PSV-614). The pressure regulated by ECRT-PCV-614 supplies a controlled, consistent driving force across porous metal flow restrictor ECRT-FO-611, controlling the nitrogen flow rate supplied by Auxiliary Ventilation System Train A. The nitrogen flow rate is displayed on rotameter FI-760-612; the observed flow rate can be corrected to standard temperature and pressure using PI-760-616 and TI-760-612 located near the inlet to the rotameter. Duplicate equipment is provided on the Nitrogen Supply Panel for Train B.

From Nitrogen Supply Panel ECRT-ME-602, the nitrogen gas supply tubing for Trains A and B is individually routed through pass-through penetrations in the 105KW Annex wall and into the Sludge Loading Bay. Inside the Sludge Loading Bay, the tubing (again supported by 3/8 in. thick 4 in. by 6 in. stainless steel angle) is routed to Nitrogen Purge Panel ECRT-ME-601 mounted on the west wall of the Sludge Loading Bay.

For Train A, Nitrogen Purge Panel ECRT-ME-601 contains safety-significant solenoid valve ECRT-SOV-612 that initiates nitrogen flow when required, and safety-significant flow meter, FE/FIT-760-613. Duplicate equipment is provided for Train B.

At Nitrogen Purge Panel ECRT-ME-601, Train A and B join in a single line that is interconnected to the general service Inert Gas System. Backflow from the safety-significant auxiliary ventilation supply into the general service portions of the Inert Gas System is prevented by safety-significant check valve ECRT-CV-605. The interconnection allows supplemental nitrogen flow from the Inert Gas System to the STSC purge inlet during inerting of the STSC.
From Nitrogen Purge Panel ECRT-ME-601, nitrogen is routed through tubing supported by either stainless steel 3/8 in. thick 4 in. by 6 in. angle or Unistrut® channel to where the tubing joins at a tee with the Low Pressure Air Purge Piping assembly (ECRT-ME-604). The Low Pressure Air Purge Piping assembly includes the room inlet airline and redundant safety-significant flow sensors (ECRT-FE/FIT-760-651 and -652), which monitor the air flow to the STSC and provide input to Auxiliary Ventilation Control Panel ECRT-PNL-602.

At Auxiliary Ventilation Control Panel ECRT-PNL-602, the signal from Auxiliary Ventilation Train A flow sensor ECRT-FE/FIT-760-651 is routed to a signal isolator FY-760-651 (allowing the signal to connect to both safety-significant and general service instrumentation) then to safety-significant low flow current switch FSL-760-651, then to safety-significant time delay relays FKK-760-651-1 and -651. Five minutes after FSL-760-651 detects inadequate purge flow (i.e., less than 1 scfm) through the STSC, FKK-760-651-1 removes power from associated solenoid ECRT-SOV-612 thereby initiating Train A Auxiliary flow of at least 0.5 standard cubic feet per minute (scfm). At the same time, FKK-760-651 also removes power from outdoor light ECRT-IL-651 that is normally illuminated to indicate normal STSC ventilation flow. At ECRT-PNL-602, Train B has independent, duplicate controls like those discussed above for Train A.

Components of the Low Pressure Air Purge Piping ECRT-ME-604 are designated safety-significant up to and including the fail-closed vacuum breaker/back flow preventer ECRT-PCV-632 and -633; by design, these vacuum breakers will not permit backflow from the Auxiliary Ventilation System to the room air inlet. Pressure safety valve ECRT-PSV-612 protects pressure controls valves ECRT-PCV-632 and -633 from over-pressurization. The peak pressure associated with actuation of the Auxiliary Ventilation System solenoid valve was observed to be 0.19 psig during testing (STP-GAH-17-001, “Auxiliary Ventilation System Supplemental Data Testing”). This very low system back pressure ensures that the 8 psig setting of ECRT-PSV-612 is not challenged. ECRT-PSV-612 is a code-compliant pressure relief valve that is considered an active design feature. Active components of the Auxiliary Ventilation System must meet single failure criterion for more probable failure modes. Creating excessive backpressure pressure in the Low Pressure Air Purge Piping is a low probability event. Therefore a single pressure relief valve is sufficient. Hose ECRT-H-604 connects the permanent inlet piping to the STSC. The inlet hose utilizes corrugated stainless steel with a braided stainless steel cover to achieve the high temperature rating (greater than or equal to 800°F) specified for fire resistance.

The exhaust pathway for the flow provided to the STSC through the purge inlet line (whether that flow is coming from normal ventilation room air, the Inert Gas System, or the Auxiliary Ventilation System) is through the safety-significant purge outlet line (ECRT-H-659 to ECRT-NIT-401) to the exhaust ventilation system. When connected, general service STSC vent hose ECRT-H-501 to ECRT-AIR-400, also provides a flow path to the exhaust ventilation system. For normal ventilation operation, an exhaust fan induces the room air inlet flow and

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24 Unistrut is a registered trademark of Unistrut International, Wayne, Michigan.

25 While the normal ventilation hose is being disconnected prior to the start of inerting, startup of the Auxiliary Ventilation System is not appropriate as it would increase the pressure in the STSC and potentially compromise the contamination control strategy pending closure of the now unused Nozzle F1. Removal of ECRT-H-501 from
vacuum breakers near the room air inlet HEPA filter maintain the STSC at a negative pressure of at least 1 in. of water. Auxiliary ventilation flows are sufficiently low that the STSC will remain negative after actuation of the Auxiliary Ventilation System as long as the exhaust fan is running. Without the exhaust fan running a slight positive pressure is created in the STSC. Purge discharge will flow to other interconnected air spaces; the discharged gasses are not combustible (less than 1 percent hydrogen).

There is an option for manual actuation of auxiliary ventilation flow from outside the facility that is provided by ECRT-V-666 and -676, respectively. These valves open a bypass around solenoid valves ECRT-SOV-612 or -622 and the corresponding manual isolation valves (ECRT-V-667 and -677) that are located inside the facility. A decision to manually actuate either train could be made if flow sensors FI-760-612 or -622 indicated inadequate auxiliary ventilation flow (i.e., less than 0.5 scfm) when the nearby STSC normal ventilation indicator light(s) are off. The flow sensors are mounted on Nitrogen Supply Panel ECRT-ME-602 which is located on the exterior west wall of the Sludge Loading Bay.

Proper valve alignment is important for the Auxiliary Ventilation System to be operable. One manual valve in each train (ECRT-V-667 and -677), for example, is located inside the Sludge Loading Bay in series with the automatic actuation valve for the train (ECRT-SOV-612 and -622). These valves must be verified to be open before the facility is evacuated to initiate a transfer operation. Valves on individual gas cylinders or their headers will also defeat the safety function if not left open. Proper valve alignment is confirmed by a functional test of the Auxiliary Ventilation System performed for each STSC (see Section 5.5.2.2, “Limiting Condition for Operation 3.2-Auxiliary Ventilation System”).

To regulate the Auxiliary Ventilation System to ensure both sufficient flow and adequate tank capacity, safety-significant flow-restricting orifices ECRT-FO-611 and -612 are located in Nitrogen Supply Panel ECRT-ME-602. These orifices serve to meter the supplied flow upon actuation of the Auxiliary Ventilation System to ensure sufficient flow to perform the hydrogen dilution safety function, but not so much flow that the 96-hour nitrogen supply could be depleted prematurely.

Train A and Train B are each provided with two, 12-cylinder cradles. A single cradle, if completely full, can supply 96 hours of nitrogen flow. Two cradles are provided, however, to avoid having to declare the system inoperable and refill essentially full nitrogen cylinders should minor leakage occur or if operability testing is performed. Local safety-significant pressure gauges are installed on all the Auxiliary Ventilation System cylinder cradle manifolds. These gauges allow verification that the cylinders contain nitrogen pressure sufficient to ensure greater than 96 hours of nitrogen flow. Periodic monitoring of the STSC ventilation normal lights ECRT-IL-651 and -652 ensures that the Auxiliary Ventilation System can be manually

Nozzle F1 reduces the measured airflow through the STSC enough that the low flow switches would actuate the Auxiliary Ventilation system. Because of this, a 5-minute time delay is provided to temporarily delay the opening of the solenoid valves ECRT-SOV-612 and -622 for Trains A and B. A 5-minute delay does not impair the safety function as it takes greater than 30 minutes for hydrogen to accumulate to 1 percent even at the bounding generation rate (PRC-STP-CN-N-00935, Sludge Treatment Project – Thermal and Gas Analyses of the Process/Exhaust and Auxiliary Ventilation Systems for the Sludge Transport and Storage Container (STSC) in the 105-KW Annex Building).
connected to the spare 12-cylinder cradle prior to the depletion of the nitrogen inventory in the connected cylinders.

### 4.4.6.3 Functional Requirements

Functional requirements and associated performance criteria for the Auxiliary Ventilation System are identified in Table 4-7.

#### Table 4-7. Auxiliary Ventilation System Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Auxiliary Ventilation System shall automatically actuate on loss of normal STSC ventilation.</td>
<td>ECRT-SOV-612/622 shall open if the room airflow rate into the STSC ventilation intake pipe is &lt; 1.0 scfm actual flow.</td>
</tr>
<tr>
<td>2. The Auxiliary Ventilation System shall maintain the hydrogen concentration at or below 25% of the LFL in air for the maximum sludge quantities allowed for interim storage.</td>
<td>Each train of the Auxiliary Ventilation System shall be capable of delivering a minimum of 0.5 scfm of nitrogen to the STSC when ECRT-SOV-612/622 are open.</td>
</tr>
<tr>
<td>3. The Auxiliary Ventilation System shall be fail safe for more probable failure modes.</td>
<td>1. ECRT-SOV-612/622 shall open: • If there is a loss of signal from FE-760-651 or -652. If there is no power to panel ECRT-PNL-602. 2. Safety-significant components (e.g., check valves, signal isolators) shall protect interfaces with non-safety systems. 3. Once initiated, auxiliary ventilation flow shall be passively maintained unless normal ventilation is restored. 4. Active components shall meet the single failure criterion.</td>
</tr>
<tr>
<td>4. The Auxiliary Ventilation System shall be designed to maintain the combustible concentration at or below 25% of the LFL for a period of 96 hr.</td>
<td>1. The quantity of nitrogen available in the Auxiliary Ventilation System shall be a minimum of 5422 gram moles with an appropriate design margin. 2. The maximum nitrogen flow rate shall be 0.8 scfm.</td>
</tr>
<tr>
<td>5. The Auxiliary Ventilation System shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions associated with an appropriate design margin.</td>
<td>1. Auxiliary ventilation components installed indoors shall be designed to perform their safety function over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F. Auxiliary ventilation components located outdoors shall be suitable for operation over an ambient temperature range of -27° to 110°F. 2. Auxiliary Ventilation Control Panel ECRT-PNL-602 shall be NEMA 4X rated (at a minimum) to protect equipment from airborne hazards including moisture and dust. 3. Nitrogen Supply Panel ECRT-ME-602 shall be NEMA 3R rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.</td>
</tr>
</tbody>
</table>
Table 4-7. Auxiliary Ventilation System Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Auxiliary Ventilation System STSC inlet hose ECRT-H-604 shall be of noncombustible construction.</td>
<td>Inlet hose ECRT-H-604 shall be of stainless steel construction rated for a temperature of at least 800°F.</td>
</tr>
<tr>
<td>7. The Auxiliary Ventilation System shall meet SDC-1 requirements.</td>
<td>The Auxiliary Ventilation System shall be shown to meet SDC-1 seismic requirements.</td>
</tr>
<tr>
<td>8. Vulnerable portions of the Auxiliary Ventilation System shall be designed for PC-2 wind loads as defined in PRC-PRO-EN-097.</td>
<td>Vulnerable portions of the Auxiliary Ventilation System shall withstand a 91 mi/hr wind.</td>
</tr>
<tr>
<td>9. Vulnerable portions of the Auxiliary Ventilation System shall be designed for PC-2 snow and ashfall loads as defined in PRC-PRO-EN-097.</td>
<td>Vulnerable portions of the Auxiliary Ventilation System shall withstand a 20 psf load for snow and ashfall combined.</td>
</tr>
<tr>
<td>10. Vulnerable portions of the Auxiliary Ventilation System shall be protected against vehicle impact.</td>
<td>Vulnerable portions of the Auxiliary Ventilation System shall be protected by DOT Type 2 Jersey Barriers.</td>
</tr>
</tbody>
</table>

4.4.6.4 System Evaluation

The performance criteria identified in Table 4-7 characterize the specific operational responses and capabilities necessary for the Auxiliary Ventilation System to meet functional requirements. The following sections evaluate the capabilities of the Auxiliary Ventilation System to meet the identified performance criteria.

Information presented in this section is derived from engineering calculations, specifications, and design drawings.

Conservative Design Features—The Auxiliary Ventilation System is designed to provide a flow rate through the STSC that will maintain the hydrogen concentration below 25 percent of the LFL for hydrogen. As documented in calculation PRC-STP-CN-N-00935, given a hydrogen generation rate of 175 L per day (PRC STP CN N 00935, Case 6.2), a nitrogen flow rate of 0.5 scfm from a single train will maintain the hydrogen concentration in an STSC below 25 percent of the LFL for greater than 96 hours, and below the LFL indefinitely. With each train providing a flow rate of 0.5 scfm (i.e., 1 scfm total), the hydrogen concentration in an STSC is maintained below 25 percent of LFL indefinitely. Higher hydrogen generation rates can be calculated (e.g., PRC STP CN N 00935, Case 6.3). However, the 175 L/day value is judged to be reasonably conservative given the conservative nature of the assumptions used in the analysis.

Redundant flow switches ensure the actuation of the Auxiliary Ventilation System if the normal ventilation flow drops below 1.0 scfm. As documented in PRC-STP-00754, based on the accuracy of the flow instrumentation, signal isolators and current switches, a setpoint of 1.6 scfm has been selected to ensure actuation at 1.0 scfm.

The Auxiliary Ventilation System is required to provide a minimum flow rate of 0.5 scfm. As documented in PRC-STP-00754, based on the accuracy of the flow instrumentation, a minimum
flow rate setpoint of 0.063 scfm has been selected. Verification of the flow rates and setpoints will be performed as part of 105KW Basin/Annex Pre-Operational Acceptance Testing (KPAT).

A functional requirement specified for the Auxiliary Ventilation System is that it be designed to maintain the combustible concentration at or below 25 percent of the LFL for a period of 96 hours. The associated performance criterion requires the quantity of nitrogen available in the Auxiliary Ventilation System to be a minimum of 5422 gram moles with an appropriate design margin. The 96 hours is provided by an installed 48-hour capacity, and a reserve 48-hour capacity. Changeover from the installed to the reserve capacity requires operator action.

A minimum pressure of 1357 psig is required to ensure that each nitrogen cylinder cradle can supply nitrogen for 48 hours. A minimum pressure setpoint of 1500 psig has been selected to provide a significant design margin.

As documented in calculation PRC-STP-CN-M-00752, STP ECRTS – Inert Gas System Auxiliary Ventilation System Cylinder Sizing Analysis, the 5422 gram moles would be an adequate inventory of nitrogen to flow up to 0.8 scfm for 96 hours. Dedicated supplies of nitrogen gas are provided for the two trains of the Auxiliary Ventilation System from nitrogen cylinder cradles (ECRT-PURGE-602A/B) located outside on the north side of the 105KW Annex. Each cradle contains 12 cylinders with a minimum void space “water capacity” of 64.7 L (2.28 ft³). Each entire 12-cylinder cradle provides a total void space of 776 L or 27.4 ft³. The DOT Service Pressure of the cylinders is 2400 psi at 70°F, and the allowed 10 percent overfill pressure is 2640 psi at 70°F. At the standard fill temperature of 70°F, and with the allowed 10 percent overfill pressure, a cradle of 12 cylinders contains approximately 5670 gram moles of nitrogen. While calculation PRC-STP-CN-M-00752 indicates that a completely full 12-cylinder cradle is capable of providing 96 hours of nitrogen flow at 0.8 scfm, the project has chosen to install spare nitrogen cylinder cradles so that each Auxiliary Ventilation System cylinder cradle can have close to a 50 percent operational margin to ensure that the Auxiliary Ventilation System remains operable even if a large portion of the gas inventory is consumed.

To ensure that the Auxiliary Ventilation System has adequate inventory to provide nitrogen flow for at least 96 hours, the maximum allowed flow rate is 0.8 scfm. PRC-STP-CN-M-00752, demonstrates that approximately 50 percent of the available inventory in full cylinders is adequate to provide a flow rate of 0.8 scfm for 48 hours. The flow meters used to establish the flow rate have a maximum flow rate setpoint of 0.67 scfm to ensure that the actual flow rate does not exceed 0.8 scfm.

It is noted that the required flow rate of 0.5 scfm is designed to control the hydrogen concentration to no more than 25 percent of the LFL in air whereas the Auxiliary Ventilation System uses nitrogen. The atmosphere in the STSC will thus trend toward lower oxygen concentrations with the introduction of nitrogen.

Safe Failure Modes—The Auxiliary Ventilation System is actuated automatically on detection of normal ventilation inlet flow at a rate approaching the minimum required flow rate of 1.0 scfm. To maximize operability and enhance reliability, as shown in the failure modes and effects analysis (PRC-STP-CN-CS-00776), the auxiliary ventilation design provides two separate trains, either of which is capable of performing the safety function. Thus, auxiliary ventilation complies with the single failure criterion for SISs established in PRC-STP-CN-CS-00776. Redundant flow signal isolators and current switches trigger the opening of a solenoid valve in
each redundant train (ECRT-SOV-612 and -622). As documented in PRC-TP-00933, Safety Significant Auxiliary Ventilation Equipment Specification for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, these valves are specified to fail open on removal of power (from a trip due to low STSC airflow, from loss of power to panel ECRT-PNL-602, on loss of signal from FE/FIT-760-651 or -652, or on loss of signal to the solenoids). These requirements were verified by the Commercial Grade Dedication Package (CGD-15-CHP-166-13) and the Fabrication, Inspection, and Test Plan (FP-1507-CHP-166-009), which were submitted in the Final Data Package for ECRT-PNL-602 (53920-008-SUB-064 001).

Pressure and flow indication at ECRT-ME-602 afford the means to verify proper system operation from outside the facility. There are manual valves available to bypass solenoid valves ECRT-SOV-612 or -622, if necessary. At least two 12-cylinder nitrogen cradles will be provided for each train of the Auxiliary Ventilation System to support STSC loading. The use of the same cylinder design for the Inert Gas and Auxiliary Ventilation Systems, each designated safety-significant, helps both to manage the nitrogen gas inventory and to ensure backup gas is available.

Use of a porous metal filter in the flow restrictor rather than an orifice reduces the potential for plugging. The high purity nitrogen supply is also free of particulates and moisture, reducing the potential for failure of downstream components due to these potential contaminants.

Safety-significant vacuum breaker/back flow preventers ECRT-PCV-632 and -633 at the interface between the room air intake and the Auxiliary Ventilation System are designed and verified to fail closed.

Environmental Design—The Auxiliary Ventilation System is credited with preventing a hydrogen explosion; therefore, no design requirements have been specified for post-hydrogen explosion environmental conditions. As documented in 44577-S-CALC-002, Natural Phenomena Hazard Loads; PRC-TP-CN-M-00769, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Stress Analysis of the Transport System Gas Bottle Rack; 44577-M-CALC-015, Gaseous Nitrogen Pipe Stress Evaluation; and 44577-M-CALC-023, Piping Support Evaluation; the system is designed to SDC-1 seismic requirements and to PC-2 requirements for wind, snow, and ashfall loads.

The Auxiliary Ventilation System nitrogen supply cylinders are located on the north side of the 105KW Annex, away from potential missile hazards originating from equipment failures in the Mechanical Equipment Room (e.g., air receiver tank failure). Type 2 Jersey barriers will be provided to protect the nitrogen supply cradles from vehicle impact.

Interior portions of the Auxiliary Ventilation System are protected by the 105KW Annex structure. Snow loading in calculation 44577-S-CALC-002 considers design criteria established for PC-3 (more conservative than the PC-2 requirement) in PRC-PRO-EN-097 in determining roof loads, including roof snowdrift. Values for snow and ash loading are per PRC-PRO-EN-097, Section 2.5.6, as shown in the roof snow load diagram in calculation 44577-S-CALC-002. As the base snow load accounted for is 20 psf, no additional ash loading is specified, in accordance with PRC-PRO-EN-097, Section 2.5.6.

Wind loading in calculation 44577-S-CALC-002 considers design criteria established for PC-2 in PRC-PRO-EN-097 in determining main wind force resisting system wind loads and
component wind loads. Design wind speed and exposure category are identified on H-1-96799, *Structural General Design Notes and Legend*.

The selected Auxiliary Ventilation System components are rated to perform their functions over the range of indoor and outdoor temperatures as specified in the auxiliary ventilation equipment specification (PRC-STP-00933). The all-stainless steel Swagelok<sup>26</sup> FJ series hose used to connect the auxiliary ventilation supply to the STSC has a pressure rating above 300 psi over an operating temperature range from -325° to 800°F ensuring normal operation and the required fire resistance. The supply hose is also provided with a fire jacket to facilitate decontamination (if required) that also provides some additional thermal protection. The hose used to connect the STSC purge outlet is rated to operate over a temperature range from -40° to 200°F. The regulators and outside nitrogen supply equipment are rated to operate over a temperature range from -40° to 140°F. The pressure relief valves are rated to operate over a temperature range from -40° to 200°F. The rotameter is rated to operate over a temperature range of -112° to 392°F.

Given the Auxiliary Ventilation System equipment locations, radiation levels are not a design consideration.

Nitrogen Supply Panel ECRT-ME-602 is NEMA 3R rated. The rating is shown on Bill of Material H-1-92566 and was verified by a review of the associated Certificate of Conformance. Auxiliary Ventilation Control Panel ECRT-PNL-602 is NEMA 4X rated. The rating is shown on Bill of Material H-1-92753 and was verified by a review of the associated Certificate of Conformance.

Nitrogen Purge Panel ECRT-ME-601 is not a typical panel but rather is a rack with a sheet metal top plate that provides some protection to the safety-significant solenoid valves that open to allow nitrogen gas flow to the STSC, safety-significant valves, tubing and flow meters, the safety-significant check valves that prevent backflow from the Auxiliary Ventilation System to the Inert Gas System, and various general service Inert Gas System pressure and flow indicators. The solenoid valves and electronic flow meters are provided with NEMA 4X watertight covers, and the check valve does not require water protection. Therefore, the rack provides partial enclosure and is not NEMA rated.

Low pressure air purge piping ECRT-ME-604 is also a rack. The safety-significant flow elements that measure the airflow into the STSC, safety-significant pressure control valves, and general service room air inlet components are mounted on this rack. Safety-significant instruments are provided with their own NEMA 4X enclosures; therefore, the rack is not NEMA rated. All Auxiliary Ventilation System panels/racks are seismically qualified per SDC-1 requirements.

Besides dust, the NEMA rating of the panels and rack-mounted components protect against suspended ash in the event of a volcanic eruption. In addition, Auxiliary Ventilation System wiring, both power and instrument, is located within conduit or cable trays within the 105KW Annex and within conduit if outdoors such that ash will not come in to direct contact with wiring. Auxiliary Ventilation System panels, instruments, and components are installed in accordance with National Electric Code (NEC) 2014, article 250, “Grounding and Bonding.”

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<sup>26</sup> Swagelok is a registered trademark of the Swagelok Company, Solon, Ohio.
The conductive cases of the panels, instruments, and conduit are grounded such that a static charge, if caused by ash, will be directed safely to ground without affecting system operability.

The Auxiliary Ventilation System is a preventive control, as such there are no accident environment conditions to consider.

**Support Systems**—The Auxiliary Ventilation System does not rely on the operability of support SSCs for performance of its safety function. As stated in the “Safe Failure Modes” subsection above, valves ECRT-SOV-612 and -622 fail open on loss of power or loss of signal.

**Interface Design**—The Auxiliary Ventilation System interfaces with portions of the general service Process/Exhaust Ventilation System and the Inert Gas System.

The Auxiliary Ventilation System interfaces with the Inert Gas System in two places: Nitrogen Supply Panel ECRT-ME-602 and Nitrogen Purge Panel ECRT-ME-601. In each case, a safety-significant check valve precludes Auxiliary Ventilation System flow into the general service Inert Gas System. Shared components, including piping, on the auxiliary ventilation side of the check valves are designated safety-significant.

The Auxiliary Ventilation System interfaces with the Process/Exhaust Ventilation System downstream of Nitrogen Purge Panel ECRT-ME-601 where the room air inlet line joins the purge inlet line in a tee intersection. Components of the room air inlet line upstream of the tee are located on low air purge piping ECRT-ME-604 and are designated safety-significant up to and including the fail-closed vacuum breaker/back flow preventer ECRT-PCV-632 and -633. In the event of loss of STSC negative pressure (due to loss of electrical power or other problems with the normal ventilation system) spring loaded vacuum breaker/back flow preventer ECRT-PCV-632 and -633 will close. By design, these vacuum breakers will not permit backflow from the Auxiliary Ventilation System to the room air inlet. Two safety-significant manual valves (ECRT-V-642 and -643) on bypass lines around these regulators must be closed for the Auxiliary Ventilation System to be operable. A second interface between the Auxiliary Ventilation System and the Process System is in the exhaust pathway addressed in the system description above (Section 4.4.6.2).

Signal isolators ECRT-FY-760-651 and -652, located in panel ECRT-PNL-602, provide the interface between the safety-significant auxiliary ventilation flow meters and general service displays.

**Specific Criteria**—The Auxiliary Ventilation System is designed to meet the requirements set forth in NFPA 69, *Standard on Explosion Prevention Systems*, Chapter 8, “Deflagration Prevention by Combustible Concentration Reduction,” and Chapter 15, “Installation, Inspection, and Maintenance of Explosion Prevention Systems.” These chapters provide the specific requirements relevant to ensuring that the system is capable of performing its safety function to prevent a hydrogen explosion in a STSC by preventing flammable hydrogen concentrations during sludge retrieval activities. The requirements are summarized as follows:

- The combustible concentration shall be maintained at or below 25 percent of the LFL.
- Instrumentation shall be provided to monitor the concentration of combustible components.
- Ventilation exhaust shall be located such that hazardous concentrations of exhaust air cannot be drawn into fresh air intakes.
- Instrumentation and interlocks shall be calibrated, inspected, tested, and maintained according to the requirements of NFPA 69, Chapter 15.

The principal design code for the system is ASME B31.3. Piping design and fabrication requirements for the Auxiliary Ventilation System are detailed in PRC-STP-00132, and in PRC-STP-00933.

The Auxiliary Ventilation System is also credited with performing its safety functions during and after an SDC-1 seismic event and for design basis wind, snow, and ashfall events. Natural phenomena hazard resistance was ensured by design, analysis, and testing. Seismic testing results are documented in Seismic Test Reports PR040656-010TR-16 and PR04656-TR-16, which are included in the Final Data Packages for ECRT-ME-601 (53921-004-SUB-037001), and ECRT-ME-604 (53921-004-SUB-040001), respectively.

4.4.6.5 Controls (Technical Safety Requirements)

The Auxiliary Ventilation System is an active, engineered control, which must be operable to perform its credited safety function. Therefore, an LCO/SR has been established as described in Section 5.5.2.2, “Limiting Condition of Operation 3.2 - Auxiliary Ventilation System.” A SAC has also been established to ensure that actuation of the Auxiliary Ventilation System is detected and that nitrogen consumption is monitored as described in Section 4.5.16, “Auxiliary Ventilation System Actuation Notification.”

4.4.7 Oxygen Analyzer

The STSC Inerting Limit SAC (see Section 4.5.9) and the STS Cask Inerting and Pressurization Limits SAC (see Section 4.5.11) are credited with preventing a hydrogen explosion in an STSC and STS Cask by verifying that the oxygen concentration is sufficiently low to preclude combustion. The oxygen concentration is measured and indicated by Oxygen Analyzer ECRT-CAB-601. The Oxygen Analyzer is therefore classified as safety-significant in accordance with DOE-STD-1186-2004, Specific Administrative Controls, Section 1.6.2, “Derivation of Hazard Controls in the DSA.”

4.4.7.1 Safety Function

The Oxygen Analyzer is safety-significant because a hydrogen explosion in an STSC or STS Cask can result in facility worker serious injury or death. The safety function of Oxygen Analyzer ECRT-CAB-601 is to measure and indicate the oxygen concentration in the STSC and STS Cask headspace so Operations can verify that an inert atmosphere has been established, thereby preventing a hydrogen explosion.

Given this safety function, the Oxygen Analyzer is a support SSC to the STSC Inerting Limit SAC and the STS Cask Inerting and Pressurization Limits SAC, as discussed above.

4.4.7.2 System Description

The Oxygen Analyzer is connected to and withdraws samples from the STSC/STS Cask 1.5-in. purge outlet line ECRT-NIT-401. The purge outlet line connects via hose to Nozzle F2 of the STSC during STSC inerting; and to one of the two STS Cask vent ports during STS Cask inerting.
The Oxygen Analyzer (including the supporting pump, piping, and valves) consists of a vendor-supplied package contained in a cabinet designated ECRT-CAB-601. ECRTS-CAB-601A includes a safety-significant voltage relay that turns off oxygen indication if voltage drops below 20 VDC to prevent erroneous oxygen concentration indications. Figure 4-5 provides a simplified system drawing.
Oxygen Analyzer pump ECRT-P-601 diverts a flow of approximately 0.15 scfm from the purge outlet line for sampling. The pump creates the pressure differential needed to drive the sample flow past the oxygen sensor where the reaction of oxygen with lead produces an electrical signal proportional to the oxygen concentration. A relatively high sample flow is used to ensure that the reading reflects the current purge outlet line oxygen concentration. To facilitate the higher sample flow, a bypass path controlled by needle valve ECRT-V-621 directs approximately 3/4 of the flow to bypass the sensor. The sensor is designed to be replaced when the lead is consumed; the vendor rates the unit for a life expectancy of 8 months in air.

The Oxygen Analyzer monitors the purge outlet stream for oxygen content during either STSC or STS Cask inerting. The inerting utilizes a nitrogen purge supplied from the general service inert gas supply. Under NFPA 69, the oxygen concentration in the STSC or STS Cask after inerting must be limited to less than 40 percent of the limiting oxidant concentration, because continuous monitoring will not be provided for the container and cask headspace. As shown in NFPA 69, Table C.19(a), “Limiting Oxidant Concentrations for Flammable Gases When Nitrogen or Carbon Dioxide Are Used As Diluents,” the limiting oxidant concentration for hydrogen gas in a mixture of nitrogen and air is 3 vol%; thus the requirement would be to limit the final oxygen concentration to less than 1.2 vol%.

To comply with the NFPA requirement, the STSC will be inerted to 0.5 vol%, which provides sufficient margin to the 1.2 vol% requirement to ensure that cumulative inleakage of oxygen over the time required for STS Cask Lid installation and inerting could not cause the total to exceed 1.2 vol%.

4.4.7.3 Functional Requirements

Table 4-8 below identifies the functional requirements and associated performance criteria for the oxygen analyzer.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oxygen Analyzer ECRT-CAB-601 shall be capable of measuring an oxygen concentration of &lt; 0.5 vol% for the STSC and &lt; 1.2 vol% for the STS Cask.</td>
<td>The Oxygen Analyzer shall be shown, through testing and calibration, to be capable of measuring an oxygen concentration 0.5 vol% or less with sufficient accuracy for practical use during STSC inerting.</td>
</tr>
<tr>
<td>2. Oxygen Analyzer ECRT-CAB-601 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>1. The Oxygen Analyzer shall be designed to operate in the range of temperatures expected in the 105KW Annex of 40°F to 100°F. 2. Oxygen Analyzer Cabinet ECRT-CAB-601 shall be NEMA 4 rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.</td>
</tr>
</tbody>
</table>

4.4.7.4 System Evaluation

The performance criteria identified in Table 4-8 characterize the specific operational responses and capabilities necessary for the Oxygen Analyzer to meet functional requirements. The
following sections evaluate the capabilities of the Oxygen Analyzer to meet the identified performance criteria.

Conservative Design Features—The applicable NFPA requirements afford substantial margins to conditions where combustion could actually occur.

The capability of the oxygen analyzer to measure an oxygen concentration of less than 0.5 vol% has been verified by testing and calibration as part of commercial grade dedication package CGD-15-CHP-124-02 (Rev. 5), documented in the Oxygen Analyzer Assemblies Final Data Package (53920-005-SUB-015 001) for ECRTS-CAB-601 and Voltage Relay EK-760-601. As documented in PRC-STP-00754, an indicated value of ≤0.2 vol% was selected for the STSC, and an indicated value of ≤0.9 vol% was selected for the STS Cask, to account for instrument uncertainty and to provide design margin.

Testing of the Oxygen Analyzer was performed at MASF to demonstrate STSC inerting. Inerting to 0.1 vol% oxygen was demonstrated within 15 and 21 minutes at flow rates of 5 and 3.5 cfm, respectively. The resulting plots of measured discharge oxygen concentration versus time were qualitatively evaluated for evidence of multiple mixing zones that could indicate the discharge oxygen concentration was not representative of the internal average concentration. The evaluation was performed due to the relative proximity of the inlet and outlet nozzles in the STSC head. The curve of discharge oxygen concentration versus time in each instance was concluded to demonstrate smooth, exponential decay representative of single volume mixing and thus indicative of a discharge reading that corresponded with the internal average concentration. The location of the nozzles for the STS Cask (inlet at the bottom on one side, outlet at the top near the center) was judged a sufficient basis for concluding that it too would experience single volume mixing.

Safe Failure Modes—The concept of fail-safe design is not applicable to the Oxygen Analyzer. This unit is required to perform its safety function only on demand; automatic actuation is not necessary for any postulated accident condition. Inerting will not proceed without an operable oxygen analyzer (also see below discussion of electrical power and nitrogen supply as support systems).

Environmental Design—Oxygen Analyzer ECRT-CAB-601 consists of an insta-trans trace and percent oxygen transmitter with supporting pump, piping, and valves. As shown in the Final Data Package (53920-005-SUB-015 001), this unit is designed to operate in an environment with temperatures from 32° to 122°F and relative humidity of 0 to 100 percent.

Oxygen Analyzer ECRT-CAB-601 is a vendor-supplied package consisting of a panel that houses and protects safety-significant Oxygen Analyzer equipment. The panel itself was delivered with a NEMA 4 rating, but was installed with non-compliant piping penetrations. The oxygen sensor and readout contained within the panel have a NEMA 4X rating separate from the panel that houses them.

The Oxygen Analyzer is a preventive control, as such there are no accident environment conditions to consider.

Support Systems—Oxygen Analyzer ECRT-CAB-601 requires electrical power to operate and thus electrical power is a support system. Power is provided by Oxygen Analyzer Electrical Control Cabinet ECRT-CAB-601A. Inerting activities will not be initiated if the Oxygen
Analyzer is not operable for any reason, including a loss of power. Should electrical power be lost during STSC inerting the safety-significant Auxiliary Ventilation System will maintain purge flow through the STSC ensuring a safe condition pending recovery. If electrical power to the Oxygen Analyzer is lost during STS Cask inerting, nitrogen flow will continue but the ability to verify oxygen concentration will be lost. In an unmitigated scenario, the STS Cask headspace could eventually reach 25 percent of the LFL. This potential hazard is controlled by the STS Cask Inerting and Pressurization Limits SAC which requires that the STS Cask be inerted and pressurized within 24 hours. The 24-hour time limit is based on calculations in PRC-STP-CN-N-00989, *Thermal and Gas Analyses for a Sludge Transport and Storage Container (STSC) During Transportation to T Plant with KW Annex Staging*, which show that the hydrogen concentration in the STS Cask headspace after 24 hours is less than 25 percent of the LFL such that the STS Cask Lid can be safely removed and corrective actions taken. Therefore, electrical power to the Oxygen Analyzer is classified as general service.

As stated above, the Oxygen Analyzer is connected to and withdraws a sample from the STSC/STS Cask purge outlet line. In order for the Oxygen Analyzer to measure and indicate the oxygen concentration in the STSC and STS Cask headspace, the nitrogen flow rate into the STSC or STS Cask and out the purge outlet line must be greater than the approximately 0.15 scfm extracted for sampling by pump ECRT-P-601. If the flow rate is lower, the Oxygen Analyzer will not indicate the oxygen concentration in the STSC or STS Cask. Thus nitrogen flow is thus a support system required for the Oxygen Analyzer to perform its safety function. However, if the nitrogen flow rate is less than approximately 0.15 scfm, then air in the purge outlet line will be drawn into the Oxygen Analyzer with the result that the required oxygen concentrations would never be achieved. Operators monitoring the inerting process would be aware of the off-normal condition because the oxygen concentration would not be decreasing as expected; and corrective actions taken. Because there are no low nitrogen flow rate scenarios that would result in a false indication of a compliant condition (e.g., indicating < 1.2 vol% oxygen when the actual concentration was higher), the Inert Gas System is classified as general service. It is noteworthy that when inerting the STSC, the safety-significant Auxiliary Ventilation System remains connected to the STSC and will provide a minimum nitrogen flow rate of 0.5 scfm even if there were no or low nitrogen flow from the Inert Gas System.

**Interface Design**—The Oxygen Analyzer interfaces with general service electrical power as discussed above in “Support Systems.” Completed Test Procedure TB-1505-CHP-124-003 documented on page 99 of 195 in the Oxygen Analyzer Final Data Package (53920-005-SUB-015 001) confirmed that variations in power supply voltage do not impact the measurement accuracy.

**Specific Criteria**—The Oxygen Analyzer will be procured and installed in accordance with NFPA 70. NFPA 70 describes wiring methods and materials to protect people and property from electrical hazards. The Oxygen Analyzers received UL698A listing marks as documented on page 23 and 24 of 195 pages in the Oxygen Analyzer Final Data Package (53920-005-SUB-015 001). In addition, as discussed above, the Oxygen Analyzer supports compliance with NFPA 69.

**4.4.7.5 Controls (Technical Safety Requirements)**

The Oxygen Analyzer works in concert with required operator actions to verify an inert atmosphere has been established within the STSC and STS Cask. These actions are required by
SACs as discussed in Section 4.5.9, “Sludge Transport and Storage Container Inerting Limit,” and Section 4.5.11, “STS Cask Inerting and Pressurization Limits.” These SACs have been developed in LCO format. Accordingly, surveillance requirements for the Oxygen Analyzer are addressed by an LCO/SR as described in Section 5.5.2.4, “Limiting Condition for Operation 3.4-STSC and STS Cask Inerting and Shipment Preparation.”

4.4.8 Sludge Transport and Storage Container and Transport Vent Assemblies

4.4.8.1 Safety Function

The STSC is safety-significant because a hydrogen explosion in an STSC, or an STSC over-pressurization, can result in facility worker serious injury or death.

STSC design features have the following safety functions:

- **STSC Boundary**: Prevent a hydrogen explosion in the STSC by maintaining an inert atmosphere in the STSC once established.

- **STSC Transport Vent Assemblies**: Prevent STSC over-pressurization by venting pressure. STSC Transport Vent Assemblies are components of the STSC Boundary and thus also function to prevent a hydrogen explosion in the STSC by maintaining an inert atmosphere in the STSC once established.

- **STSC Dimensions**: Prevent a hydrogen explosion by protecting initial conditions assumed in the STSC thermal and gas analysis regarding the STSC dimensions.

- **STSC Sloped Fin**: Prevent a hydrogen explosion in the STSC by limiting the volume of a vessel-spanning bubble.

- **STSC Seismic Wedges**: Protect initial conditions assumed in the development of seismic response spectra for the top of the STSC.

- **STS Trailer Seismic Dampener Shoes**: Protect initial conditions assumed in the development of seismic response spectra for the top of the STSC.

4.4.8.2 System Description

A simplified system drawing of the STSC and Transport Vent Assemblies is provided by Figure 4-6. An STSC is an ASME BPVC, Section VIII, Division 1, pressure vessel rated at 150 psig and full vacuum. It is approximately 10 ft tall and 5 ft in diameter with semi-elliptical heads on top and bottom. The STSC shell and bottom semi-elliptical head are constructed of 0.5-in. thick stainless steel, and the top semi-elliptical head is constructed of 0.75-in. thick stainless steel. The top semi-elliptical head has 10 nozzles that vary in diameter from 2 to 26 in.

The STSC is provided with a skirt that is perforated to allow movement of air within the skirt. The holes in the skirt are provided to enhance heat transfer from the STSC bottom, and to allow nitrogen to be added through the bottom of the cask to flow out from the skirt and up past the STSC.
Figure 4-6. STSC Boundary
STSC Boundary—The STSC boundary is credited within maintaining an inert atmosphere in the STSC once it is established. The STSC boundary is composed of the following components:

- STSC shell and top and bottom semi-elliptical heads
- Manway flange on Nozzle F
- Cap on Nozzle F1
- Flange and associated Camlock fitting and cap on Nozzle S1
- Overfill Recovery Tool on Nozzle D
- Radar level element/transmitter connected at Nozzle C
- LSH-740-402 connected at Nozzle E
- Self-sealing Stäubli quick disconnects, Transport Vent Assembly check valves, and associated Camlocks connected at Nozzles S2 and F2
- Sludge and decant connector interface spool assemblies, leak detectors, and flush and drain lines connected at Nozzles A and B

Immediately prior to initiating inerting, only the purge inlet and purge outlet lines are connected. Other lines will have been capped or remain connected to instruments with a closed boundary. Following inerting, the purge inlet and outlet lines are disconnected with the remaining Stäubli valves closing the boundary until the STSC Transport Vent Assemblies are installed.

STSC Transport Vent Assemblies—After the purge inlet and outlet lines are disconnected, the STSC Transport Vent Assemblies are installed on the Stäubli quick disconnects at Nozzles S2 and F2. Each vent assembly is equipped with an inlet check valve and a discharge check valve. These valves function to minimize air in-leakage until the STS Cask Lid is put in place and the cask is inerted. Once the STS Cask is inerted, air inleakage into the STSC is no longer possible. Each vent assembly is equipped with a NucFil filter to minimize the spread of contamination.

The discharge check valve prevents a significant pressure buildup within the STSC due to gas generated by the sludge. An inlet check valve is required because the STS Cask is intentionally pressurized from 3 to 15 psig with nitrogen in preparation for shipment. The inlet check valve allows the STSC pressure and STS Cask pressure to partially equilibrate during the cask pressurization process.

STSC Dimensions—Thermal and gas analyses have been performed for a STSC containing sludge (PRC-STD-00688; PRC-STD-00241, Sludge Treatment Project-Engineered Container Retrieval and Transfer System – Thermal and Gas Analyses for Sludge Transport and Storage Container (STSC) Storage at T Plant; PRC-STD-CN-N-00819, Sludge Treatment Project – Engineered Container Retrieval and Transfer System Supplemental Thermal and Gas Calculations for Engineered Container SCS-CON-230 Settler Sludge; and PRC-STD-CN-N-00935). The analyses include calculations of the hydrogen gas generation rate and the ventilation flow rate necessary to maintain the hydrogen concentration in the STSC headspace below flammability.

The dimensions that are most sensitive in the above-referenced analyses have been identified as key dimensions. These include:

- STSC inside diameter of 58 in.
- 2:1 radius semi-elliptical top and bottom heads
- The overall vessel length is 104 7/8 in. from the vessel bottom to the top flange

These dimensions suffice to establish the internal volume of the STSC and the headspace volume in a loaded STSC when the water level is controlled as planned. PRC-STP-00688 includes a discussion showing that results are not sensitive to fractional differences in dimensions resulting from specified manufacturing tolerances.

**STSC Sloped Fin**—Hydrogen generated within an STSC during long-term storage at T Plant could potentially form. As discussed in HNF-41051, *STP Container and Settler Sludge Process System Description and Material Balance*, the storage of sludge in an STSC over an extended period of time may lead to the formation of a stable sludge plug. The stable sludge plug is caused when substantial sludge shear strength develops in a sludge layer that then hinders the release of hydrogen and other gases generated by the sludge. The retention of gases under such a layer could lead to the formation of a vessel-spanning bubble. If the retained gas were suddenly released, it could form a flammable concentration in the STSC.

The design of the STSC includes a passive, engineered feature called the sloped fin. As shown on drawing H-1-92550, *STP ECRSTS Transport System STSC Vessel*, the sloped fin is T-shaped in cross-section, with the top of the T, 4-in.-wide facing the center of the vessel. The fin extends out at the base, on the bottom head, tapering towards the vessel wall 5 degrees from vertical to a point above the maximum sludge height. The fin is constructed of ASME SA240 T304/304L stainless steel and is welded in its intended position.

Should a stable sludge plug form and trap hydrogen and other gases, the sloped fin creates gas-release pathways that allow gases to escape thus limiting the volume of a vessel spanning bubble.

**STSC Seismic Wedges**—The STSC Seismic Wedges are designed to be placed between the STSC and the STS Cask. The wedges are constructed of 0.5-in.-thick stainless steel and are approximately 7 in. long. The wedges are curved and tapered to ensure that they fit between the STSC and the STS Cask independent of actual clearance, they resemble a pair of stacked curved apostrophes joined by a bail. Eight sets of wedges are distributed around the circumference of the STSC to occupy space between the STSC and the STS Cask precluding the STSC from moving out of sync with and thus potentially hitting the cask during a seismic event. The wedges are installed prior to the initial transfer of IXM water into the STSC, and are removed prior to STSC shipment to T Plant. The wedges are passive design features installed to limit independent motion of the STSC and STS Cask.

**STS Trailer Seismic Dampener Shoes**—The design of the STS Trailer Seismic Dampener Shoe includes a stack of safety-significant impact absorbing pads that are contained in a general service cylindrical aluminum holder for ease of placement under the STS Trailer front landing gear. The impact absorbing pads are approximately 17 in. in diameter, and the inside diameter of the general service holder is approximately 18 in. in diameter. The impact absorbing pads are made of Nitrile. Individual pads are 0.5 in. thick, and the total stack height is 3.5 in. The Seismic Dampener Shoes are passive design features, and are placed under each landing gear footing when the STS Trailer is positioned on the truck scale in the 105KW Annex.
4.4.8.3 Functional Requirements

Table 4-9 identifies the functional requirement and associated performance criteria for the STSC boundary.

**Table 4-9. Sludge Transport and Storage Container Boundary and Transport Vent Assembly Functional Requirements and Performance Criteria**

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The STSC boundary shall be capable of preventing significant air inleakage prior to STS Cask inverting.</td>
<td>After inerting to 0.5% oxygen, air inleakage shall be sufficiently low to result in the oxygen level in the STSC remaining below 1.2% for at least 9 days after disconnection of the purge inlet and purge outlet lines.</td>
</tr>
<tr>
<td>2. The STSC boundary shall meet SDC-1 requirements.</td>
<td>The STSC boundary design shall be capable of withstanding SDC-1 seismic loads while maintaining leak tightness.</td>
</tr>
<tr>
<td>3. STSC transport vent assembly discharge check valves ECRT-CV-403 and -405 shall open at a cracking pressure of no more than 5 psig.</td>
<td>Each STSC transport vent assembly discharge check valve shall open at a cracking pressure of no more than 5 psig.</td>
</tr>
<tr>
<td>4. STSC transport vent assemblies shall each have a flow capacity at the STSC design pressure of at least 400 L/day (0.01 scfm).</td>
<td>Each STSC transport vent assembly shall be capable of flowing greater than 0.01 scfm with a differential pressure of 1 atmosphere (14.7 psi) or less.</td>
</tr>
</tbody>
</table>
| 5. Nominal key dimensions of the STSC shall be consistent with those used in the thermal model. | 1. STSC inside diameter of 58 in.  
2. 2:1 radius semi-elliptical heads.  
3. Overall vessel length of 104 7/8 in. from the vessel bottom to the top flange.                                                                  |
| 6. The sloped fin shall create gas release pathways should a stable sludge layer form and retain hydrogen gas. | 1. The sloped fin shall be consistent with a configuration shown to be effective in disrupting the formation of a vessel-spanning bubble in the analysis provided in PNNL-19345.  
2. The sloped fin shall be T-shaped, with the top of the T, 4-in.-wide facing the center of the vessel. The fin shall extend out at the base, on the bottom head, tapering towards the vessel wall 5 degrees from vertical to a point above the maximum sludge height.  
3. The sloped fin shall be firmly attached to the STSC interior to keep it in its intended position. |
| 7. The STSC Seismic Wedges shall limit independent motion of the STSC and STS Cask.     | The STSC Seismic Wedges shall prevent secondary impacts between the STS cask and the STSC vessel resulting from ground acceleration(s) in any horizontal direction.                                                    |
| 8. The STS Trailer Seismic Dampener Shoes shall maintain the trailer landing gear in contact with the truck scale during an SDC-1 seismic event. | Static Spring Rate (Ks): \(35 \leq Ks \leq 107\) kip/in. at 18,000 lb load                                                                                                                                             |
4.4.8.4 System Evaluation

The performance criteria identified in Table 4-9 characterize the specific operational responses and capabilities necessary for the STSC boundary to meet functional requirements. The following sections evaluate the capabilities of the STSC boundary to meet the identified performance criteria.

Conservative Design Features—A conservative calculation of air leakage into an STSC is documented in PRC-STP-CN-M-00774, Analysis of Oxygen Ingress into Inerted STSC Headspace. The calculation addresses 10 leak paths, each with a leak rate of 1.0E-3 cm$^3$/s, for a total leakage rate of 1.0E-2 cm$^3$/s. The calculation predicts that more than 18 days are required for the oxygen concentration to increase from 0.5 percent to 1.2 percent, a time well in excess of the 9-day performance criteria.

The 1.0E-2 cm$^3$/s leak rate is verified by leak testing of the STSC during fabrication with all STSC boundary components installed. A conservative acceptance criteria of 1.0E-3 cm$^3$/s is used.

The STSC is an ASME BPVC, Section VIII, Division 1, pressure vessel. Specification PRC-STP-00442 requires the fabricator of the STSC to provide an ASME required vessel code calculation that includes seismic loads. Seismic and transportation vessel loads were included in the Section VIII Division 1 Code Analysis of STSC Vessels as documented in submittal 55309-000-SUB-009-002-01. Instrumentation and other appurtenances attached to the STSC will be seismically qualified on a shaker table as required by the STSC Vessel Appurtenance Seismic Test Fixture Functional Test Procedure in submittal 53920-006-SUB-041-002. The safety-significant STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes protect initial conditions assumed in the seismic testing. Conformance of the STS Trailer Seismic Dampener Shoes to the static spring rate performance criteria is documented in CGD-RPT-MC179658-0, Rev. 0 contained in submittal number 53920-006-SUB-055 003. The tapered shape of the STSC Seismic Wedges prevent secondary impacts between the STS Cask and the STSC vessel.

STSC transport vent assemblies have been procured with discharge check valves that open at a cracking pressure of 1 to 2 psig, which meets the performance criteria that the valves open at a cracking pressure of no more than 5 psig. The discharge check valves, which have a flow coefficient (Cv) of 0.17, have the most significant restriction to flow through the transport vent assembly. As documented in PRC-STP-CN-M-00905, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Characteristic Curves and Flow Coefficients for Configurations of the Transport Vent Assembly, at a differential pressure of 14.7 psig, the installed transport vent assembly will flow more than 2.5 scfm out from the STSC, which is more than 250 times the required flow.

Drawing H-1-92550 identifies three STSC key dimensions.

- STSC inside diameter of 58 in.
- 2:1 radius semi-elliptical heads.
- Overall vessel length of 104 7/8 in. from the vessel bottom to the top flange.
As required by procurement specification PRC-STP-00422, *Sludge Transport and Storage Container (STSC) Design and Fabrication Specification of the Sludge Treatment Project Engineered Container Retrieval and Transfer System*, the key dimensions will be verified by inspection.

The capability of a sloped fin to disrupt a vessel-spanning bubble is documented in PNNL-19345. Experiments were performed in various-sized vessels (5, 10, and 23 in. diameters, with and without the bottom 2:1 semi-elliptical head) using kaolin clay simulants of varying shear strengths and a KW containerized sludge simulant. This simulant is the most realistic for physical modeling of actual K Basin sludge. The vessel configurations and simulant shear strengths tested were designed to scale to the STSC and address the range of actual sludge shear strengths. The test results for this simulant show that fins at larger scale would release vessel spanning bubbles. Because the scale-up trend is that fin performance improves in larger vessels, the fins will perform better at full-scale and with actual K Basin sludge. The experiments demonstrate that for weaker sludges, vessel-spanning bubbles are unstable. For stronger sludges capable of forming vessel spanning bubbles, the experiments demonstrate that a sloped fin creates gas-release pathways that remain open (i.e., the sludge does not slump and close them) to release gas.

**Safe Failure Modes**—The STSC transport vent assemblies, with dual check valves and NucFil filters, afford a vent pathway that precludes over-pressurization of a closed STSC. The performance criteria specify a minimum flow rate at least twice the maximum hydrogen generation rate, in part to bound pressurization due to temperature changes which pose a lesser challenge than hydrogen generation. Individual components in the flow path are evaluated at the conservatively chosen 1 atmosphere (14.7 psi) driving pressure to ensure that the minimum flow rate is achieved. STSC boundary does not incorporate other fail-safe design provisions. This boundary is passive.

The STSC dimensions are a passive design feature. The STSCs have been procured, inspected and accepted, and verified in accordance with PRC-MP-QA-599 requirements for Quality Level 2 items. No mechanism for failure of these dimensions once verified has been identified.

The STSC sloped fin is a passive design feature. The STSC sloped fins were procured, inspected/accepted, and verified in accordance with PRC-MP-QA-599 requirements for Quality Level 2 items to ensure they are consistent with the design configuration shown to be effective in disrupting a vessel-spanning bubble.

**Environmental Design**—The STSC boundary performs its safety function while in the environmentally controlled 105KW Annex. None of the STSC boundary components are sensitive over the defined range of temperature variation, nor are the potential radiation fields high enough to damage the penetrations, their seals, or the instrumentation. The seals used are Pipeline Seal & Insulator, Inc. LineBACKER® made of EPDM seals with a rated temperature range of -165° to 300°F, or EPDM O-rings with a rated temperature of -65° to 180°F. The STSC is fabricated from stainless steel which is not subject to brittle fracture at low temperatures.

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27 Linebaker is a registered trademark of Garlock Pipeline Technologies, Inc., Wheat Ridge, Colorado.
The STSC key dimensions are nominal values at room temperature credited with protecting initial conditions assumed in thermal and gas analyses. There are no environmental conditions associated with postulated accident scenarios that are applicable to the STSC key dimensions.

The sloped fin is constructed of stainless steel and can perform its function over the identified temperature range for ECRTS interior spaces of 40° to 100°F. Any temperature driven expansion or contraction of the materials of construction will be consistent with the STSC itself and could not cause failure of the attachments. The fin is made of stainless steel and is not subject to corrosion during long-term storage at T Plant. There are no environmental conditions associated with postulated accident scenarios that the STSC sloped fin is required to survive.

Support Systems—The STSC does not rely on the operability of support SSCs to perform its safety function.

Interface Design—Following inerting, the STSC boundary and transport vent assemblies interface with the safety-significant STS Cask but do not interface with non-safety systems.

Specific Criteria—The STSC boundary must maintain an inert environment in the STSC long enough to allow closure and inerting of the STS Cask prior to transport. As explained above, this is an oxygen limit of 1.2 percent per NFPA 69. The referenced calculation demonstrates an actual window of 18 days, conservatively reduced to 9 days but still affording a broad margin for STSC compliance with the performance criterion (i.e., remaining inert to less than 1.2 percent oxygen prior to inerting of the cask).

4.4.8.5 Controls (Technical Safety Requirements)

The STSC boundary, STSC dimensions, and sloped fin are passive, engineered controls included in the TSR as described in Section 5.6.5, “Sludge Storage and Transport Container.” The Transport Vent Assemblies are active components in that the inlet and discharge check valves change state to perform their function. However, the change in state is in response to system pressure, and the check valves are not subject to change by Operations personnel. Therefore, the Transport Vent Assemblies are addressed in the TSRs as a design feature as described in Section 5.6.5, “Sludge Transport and Storage Container.”

The STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes are passive engineered controls included in the TSR as design features as described in Section 5.6.6, “STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes.”

The Conduct of Operations key attribute of the Operational Safety SMP is credited for verifying installation of the Transport Vent Assemblies, STSC Seismic Wedges, and STS Trailer Seismic Dampener Shoes.
4.4.9 Sludge Transport System Cask Pressure Boundary, STS Cask Vent Tool, and STS Pressurization Check Tool

4.4.9.1 Safety Function
The STS Cask pressure boundary is safety-significant because a hydrogen explosion in the cask can result in facility worker serious injury or death. The STS Cask pressure boundary has the following safety function:

- Prevent a hydrogen explosion in the STS Cask by maintaining an inert atmosphere in the STS Cask once established.

The STS Cask Vent Tool and STS Pressurization Check Tool are safety-significant because over-pressurization of the STS Cask can result in facility worker serious injury or death. The two tools have the following safety function:

- Prevent STS Cask over-pressurization by venting the cask.

4.4.9.2 System Description
A simplified system drawing of the STS Cask Pressure Boundary, STS Cask Vent Tool and STS Pressurization Check Tool is provided by Figure 4-7. The STS Cask is an existing SSC. Two STS Casks were procured in 2002/2003 in support of a now terminated project to transport large diameter containers containing sludge to T Plant.

The STS Cask is a right circular cylinder constructed primarily of Type 304 stainless steel and lead. It is approximately 11 ft high and 6 ft in diameter. The cask is constructed of a 1-in.-thick stainless steel inner shell and 1.5-in.-thick stainless steel outer shell. The inner and outer shells are welded to a 6-in.-thick stainless steel bottom forging. At the top, the inner and outer shells are welded to a stainless steel upper forging. The approximately 3-in. annulus between the two shells is filled with lead for gamma radiation shielding. The STS Cask Lid, fabricated from 5-in.-thick stainless steel, is secured to the cask upper forging with twenty-four, 1.5-in.-diameter bolts. The cask has a bottom drain port in the shell, and two vent ports and a test port in the lid.

The STS Cask pressure boundary consists of the following:

- Inner shell
- Lower end forging
- Upper end forging
- Closure lid
- Metallic inner O-ring seal (for lid closure)
- Closure bolts and associated flat washers
- Vent and drain port plugs and associated metallic sealing elements
Figure 4-7. STS Cask Pressure Boundary
Before transportation, the Inert Gas System is used to purge the STS Cask with nitrogen until the indicated oxygen concentration is less than 1.2 vol%. The STS Cask is then pressurized with nitrogen to at least 3 psig and not more than 15 psig. The minimum 3 psig lower pressure limit is based on maintaining an inert atmosphere in the STS Cask for the duration of the shipping window. The shipping window begins when the STS Cask inerting and pressurization has been completed, and ends when the STS Trailer is received at T Plant. The shipping window includes a staging period in the Sludge Loading Bay and transportation time to T Plant.

The STS Cask Vent Tool consists of a Stäubli self-sealing quick disconnect attached via a 0.5-in. hex nipple and a 0.5 by 1-in. bushing to the brass body vent tool that was designed in conjunction with the STS Cask. The Stäubli self-sealing, quick disconnect has a published Cv of 13.6, providing a low restriction connection to STSC/STS Cask purge outlet hose ECRT-NIT-401. The brass body STS Cask Vent Tool screws into and seals against one of two available vent ports on the existing STS Cask Lid, a rotatable bar inside the tool body allows the removal and reinstallation of a plug into the STS Cask Lid.

The STS Pressurization Check Tool (ECRT-ME-603) is connected, if required, to the STS Cask Vent Tool via a Stäubli self-sealing quick disconnect. The check tool consists of the Stäubli self-sealing quick disconnect, pressure indicator PI-760-630, ball valve ECRT-V-630, check valve ECRT-CV-630, and filter ECRT-F-0630. Pressure indicator PI-760-630 is available to monitor the STS Cask pressure in the event there are delays in shipping the STS Cask to T Plant. If necessary, the cask pressure gas can be vented by opening valve ECRT-V-630 while directing the flow to the open end of 6-in. contamination control hood suction hose ECRT-H-605. The nominal 600 cfm air flow into the ECRT-H-605 provides rapid dilution of any hydrogen released from the STS Cask. Check valve ECRT-CV-630 prevents the potential ingress of air and thus maintains the inert atmosphere in the STS Cask. In addition, the check valve limits the flow rate of hydrogen and nitrogen out of the cask if venting is required. Filter ECRT-F-630 minimizes the potential spread of contamination if the cask must be vented.

### 4.4.9.3 Functional Requirements

Table 4-10 identifies the functional requirements and associated performance criteria for the STS Cask pressure boundary.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The STS Cask pressure boundary shall be capable of maintaining an inert atmosphere for the duration of the shipping window with an appropriate design margin.</td>
<td>The STS Cask shall be designed for a maximum leak rate of 9.0E-4 standard cm$^3$/s air.</td>
</tr>
<tr>
<td>2. The STS Cask pressure boundary shall be capable of maintaining an inert atmosphere within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>The STS Cask shall be designed for temperature extremes of -27° to 110°F.</td>
</tr>
</tbody>
</table>
Table 4-10. Sludge Transport System Cask Pressure Boundary Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. The STS Cask pressure boundary shall meet SDC-1 requirements.</td>
<td>The STS Cask pressure boundary design shall be capable of withstanding SDC-1 seismic loads while maintaining leak tightness.</td>
</tr>
<tr>
<td>4. The STS Cask Vent Tool and STS Pressurization Check Tool shall have a flow capacity at the STS Cask design pressure of at least 400 L/day (0.01 scfm).</td>
<td>The STS Cask Vent Tool and STS Pressurization Check Tool shall be shown by analysis or testing to be capable of flowing greater than 0.01 scfm with a differential pressure of 1 atmosphere (14.7 psi) or less.</td>
</tr>
</tbody>
</table>

Notes:
The STS Cask pressure boundary is composed of the STS Cask, STS Cask Lid, STS Cask Lid metal O-ring, and port seals.

4.4.9.4 System Evaluation

The performance criteria identified in Table 4-10 characterize the specific operational responses and capabilities necessary for the STS Cask pressure boundary, STS Cask Vent Tool, and STS Cask Pressurization Check Tool to meet functional requirements. The following sections evaluate the capabilities of the SSCs to meet the identified performance criteria.

Conservative Design Features—The STS Cask pressure boundary has been designed and fabricated to a design pressure of 80 psig. The STS Cask has been pressure tested to 150 percent of the cask design pressure per the requirements of 10 CFR 71, “Packaging and Transportation of Radioactive Material.” The STS Cask design pressure is 80 psig and the hydrostatic test pressure was 120 psig. As shown in SNF-8163, Performance Specification for the K East Basin Sludge Transportation System - Project A.16, the pressure boundary is designed to meet the allowable leakage rate in accordance with ANSI N14.5. After fabrication, the STS Cask received a verification leak test of the vent ports, drain port and closure lid containment boundary meeting a cumulative leakage rate of less than or equal to 2.0E-4 standard cm$^3$/s of air.

A minimum of three leak tests are performed each time the STS Cask Lid is placed on the STS Cask following loading of the STSC. This includes a leak test of at least one of the vent port bolts, the drain port bolt, and the closure lid seal. The currently applicable leak rate criterion is 9.0E-4 standard cm$^3$/s air as established in CHPRC-03111, One-Time Request for Shipment for Sludge Transport from K West Basin to T Plant.

As documented in SNF-8163, the STS Cask is demonstrated by analysis to maintain containment under the bounding normal-condition load combination of free drop and maximum internal pressure at hot ambient temperatures (i.e., 115°F). The transportation safety free drop design requirements exceed the required SDC-1 seismic requirements.

Evaluated hydrogen generation rates are protected by a SAC limiting the sludge content (see Section 4.5.6) loaded into the STSC that is vented to the STS Cask headspace.

Safe Failure Modes—The STS Cask boundary is passive and thus does not incorporate fail-safe design.
The most probable failure mode is over-pressurization of the pressure boundary resulting from a delay in transportation-related activities and the attendant gas generation. The allowed STS Cask staging period and transportation period ensures that such a failure will not occur within the Sludge Loading Bay or at T Plant. If required, the cask can be vented by use of the STS Cask Vent Tool and STS Pressurization Check Tool. The STS Cask Vent Tool/STS Pressurization Check Tool affords a vent pathway with sufficient flow capacity to prevent over-pressurization once the vent is manually activated. The 400 L/day performance criteria bounds pressurization due to temperature changes which pose a lesser challenge than hydrogen generation. Individual components in the flow path are evaluated at the conservatively chosen 1 atmosphere (14.7 psi) driving pressure to ensure that the minimum flow rate is achieved. As documented in PRC-STP-CN-M-00905, at a differential pressure of 14.7 psi, each of the two the installed transport vent assembly will flow more than 2.5 scfm out from the STSC, which is more than 250 times the required flow.

**Environmental Design**—Structural and thermal analyses show that the STS Cask remains leak-tight for normal conditions of transport and for hypothetical accident conditions. Acceptable structural performance is demonstrated by compliance with the code allowable stresses. The closure lid and penetration seals are metallic and thus insensitive to both radiation and temperature.

The STS Cask pressure boundary is a preventive control, as such there are no accident environment conditions to consider.

**Support Systems**—Once the STS Cask is inerted and pressurized, the STS Cask pressure boundary is leak tested using the STS Cask Leak Tester. The STS Cask Leak Tester is a safety-significant SSC and is described and evaluated in Section 4.4.11.

**Interface Design**—The STS Cask is designed to interface with the general service Inert Gas System. The STS Cask is inerted using the vent port and drain port tools. Once an inert atmosphere has been verified and the STS Cask is pressurized, the tools are removed, and the pressure boundary is established by the vent port and drain port plugs and associated metallic sealing elements. Therefore, the Inert Gas System cannot prevent the STS Cask pressure boundary from performing its required safety function.

**Specific Criteria**—The STS Cask boundary has been designed and fabricated to a design pressure of 80 psig. The STS Cask has been pressure tested to 150 percent of the cask design pressure per the requirements of 10 CFR 71.85, “Preliminary Determinations.” The STS Cask pressure boundary is designed to meet the allowable leakage rate in accordance with CHPRC-03111.

**4.4.9.5 Controls (Technical Safety Requirements)**

The STS Cask pressure boundary is a passive, engineered control included in the TSR as a design feature as described in Section 5.6.6, “Sludge Transport System Cask Pressure Boundary.”

The STS Cask Vent Tool/STS Pressurization Check Tool is manually installed and operated, if required. Use of the tools are dictated by the STS Cask Staging Limit SAC as described in Section 4.5.13, “Sludge Transport System Cask Staging Limit.”
4.4.10 Sludge Transport System Cask Pressure Indicator

The STS Cask Inerting and Pressurization Limits SAC (see Section 4.5.11) is credited with preventing a hydrogen explosion in an STS Cask and verifying that the STS Cask has been pressurized from 3 to 15 psig prior to shipment to T Plant. The STS Cask pressure is measured and indicated by pressure indicator ECRT-PI-760-606. The pressure indicator is therefore classified as safety-significant in accordance with DOE-STD-1186-2004.

4.4.10.1 Safety Function

The STS Cask pressure indicator ECRT-PI-760-606 is safety-significant because a hydrogen explosion in the cask can result in facility worker serious injury or death. The safety function of the pressure indicator is to measure and indicate the STS Cask pressure so Operations can verify that it is within limits, thereby preventing a hydrogen explosion.

Given this safety function, pressure indicator ECRT-PI-760-606 is a support SSC to the STS Cask Inerting and Pressurization Limits SAC, as discussed above.

4.4.10.2 System Description

The STS Cask must be pressurized with nitrogen to between 3 psig and 15 psig. Pressurizing to greater than 3 psig prevents air inleakage during STS Cask staging in the Sludge Loading Bay and transport to T Plant. Pressurizing to less than 15 psig ensures that the STS Cask will not exceed its pressure rating during transportation. To pressurize the cask, the general service Inert Gas System is aligned to supply nitrogen to the STS Cask through the STS drain port. The cask is then pressurized to within the required range as detected by safety-significant pressure indicator ECRT-PI-760-606.

4.4.10.3 Functional Requirements

Table 4-11 identifies the functional requirements and associated performance criteria for the STS Cask pressure indicator.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pressure indicator ECRT-PI-760-606 shall measure the STS Cask pressure.</td>
<td>The specified indicator must be shown to be capable of measuring the cask pressure over the range of 0 to 15 psig.</td>
</tr>
<tr>
<td>2. Pressure indicator ECRT-PI-760-606 shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin.</td>
<td>Pressure indicator ECRT-PI-760-606 shall be designed to operate in the environmentally controlled 105KW Annex over the allowed operating temperature range of 40° to 100°F.</td>
</tr>
</tbody>
</table>

4.4.10.4 System Evaluation

The performance criteria identified in Table 4-11 characterize the specific operational responses and capabilities necessary for the STS Cask pressure indicator to meet functional requirements.
The following sections evaluate the capabilities of the STS Cask pressure indicator to meet the identified performance criteria.

Information presented in this section is derived from engineering drawings, specifications, and system piping and instrument diagrams.

**Conservative Design Features**—Following completion of the nitrogen purge, the STS Cask is pressurized with nitrogen to between 3 psig and 15 psig. To ensure the required STS Cask final pressure range, ECRT-PI-760-606 has a range of 0 to 30 psig, as shown on drawing H-1-92567, *STP ECRTS Transport System Nitrogen Purge Panel*.

As documented in PRC-SP-00754, taking into account the accuracy of the pressure gauge and design margin, the gauge reading must be ≥5 psig to ensure an actual pressure of at least 3 psig, and ≤13 psig to ensure an actual pressure less than 15 psig.

Pressurizing the STS Cask with nitrogen after inerting further reduces the oxygen concentration, affording additional design margin for compliance with the NFPA requirement for an oxygen concentration below 1.2 percent.

**Safe Failure Modes**—The STS Cask pressure indicator is a simple, non-powered, direct indicating mechanical device. While this device is not subject to electrical interference it could be subject to impact damage. Impact damage that could cause damage or failure of this device would be readily apparent (e.g., dented case, or broken window).

**Environmental Design**—The STS Cask pressure indicator will perform its safety function over the operating temperature range of 40° to 100°F in the 105KW Annex. The dry gas filled stainless-steel pressure gauge is rated by the manufacturer for a temperature range of -30° to 150°F, with some loss in accuracy as temperature varies from the 70°F calibration temperature. The indicator is located at a significant distance from the STS Cask and is, therefore, not exposed to a radiation environment. No other special environmental criteria apply.

**Support Systems**—The STS Cask pressure indicator is a safety-significant component of the general service Inert Gas System. It does not rely on support systems for the performance of its safety function (e.g., electrical power is not required). However, if there is an insufficient nitrogen supply, then the Inert Gas System cannot pressurize the STS Cask to within 3 to 15 psig. Operators monitoring the pressurization process would be aware of the off-normal condition as the cask pressure would not be increasing as expected; and corrective actions would be taken.

**Interface Design**—The STS Cask pressure indicator interfaces with the STS Cask and, as stated above, is a safety-significant component of the general service Inert Gas System. The pressure indicator is located on inert gas supply line ECRT-NIT-601. The pressure indicator connects to inert gas supply line ECRT-NIT-601 via a “gauge root” valve (ECRT-V-626). The gauge root valve must be opened for the pressure indicator to read the pressure in the gas supply line and both the inert gas isolation valve (ECRT-V-609) and the STS Drain Port Tool must be aligned properly for the gauge to read cask pressure.

**Specific Criteria**—STS Cask pressure indicator ECRT-PI-760-606 complies with the first section, B40.1, “Gauges: Pressure Indicating Dial Type—Elastic Element,” in ASME B40.100, *Pressure Gauges and Gauge Attachments*. 
**4.4.10.5 Controls (Technical Safety Requirements)**

The pressure indicator works in concert with required operator actions to verify the proper pressure within the STS Cask. This is addressed by the STS Cask Inerting and Pressurization Limits SAC as described in Section 4.5.11, “STS Cask Inerting and Pressurization Limits.” This SAC has been developed in LCO format. Accordingly, surveillance requirements for the pressure indicator are addressed by an LCO/SR as described in Section 5.5.2.4, “Limiting Condition for Operation 3.4-STS and STS Cask Inerting and Shipment Preparation.”

**4.4.11 Sludge Transport System Cask Leak Tester**

The STS Cask Leak Rate Limit SAC (see Section 4.5.12) is credited with preventing a hydrogen explosion in an STS Cask by verifying that the STS Cask leak rate is within the established limit. The leak rate is measured and indicated by the STS Cask Leak Tester. The STS Cask Leak is therefore classified as safety-significant in accordance with DOE-STD-1186-2004.

**4.4.11.1 Safety Function**

The STS Cask Leak Tester is safety-significant because a hydrogen explosion in an STS Cask can result in facility worker serious injury or death. The safety function of the leak tester is to measure and indicate the STS Cask leak rate so Operations can verify that it is within limits, thereby preventing a hydrogen explosion.

Given this safety function, the STS Cask Leak Tester is a support SSC to the STS Cask Leak Rate Limit SAC, as discussed above.

**4.4.11.2 System Description**

STS Cask Leak Tester ECRT-ME-605 is mounted on the inside north wall of the Annex. The assembly includes a shelf, a control panel (ECRT-PNL-605), a vacuum pump (ECRT-P-605), three STS Cask Leak Test Adapters (ECRT-ME-605-018 for the vent port, ECRT-ME-605-019 for the drain port, and ECRT-ME-605-020 for the main seal port), a venting manifold, a volume check tool, and test/home ports for each leak test adapter. Figure 4-8 provides a simplified system drawing.
Each leak test adapter is connected to the venting manifold via stainless steel braided hose (ECRT-H-606, ECRT-H-607, and ECRT-H-608). The vacuum pump is then connected to the other end of this venting manifold via stainless steel braided hose (ECRT-H-609). The leak test adapters have absolute pressure capacitance manometer pressure transmitters that transmit a 0-10 VDC signal (0-100 Torr) to ECRT-PNL-605 where the vacuum readings are displayed on three digital process meters (PI-605-018, PI-605-019, and PI-605-020), and on the Pressure Recorder PIR-605-001, and transmitted remotely via PXT-605.

The STS Cask vent, drain and main seal closures leak tests may be performed nearly simultaneously in time, or in series, one at a time. To leak test an STS Cask closure, the leak test adapter is threaded into its respective port and the instrumentation cables and hoses connected. The isolation valve is opened and the vacuum pump turned on. A process of vacuum conditioning is then undertaken. The vacuum conditioning may require cycles of throttled vacuum pumping, or vacuum pumping followed by time periods of unpumped conditioning.
Upon achieving adequate vacuum conditioning of a closure, the leak testing is performed in a sequence of three periods of pressure logging. These three periods are the preliminary system calibration, leak detection and measurement, and final system calibration.

For the preliminary system calibration, the calibrated leak isolation valve is opened thereby admitting a National Institute of Standards and Technology (NIST)-traceable calibrated leak to the closure evacuated volume. The pressure rise is logged with time to determine a minimum test dwell time, and to record a rate of pressure rise with the calibrated leak admitted.

For the leak detection and measurement period the calibrated leak isolation valve is closed. The pressure is then logged for a period of time at least equal to the minimum test dwell time determined during the preliminary system calibration.

For the final system calibration, the calibrated leak is again admitted to the evacuated volume to perform the final system calibration. The pressure is again logged for a period of time at least equal to the minimum test dwell time.

The evaluation of the test data is performed upon completion of the final system calibration. This evaluation includes:

1. Determining the rate of pressure rise per unit time during each of the test periods.

2. Calculating the upper bound of leakage rate during leak detection and measurement period. The leakage rate for the closure is equal to the temperature corrected leakage rate of the calibrated leak, multiplied by the ratio of the leak detection period rise in pressure during one test dwell interval divided by the difference between the change in pressure used to determine the test dwell time and the leak detection period rise in pressure during one test dwell time interval.

The overall leak rate of the STS Cask is the sum of the individual leak rates of the STS Cask closures. STS Cask ports that have not been used since the previous test do not need to be re-tested, and the previous calculated leakage rate for that port can be included in the evaluation of the total STS Cask leakage rate.

4.4.11.3 Functional Requirements

Table 4-12 below identifies the functional requirements and associated performance criteria for the STS Cask Leak Tester.
Table 4-12. STS Cask Leak Tester

Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The STS Cask Leak Tester shall be capable of measuring a cumulative cask leak rate of 9.0E-4 standard cm³/s air.</td>
<td>The STS Cask Leak Tester shall be capable of measuring a cumulative cask leak rate of 9.0E-4 standard cm³/s air, subdivided among the closures, with a sensitivity of less than one-half the acceptance criterion for each closure test.</td>
</tr>
<tr>
<td>2. The STS Cask Leak Tester shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions.</td>
<td>The STS Cask Leak Tester shall be designed to perform their safety functions over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F.</td>
</tr>
</tbody>
</table>

4.4.11.4 System Evaluation

The performance criteria identified in Table 4-12 characterize the specific operational responses and capabilities necessary for the STS Cask Leak Tester to meet functional requirements. The following sections evaluate the capabilities of the STS Cask Leak Tester to meet the identified performance criteria.

Conservative Design Features—The STS Cask Leak Tester’s absolute pressure capacitance manometer pressure transmitters and digital process meters have been specified to effectively measure the pressure rises allowing determination of the leak rate of the individual STS Cask ports and lid seal with bounding errors significantly smaller than the pressure rises required for passing the leak rate criterion. In addition to the STS Cask Leak Tester’s relative insensitivity to instrument error, a NIST-traceable leak standard is used to provide a preliminary and final calibration of the leak tester. This verifies the operability and ensures the accuracy of the STS Cask Leak Tester for each STS Cask.

Safe Failure Modes—A majority of the STS Cask Leak Tester’s design is considered to be fail-safe. All mechanical components providing the leak-tight boundary of the assembly will result in an artificially high STS Cask leak rate if the boundary of the assembly were to fail (leak). Given a failure in any one of the tubes or connections of the leak test adapters, the assembly will lose a portion of its vacuum and, depending on the magnitude of the equipment leak, the leakage rate for the STS Cask would either be over reported, or the required integrated leak rate criteria of 9.0E-4 standard cm³/s will not be met. The only parts of the assembly not considered to be fail-safe are the pressure transmitter, instrumentation cable, and process meters. However because this equipment is subjected to a preliminary and final calibration with a NIST standard as part of the leak test of each cask opening, an electrical failure that could result in an incorrect leak rate indication would be detected and the leak test would not be accepted. Additionally, these electrical components are robust and meet applicable electrical component design criteria. These components are safety-significant, will be routinely calibrated, and will be functionally tested by pumping down the equipment prior to the start of leak testing.

Environmental Design—The components that compose the STS Cask Leak Tester have been selected to meet the project operating temperature range of 40 to 100°F. Compliance with this
requirement has been verified by a review of the Certificate of Conformance and product data sheets that were required submittals per the fabrication contract Statement of Work.

**Support Systems**—The STS Cask Leak Tester requires electrical power to operate. General service power is provided to the STS Cask Leak Tester to power the safety-significant panel meters and pressure transducers via an internal 24 VDC power supply. Electrical power is also required to operate the general service vacuum pump and data logger. Failure to supply power to the STS Cask Leak Tester will not result in a false indication of low leakage rates and thus is a safe condition.

**Interface Design**—The STS Cask Leak Tester interfaces with general service electrical power as discussed above in “Support Systems.”

**Specific Criteria**—The selected components used in the assembly of the STS Cask Leak Tester were specified to meet ASME B31.3-2008, UL 508A-2009, NFPA 70-2008, and NEMA 12 per NEMA 250-2008.

**4.4.11.5 Controls (Technical Safety Requirements)**

The Cask Leak Rate Tester works in concert with required operator actions to verify that the cask leak rate is within limits. These actions are required by the STS Cask Leak Rate Limit SAC (see Section 4.5.12). This SAC has been developed in LCO format. Accordingly, surveillance requirements for the leak tester are addressed by an LCO/SR as described in Section 5.5.2.4, “Limiting Condition for Operation 3.4-STSC and STS Cask Inerting and Shipment Preparation.”

**4.4.12 Sludge Quantity Instrumentation**

The Sludge Buoyant Weight Limits SAC (see Section 4.5.6) is credited with preventing an STSC/STS Cask hydrogen explosion and STSC/STS Cask over-pressurization by verifying that the quantity of sludge in an STSC is within limits established to protect initial conditions assumed in thermal and gas analyses. The buoyant weight of sludge in an STSC is calculated based on sludge quantity instrumentation measurements and indications (i.e., liquid level and weight). The sludge quantity instrumentation is therefore classified as safety-significant in accordance with DOE-STD-1186-2004.

In addition, the STSC Final Liquid Level SAC (see Section 4.5.7) is credited with preventing an STSC hydrogen explosion at T Plant by verifying the final liquid level is within limits. Thus the liquid level instrumentation is also classified as safety-significant in support of that SAC.

**4.4.12.1 Safety Function**

Sludge quantity instrumentation is safety-significant because a hydrogen explosion in an STSC or STS Cask can result in facility worker serious injury or death. The safety function of the sludge quantity liquid level and weight instrumentation is to protect initial conditions assumed in the STSC thermal and gas analyses regarding the quantity of sludge present in an STSC.

The liquid level instrumentation has an additional safety function, which is to measure and indicate the liquid level in an STSC so Operations can verify that the final fill level is within limits, thereby preventing a hydrogen explosion at T Plant.

Given these safety functions, the sludge quantity instrumentation is a support SSC to the Sludge Buoyant Weight Limits SAC, and the STSC Final Liquid Level SAC, as discussed above.
4.4.12.2 System Description

Figure 4-9 provides a simplified system drawing of the sludge quantity instrumentation. Sludge quantity instrumentation measures the weight of the STS Trailer/STSC and the liquid level in the STSC, both before and after sludge loading. These values are used to calculate the buoyant weight of the sludge which is then compared to applicable limits. If necessary, sludge can be removed from the STSC using the Overfill Recovery Tool.
Figure 4-9. Sludge Quantity Instrumentation
During sludge retrieval and transfer, the liquid level and weight are continuously measured and transmitted to the control room and displayed for operator information. These measurements are not credited for any safety function. Only the displayed readouts on safety-significant Safety Instrument Panel ECRT-PNL-401 are used to calculate the buoyant weight.

The STSC liquid level is measured by a radar level element (designated LE-740-401) and level indicating transmitter (designated LIT-740-401) mounted on Nozzle C of the STSC. The selected radar transmitter is the Siemens® LR250; the total measurement error for the channel (sensor, transmitter, display) is 0.2 in. A new level element and transmitter, along with an associated junction box (ECRT-JB-402) is provided with each STSC and the used instruments/junction box remain installed when a loaded STSC is packaged in the shipping cask.

Junction Box ECRT-JB-402 separates safety-significant wiring for the STSC level indication from the general service wiring for the slurry transfer line coaxial connector leak detector. The junction box is NEMA 4X rated, but utilizes push/pull connectors configured such that the assembly meets NEMA 4 requirements.

From Junction Box ECRT-JB-402, the signal from the level indicating transmitter passes through Instrument Bypass Panel ECRT-PNL-402 to safety-significant Level Indicator LI-740-401 on Safety Instrument Panel ECRT-PNL-401. Instrument Bypass Panel ECRT-PNL-402, located beneath the Mezzanine adjacent to the south side of the upper STS Trailer platform, protects safety-significant wiring and is NEMA 4X rated. Safety Instrument Panel ECRT-PNL-401, located on the north wall of the Mezzanine, protects the safety-significant STSC level and truck weight indicators and corresponding signal isolators, as well as general service displays for process control. The panel is NEMA 4X rated.

The weight measurement instrumentation consists of four load cells (WE-740-401A, B, C, and D) installed on Truck Scale ECRT-SCALE-101. This instrumentation measures the weight of the STS Trailer and its contents. All four load cells provide inputs to a summation box (smart section controller, WX-740-401) that sums all four load cell signals, monitors load cell health, and outputs a single truck weight signal to WIT-740-401, where the trailer weight is displayed. WIT-740-401 is located on Safety Instrument Panel ECRT-PNL-401 on the Mezzanine in the 105KW Annex.

The selected truck scale is a Fairbanks® model Titan steel deck with rocker column load cells. A total relative accuracy of 0.02 percent is achieved and the scale is specified as complying with NTEP accuracy class IIIIL, with 10,000 divisions. These specifications ensure acceptable accuracy of the differential weight at the high and low tare values. Absolute accuracy is not important for this application. Nevertheless, the potential impact of measurement uncertainty on the allowed STSC loading is addressed in the setpoint determination.

The scale is 11 ft wide by 30 ft long. The scale is installed in a pit that is 1 ft 10 in. deep. This pit could potentially be filled with water from the sprinkler system should there be a fire in the 105KW Annex or inadvertent sprinkler discharge. Therefore, NEMA Type 6P protection is specified for the scale components in the pit.

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28 Siemens is a registered trademark of Siemens Aktiengesellschaft, München, Germany.
29 Fairbanks is a registered trademark of Fairbanks Scales, Inc., Kansas City, Missouri.
Three sets of level and weight data are used in this calculation: the high tare weight and level for the STSC filled with water, the low tare weight and level for the STSC after the initial decant, and the final weight and level of the STSC ready for transportation. The high and low tare measurements are performed before any sludge is transferred into the STSC.

### 4.4.12.3 Functional Requirements

Table 4-13 below identifies the functional requirements and associated performance criteria for the sludge quantity instrumentation.

#### Table 4-13. Sludge Quantity Instrumentation

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. STSC liquid level instrumentation shall measure the liquid level in the STSC.</td>
<td>Total measurement error shall not exceed 0.3 in.</td>
</tr>
<tr>
<td>2. Truck scale instrumentation shall measure the weight of the STS Trailer.</td>
<td>The truck scale shall have a minimum capacity of 75 tons, a total relative accuracy per load cell of 0.02%, and meet NTEP accuracy class III, with 10,000 divisions.</td>
</tr>
</tbody>
</table>
| 3. STSC liquid level instrumentation and truck scale instrumentation shall be designed to operate within the environmental parameters associated with normal and off-normal operating conditions with an appropriate design margin. | 1. Truck scale and level instruments shall be designed to perform their safety functions over the range of temperatures expected in ECRTS interior spaces of 40° to 100°F.  
2. Truck scale load cells and summation box shall be designed with appropriate protection such that they may be submersed in water to a depth which will not exceed 1 ft 10 in.  
3. The level sensor shall be fully functional in a radiation environment where the accumulated dose is 1000R or less.  
4. Safety Instrument Panel ECRT-PNL-401 and Instrument Bypass Panel ECRT-PNL-402 shall be NEMA 4X rated (at a minimum) to protect equipment from airborne hazards including moisture and dust.  
5. STSC Junction Box ECRT-JB-402 shall be NEMA 4 rated (at a minimum) to protect equipment from airborne hazards including moisture and dust. |

#### 4.4.12.4 System Evaluation

The performance criteria identified in Table 4-13 characterize the specific operational responses and capabilities necessary for the sludge quantity instrumentation to meet functional requirements. The following sections evaluate the capabilities of the chosen level sensor and weight scale to meet the identified performance criteria.

**Conservative Design Features**—For the liquid level measurement instrumentation, the total measured error of the level is no more than 0.3 in. as displayed on Safety Instrument Panel ECRT-PNL-401 over the measured water height of the STSC. This requirement is contained in
specification PRC-STP-00773, Safety Significant Level Instrumentation Equipment Specification for the Sludge Treatment Project Engineered Container Retrieval and Transfer System, and is confirmed by calibration. The detection accuracy is used in setpoint calculations documented in PRC-STP-00754, and have been verified by testing in accordance with PRC-STP-00796, Sludge Transport and Storage Container (STSC) Assembly and Test Specification for the Sludge Treatment Project Engineered Container Retrieval and Transfer System. Documentation of the calibration of the STSC level sensor and the STP ECRTS Retrieval System STSC Assembly, Assembly, Inspection and Test Plan are part of the Final Data package which is submittal 53920-006-SUB-033 001 for the First Article, but each STSC will have its own Assembly, Inspection and Test Plan and its own Final Data package.

The truck scale has a capacity of 75 tons, a total relative accuracy per load cell of 0.02 percent and meets NTEP accuracy class IIII, with 10,000 divisions. These requirements are documented in specification PRC-STP-00759, Sludge Treatment Project Engineered Container Retrieval and Transfer System (STP ECRTS) Weight Measurement Instrumentation Equipment Specification. These criteria have been verified by review of Certificate of Conformance and product data sheets which are required submittals in PRC-STP-00759. The total relative accuracy per load cell used in setpoint calculations is documented in PRC-STP-00754 and have been verified by testing in accordance with PRC-STP-00759.

Safe Failure Modes—The concept of fail-safe design is not applicable to the sludge quantity instrumentation. This level sensor and scale are required to perform their safety function at specific stages of the STSC loading process; automatic actuation is not necessary for any postulated accident condition. Similarly, the single active failure criterion adopted for project instrumentation safety systems in HNF-40475 is not applicable for this sludge quantity instrumentation since timing is not important and failure can be repaired.

STSC package closure will not proceed without confirmation of acceptable loading. STSC loading will not begin without first obtaining acceptable initial measurements. The final measurement is a prerequisite to package closure.

To facilitate recovery in the event of a scale failure during loading, the failure modes and effects analysis (PRC-STP-CN-CS-00776) recommended calibration of a spare transmitter (WIT-740-401) to maintain the necessary consistency between the initial and final measurements without an additional penalty in allowed STSC loading. This recommendation has been incorporated into the design media (PRC-STP-00759) by requiring that the supplier provide two transmitters and requiring that both transmitters be calibrated with the complete weight measurement system.

Environmental Design—The STSC level sensor operating temperature range per vendor documentation, is -40° to 176°F, which encompasses the project operating temperature range of 40° to 100°F. Operating temperature requirements are documented in PRC-STP-00773, and have been verified by a review of the Certificate of Conformance and product data sheets included in the Final Data package which is submittal 53920-006-SUB-033 001 for the First Article, but each STSC will have its own Assembly, Inspection and Test Plan and its own Final Data package.

The scale load cells have the same broad temperature range as the level sensor (-40° to 176°F), which encompasses the project operating temperature range of 40° to 100°F. Operating and
temperature requirements are documented in PRC-STP-00773, and were verified by a review of the Certificate of Conformance and product data sheets.

The operating range quoted for the limiting scale components is 14° to 104°F, which encompasses the project operating temperature range of 40° to 100°F. The vendor states that these values are based on the range over which the unit was tested for intrinsic safety, required for explosion prevention in some applications. The listed temperature range for storage of the scale components is -40° to 140°F.

A new radar level element/transmitter is exposed to radiation for each individual STSC. Over the operating cycle for one STSC, expected dose levels of 253 rad have been calculated in the failure modes and effects analysis (PRC-STP-CN-CS-00776) assuming the bounding sludge type during a normal batch operating sequence and the sludge remaining in a decanted state, where there is no additional shielding afforded by the water envelope, for no more than 4 hours. The unit is assessed to have an accumulated dose radiation tolerance of 10,000 rad, the published dose of commercial semiconductor technology. Given the large design margin, the decant time assumption in PRC-STP-CN-CS-00776 does not require protection.

STSC Junction Box ECRT-JB-402 is NEMA 4X rated. The rating is shown on the Bill of Material of H-1-92564, STP ECRTS STSC Junction Box ECRT-JB-402 Assembly, and rating was verified by review of the Certificate of Conformance and product data sheets.

Instrument Bypass Panel ECRT-PNL-402 is NEMA 4 rated. NEMA 4 provides the same level of direct spray protection as NEMA 4X, but does not ensure that the component can be washed down with detergents. The rating is shown in the Bill of Material of H-1-92558, STP ECRTS Instrument Bypass Panel ECRT-PNL-402 Assembly, and was verified by a review of the Certificate of Conformance and product data sheets.

Safety Instrument Panel ECRT-PNL-401 is NEMA 4X rated. The rating is shown on the Bill of Material of H-1-92555, STP ECRTS Safety Instrument Panel ECRT-PNL-401 Assembly, and was verified by a review of the Certificate of Conformance and product data sheets.

Truck scale components installed in the pit are protected with NEMA Type 6P. NEMA Type 6P enclosures are for “prolonged” submersion at a limited depth. Successful UL 50, Standard for Enclosures for Electrical Equipment; UL 50E, Elastomers to Electrical Equipment Enclosure Requirements; and NEMA 250:2008, Enclosures for Electrical Equipment (1000 Volts Maximum), submersion tests are required for an enclosure to provide NEMA Type 6P protection. Testing includes submerging the enclosure in 6 ft of water for 24 hours.

Abnormal environment conditions are evaluated in the failure modes and effects analysis document (PRC-STP-CN-CS-00776) and no issues were identified for this equipment.

The sludge quantity instrumentation is a preventive control, as such there are no accident environment conditions to consider.

**Support Systems**—The sludge quantity instrumentation requires electrical power to perform the required measurements and indicate the results. As discussed under “Safe Failure Modes” above, however, the required measurements can be deferred until electrical power is available.

**Interface Design**—Truck scale ECRT-SCALE-101 interfaces with the STS Trailer. For an accurate measurement, the trailer wheels must be positioned on the scale. Once on the scale, the
measurement is not sensitive to the positioning of the trailer; the four load cells are cascaded in a manner that provides an accurate measurement of the trailer weight. The load configuration for the final weight verification will be matched to the load at the time tare weights were taken (e.g., incidental tools, etc.) to ensure that the measured weight is not biased.

The sludge quantity instrumentation interfaces with a general service data logger located on retrieval/transfer control panel ECRT-PNL-101 and ECRT-PNL-201. ECRT-PNL-201 also uses the data values to compute the sludge buoyant weight, and activate level trips that trip non-safety process interlocks. Signal transmitters LI-740-401 and WIT-740-401 separate the safety-significant indications from the general service data signals with electrically isolated outputs to preclude adverse feedback from the general service equipment that might impair the safety-significant functions.

**Specific Criteria**—The general design requirements for the sludge quantity instrumentation derive primarily from NFPA 70. Safety Instrument Panel ECRT-PNL-401 design requirements are imposed by UL 508A. These requirements are applicable to I&C system installation for general industrial use.

In order to ensure that the control portions of the sludge quantity instruments are provided with protection adequate for the expected environmental conditions, the requirements of NEMA 250:2008 are applied.

Instrument setpoint development is performed in PRC-SP-00754. The criteria for setpoint development are provided in ANSI/ISA-67.04.01-2006 and ANSI/ISA TR67.04.08-1996.

Calibration of the sludge quantity instrumentation is managed in accordance with the requirements of PRC-PRO-MN-490.

### 4.4.12.5 Controls (Technical Safety Requirements)

STSC liquid level and weight measurement instrumentation work in concert with required operator actions to verify that sludge limits are met. These actions are addressed by the Sludge Buoyant Weight Limits SAC described in Section 4.5.6, “Sludge Buoyant Weight Limits.”

STSC liquid level instrumentation works in concert with required operator actions to verify that the STSC final liquid levels are met. These actions are addressed by the STSC Final Liquid Level limits SAC as described in Section 4.5.7, “Sludge Transport and Storage Container Final Liquid Level Limits.”

The Sludge Buoyant Weight Limits SAC has been developed in LCO format. Accordingly, surveillance requirements for the sludge quantity instrumentation are addressed by an LCO/SR as described in Section 5.5.2.3, “Limiting Condition for Operation 3.3-Sludge Buoyant Weight Limits.”

### 4.4.13 105KW Annex and Other Structures and Components

#### 4.4.13.1 Safety Function

The 105KW Annex and other structures are safety-significant for the prevention of slurry spray releases and hydrogen explosions. Safety-significant controls are required for slurry spray releases because the 105KW Annex and other structures associated with the ECRTS Subproject
have the below-listed safety functions. The specific SSC(s) to which a safety function is applicable is identified in brackets.

1. Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by maintaining structural integrity in a fire. [105KW Annex]
2. Prevent a fire-induced hydrogen explosion by maintaining structural integrity in a fire. [105KW Annex]
3. Prevent a fire-induced spray release of slurry during sludge retrieval and transfer by preventing vehicle fuel spills from entering the 105KW Annex. [105KW Annex: Truck Stop/Concrete Platform, Trailer entrance]
4. Prevent a fire-induced hydrogen explosion by preventing vehicle fuel spills from entering the 105KW Annex. [105KW Annex: Truck Stop/Concrete Platform, Trailer entrance]
5. Prevent a hydrogen explosion by maintaining structural integrity during a seismic event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary. [105KW Annex, Mezzanine, bridge crane and associated supports, 105KW Annex exhaust stack, fire protection sprinkler system supports, HVAC duct supports, cable tray supports, hose cradles, and South Tool Tray.]
6. Prevent a wind-induced hydrogen explosion in the STSC or STS Cask by withstanding applicable wind loads thereby preventing damage to the Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary. [105KW Annex]
7. Prevent a spray release of slurry during sludge retrieval and transfer by maintaining structural integrity during a snow and ashfall event. [105KW Annex, Horizontal Shielded Hose Chase]
8. Prevent a hydrogen explosion by maintaining structural integrity during a snow and ashfall event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary. [105KW Annex]
9. Prevent a lightning-induced hydrogen explosion by maintaining structural integrity in a fire [105KW Annex].

The seismic qualification of the Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary are addressed in Section 4.4.6, “Auxiliary Ventilation System,” Section 4.4.8, “Sludge Transport and Storage Container Boundary,” and Section 4.4.9, “Sludge Transport System Cask Pressure Boundary,” respectively.

### 4.4.13.2 System Description

**System Description, 105KW Annex**—The 105KW Annex consists of the Sludge Loading Bay, the Mechanical Equipment Room, the HEPA Filter Room, and the Interior Stair/Personnel Change Room. It is located approximately 40 ft north of the new north wall of the FTS Annex.

The 105KW Annex plan and elevations are depicted on the following drawings:

- H-1-96769, Sheet 1, *Architectural Main Floor Plan General Arrangement*
- H-1-96774, Sheets 1 through 4, *Architectural Exterior Elevations*
- H-1-96775, Sheets 1 through 4, *Architectural Sections Overall Building*
The Sludge Loading Bay is approximately 52 ft 8 in. wide (east-west) by 29 ft 6 in. deep (north-south) by 41 ft 0 in. tall. It is constructed of reinforced concrete to the 20 ft level and of fire resistive metal panels over a rigid steel frame from the top of the concrete to the 41 ft level. It includes a Mezzanine at the 20 ft level and a roll-up door on the east wall to allow for entry of the sludge transport trailer.

The Mechanical Equipment Room is approximately 23 ft 1.75 in. wide by 28 ft 7 in. deep; the HEPA Filter Room is approximately 22 ft 5 1/4 in. wide by 26 ft 1 in. deep; and the Interior Stair/Personnel Change Room is approximately 22 ft 4 in. wide by 26 ft 1 in. deep. The roofs of the Mechanical Equipment Room and the HEPA Filter Room are approximately 15 ft 4 in. high. The roof of the interior stair portion of the Interior Stair/Personnel Change Room is approximately 33 ft 10 in. high, and the roof of the Personnel Change Room is approximately 11 ft high. Part of the north wall of the Mechanical Equipment Room, and the entire north wall of the HEPA Filter Room and the Interior Stair area are formed from the south wall of the Sludge Loading Bay.

The 105KW Annex, including the Mezzanine and external stairs on the west of the building, are conservatively designed to SDC-2 seismic criteria. The 105KW Annex is designed to PC-2 wind criteria and conservatively designed to PC-3 snow and ashfall criteria. The design to SDC-2 seismic criteria and PC-3 snow and ashfall criteria is conservative in that current requirements, based on revised spray release consequence calculations and the associated control decisions, are SDC-1 for seismic and PC-2 for snow and ashfall.

**System Description, Concrete Truck Stop/Platform**—The 105KW Annex design includes a concrete monolithic truck stop located immediately west of the planned parking location for the STS Trailer. This concrete truck stop is credited to provide a physical barrier to prevent the transport tractor fuel tanks from entering the building while the STS Trailer is being positioned. The concrete truck stop also supports a platform that provides personnel access to the rear portions of the trailer. The final design includes a set of wheel stops located to prevent the trailer from physically impacting the concrete truck stop. These wheel stops do not provide a physical barrier to backing, but are meant to provide a cue to the driver. In combination with the use of a spotter, the wheel stops will prevent damage to either the trailer or the concrete truck stop and the platform it supports. Neither the concrete truck stop nor the platform has any seismic safety function during or after a seismic event. Thus, neither has any seismic design requirements.

The truck stop/concrete platform is shown on the following drawings:

- H-1-96775, Sheet 1, *Architectural Sections Overall Building*
- H-1-96782, Sheet 1, *Architectural Enlarged Floor Plan Sludge Loading Bay*
- H-1-96802, Sheet 1, *Structural Slab Plan KW Annex*

**System Description, Sloped Trailer Entrance**—The apron outside the trailer entrance (roll-up door) is sloped away from the building to ensure that fuel spills occurring adjacent to the entrance will gravity-drain away from the building. As shown in the civil site plans, the slope is 1 percent minimum away from the door for at least the first 10 ft. This design will ensure that any fuel spill occurring on approach to the facility drains away from the building. See H-1-96759, Sheet 1, *Civil Building Site Plans Grading Plan*, for the sloped trailer entrance details.
System Description, Horizontal Shielded Hose Chase—Sludge is transferred from the 105KW Basin to the STSC in the Sludge Loading Bay through HIH assemblies. These assemblies pass through two connected hose chases: the In-Basin Shielded Hose Chase and the Horizontal Shielded Hose Chase.

The Horizontal Shielded Hose Chase overlaps the north end of the In-Basin Shielded Hose Chase and runs north to the 105KW Annex, enters the HEPA Filter Room, continues north through the room, and passes through the south wall of the Sludge Loading Bay. It is constructed of concrete enclosing heavy metal plates. The Horizontal Shielded Hose Chase is conservatively designed for PC-3 snow and ashfall loads and SDC-2 seismic loads.

The following drawings depict the Horizontal Shielded Hose Chase:

- H-1-96759, Sheet 1, Civil Building Site Plans Grading Plan
- H-1-96762, Sheet 2, Civil Building Site Plans Sections & Details
- H-1-96769, Sheet 1, Architectural Main Floor Plan General Arrangement

The portion of the hose chase that is outside the annex is surrounded by non-structural insulating panels as shown in Figure 2-7. The reinforced concrete of the hose chase provides protection for PC-3 snow and ashfall loads.

System Description, Bridge Crane—A 5-ton single girder bridge crane is located above the Mezzanine level in the Sludge Loading Bay. The crane is used to remove and reinstall the STS Cask Lid. The crane and its supports are conservatively designed so that they will not fail in such a way that they could prevent a safety-significant SSC from performing its safety function during and after an SDC-2 seismic event. The following documents describe the bridge crane and its supports:

- H-1-96775, Sheet 4, Architectural Sections Overall Building, for a cross sectional view of the building with the bridge crane
- PRC-STP-00743, Sludge Treatment Project Modified KW Basin Annex Bridge Crane Specification

System Description, 105KW Annex Exhaust Stack—The 105KW Annex exhaust stack is located in the HEPA Filter Room. It is a metal stack that is 51 ft high from the floor of the room. Its diameter varies from 22 to 16 in. It is conservatively designed so that it will not fail in such a way that it could prevent a safety-significant SSC from performing its safety function during and after an SDC-2 seismic event.

System Description, Supports—Fire protection sprinkler system supports, HVAC duct supports, and cable tray supports are provided throughout the facility and shown on many project drawings. The supports are conservatively designed to prevent the general service SSCs that they support from failing during a seismic event in such a way that they could prevent a safety-significant SSC from performing its safety function during and after an SDC-2 seismic event.

System Description, Hose Cradles—Hose cradles are provided for use during operations. These supports for HIH lines are provided at various locations beneath the mezzanine. They are safety-significant to ensure they do not fail during a seismic event and allow the HIH to damage the Auxiliary Ventilation System. They are designed to SDC-2.
**System Description, South Tool Tray**—Tool trays are suspended from the mezzanine structure on the north and the south of the keyhole opening. The South Tool Tray contains a tool tray and also provides support for numerous panels, instruments, pipes, and conduits. Portions of the Auxiliary Ventilation System pass through the South Tool Tray and they could be adversely impacted during a seismic event if the tool tray were to fail. Because of this, the South Tool Tray structure is required to be safety-significant. The sheet metal shelves and weld tabs are general service because they would have no impact on the Auxiliary Ventilation System during a seismic event. The South Tool Tray is designed to SDC-2.

### 4.4.13.3 Functional Requirements

Table 4-14 below identifies the functional requirements and associated performance criteria for the 105KW Annex.

### 4.4.13.4 System Evaluation

The performance criteria identified in Table 4-14 characterize the specific operational responses and capabilities necessary for the 105KW Annex to meet functional requirements. The following sections evaluate the capabilities of the 105KW Annex to meet the identified performance criteria.

#### Table 4-14. 105KW Annex and Other Structures Functional Requirements and Performance Criteria

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The 105KW Annex structure shall be of noncombustible construction.</td>
<td>The 105KW Annex structure shall be of noncombustible construction as described in the HNF-SD-SNF-FHA-001 consistent with its classification as an IBC Type IIB building.</td>
</tr>
<tr>
<td>2. The truck stop/concrete platform shall be designed such that the tractor fuel tanks are always located outside of the 105KW Annex when the STS Trailer is positioned within the 105KW Annex.</td>
<td>The truck stop shall be no more than 42 ft 7 in. from the outside face of the 105KW Annex east wall.</td>
</tr>
<tr>
<td>3. The trailer entrance shall be sloped away from the 105KW Annex such that a tractor fuel spill, should it occur, will not enter the building.</td>
<td>The trailer entrance ramp shall be sloped at least 1% away from the 105KW Annex for the first 10 ft.</td>
</tr>
</tbody>
</table>
| 4. The following structures shall meet SDC-1 requirements: 105KW Annex and Mezzanine, bridge crane and associated supports, 105KW Annex exhaust stack, fire protection sprinkler systems supports, HVAC duct supports, cable tray supports, hose cradles, South Tool Tray, and the nitrogen storage cylinder awning. | Seismic design shall be to SDC-1 requirements as modified below:  
  a. $S_{DSH} = 0.458$  
  b. $S_{DSV} = 0.323$  
  c. Vertical Load Effect, $E_v = 0.129g* D$ where $D$ is the dead load. |
| 5. The 105KW Annex shall be designed for PC-2 wind loads as defined in PRC-PRO-EN-097. | The 105KW Annex shall be designed to withstand PC-2 wind loads which are generated by a 91 mi/h wind. |
| 6. The 105KW Annex and Horizontal Shielded Hose Chase shall be designed for PC-2 snow and ashfall as defined in PRC-PRO-EN-097. | The 105KW Annex and Horizontal Shielded Hose Chase shall be designed to withstand PC-2 snow and ashfall loads which are 20 psf combined (i.e., worst case). |
Conservative Design Features, Noncombustible Construction—The 105KW Annex construction type is classified as Type IIB in accordance with the IBC, as defined in Section 602.2, Table 601. By definition, this type of construction includes building elements constructed of noncombustible materials.

The building exterior walls are steel-frame and reinforced-concrete, or steel-frame and fire-resistive core metal wall panels. Interior walls separating the inside stair from the Personnel Change Room are gypsum wallboard assemblies as is the change room ceiling. The wall separating the Sludge Loading Bay from the Mechanical Equipment Room, HEPA Filter Room, and Personnel Change Room is steel-frame and reinforced concrete. The wall separating the HEPA Filter Room and inside stair area is steel-frame and fire-resistive core metal panels; and the wall separating the HEPA Filter Room and mechanical room is a metal stud and gypsum wallboard assembly. Drawing H-1-96769, “Architectural Main Floor Plan General Arrangement,” Sheet 1, specifies IBC Table 720.1(2) design for cast in place concrete portions of the building and UL design numbers for the remaining wall construction.

Conservative Design Features, Truck Stop—The truck stop is designed such that the tractor fuel tanks are always located outside of the 105KW Annex when the STS Trailer is positioned within the 105KW Annex. By measurement of two different tractor and trailer combinations, the distance from the back of the trailer to the fuel tanks on the worst case tractor is 42 ft 7 in. Based on measurements following the completion of construction, the distance from the concrete monolithic truck stop to outside of the 105KW Annex east wall is approximately 41 ft 7 in. This distance is further reduced to approximately 40 ft by the truck stop platform. Thus the tractor fuel tank is kept outside the 105KW Annex by more than 2 ft.

Conservative Design Features, Trailer Entry Ramp—The trailer entry ramp at the rollup door into the 105KW Annex is sloped at least 1 percent away from the door for the first 10 ft as shown on drawing H-1-96759.

Conservative Design Features, Natural Phenomena Design—The design meets all natural phenomena design (i.e., seismic, wind, snow, and ash fall) requirements. Compliance is documented in the following (see further discussion below):

- 44577-CSI-SPEC-001, Sections:
  - 211313, “Wet-Pipe Sprinkler System”
  - 233113, “Metal Ducts”
  - 260529, “Hangers and Supports for Electrical Systems”
  - 260536, “Cable Trays for Electrical Systems”
  - 260548, “Vibration and Seismic Controls for Electrical Systems”
  - 265100, “Interior Lighting”
- 44577-S-CALC-002, Natural Phenomena Hazard Loads
- 44577-S-CALC-003, Crane Runway Beam and Support Design
- 44577-S-CALC-004, Steel Framing
- 44577-S-CALC-005, Concrete Walls
- 44577-S-CALC-006, Concrete Foundation and Slab Design
The calculations contain hundreds of computations that demonstrate that the appropriate codes and standards are met with an acceptable design margin. The specific design margin for each computation is contained within the calculations. Summary tables of design margins are provided in most calculations.

**Conservative Design Features, Seismic Design**—The 105KW Annex, Mezzanine, Horizontal Shielded Hose Chase, bridge crane and associated supports, 105KW Annex exhaust stack, fire protection sprinkler system supports, HVAC duct supports, cable tray supports, hose cradles, and South Tool Tray are required to meet SDC-1 requirements as modified below:

- $S_{DSH} = 0.458g$
- $S_{DSV} = 0.323g$
- Vertical Load Effect, $E_v = 0.129g*D$ where D is the dead load

These parameters, along with the appropriate importance factors, site classes, and limit states, were used in the calculations and designs for the listed SSCs.

The limit states used and relevant supporting documents for each SSC that is subject to seismic design requirements are provided in Table 4-15.

<table>
<thead>
<tr>
<th>Structure, System, or Component</th>
<th>Limit State</th>
<th>Supporting Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>105KW Annex</td>
<td>B</td>
<td>44577-S-CALC-002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-006</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-011</td>
</tr>
</tbody>
</table>
Table 4-15. Supporting Documents for Seismic Design

<table>
<thead>
<tr>
<th>Structure, System, or Component</th>
<th>Limit State</th>
<th>Supporting Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>105KW Annex Mezzanine</td>
<td>B</td>
<td>44577-S-CALC-002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-004</td>
</tr>
<tr>
<td>Bridge Crane And Associated Supports</td>
<td>B</td>
<td>44577-S-CALC-002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CALC-1301-CHP-019-001</td>
</tr>
<tr>
<td>105KW Annex Exhaust Stack</td>
<td>A</td>
<td>44577-S-CALC-002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-S-CALC-007</td>
</tr>
<tr>
<td>Fire Protection Sprinkler System Supports</td>
<td>B</td>
<td>44577-CSI-SPEC-001-211313</td>
</tr>
<tr>
<td>HVAC Duct Supports</td>
<td>B</td>
<td>44577-CSI-SPEC-001-233113</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-CSI-SPEC-001-260548</td>
</tr>
<tr>
<td>Cable Tray Supports</td>
<td>B</td>
<td>44577-CSI-SPEC-001-260536</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44577-CSI-SPEC-001-260548</td>
</tr>
<tr>
<td>Hose Cradles</td>
<td>B</td>
<td>PRC-STP-00954</td>
</tr>
<tr>
<td>South Tool Tray</td>
<td>B</td>
<td>PRC-STP-00954</td>
</tr>
<tr>
<td>Nitrogen Cylinder Storage Awning</td>
<td>B</td>
<td>PRC-STP-00987</td>
</tr>
</tbody>
</table>

Conservative Design Features, Wind Design—The 105KW Annex was designed to withstand a 91-mph wind and meets the requirements of PC-2 wind loads as documented in 44577-S-CALC-002, 44577-S-CALC-004, 44577-S-CALC-005, and 44577-S-CALC-006.

Conservative Design Features, Snow, and Ashfall Design—The 105KW Annex and Horizontal Shielded Hose Chase are required to meet PC-2 snow and ashfall requirements. They were conservatively designed to a 20 psf snow and ashfall load and meet the requirements for the worst case for PC-3 snow/ashfall as documented in 44577-S-CALC-002 and 44577-S-CALC-004.

Safe Failure Modes—The construction of the 105KW Annex and the features of construction called out in the functional design requirements are passive design features that are required to withstand the specified accident scenarios and natural phenomena without failure.

Environmental Design—The 105KW Annex and other structures are not sensitive to ambient temperature and thus accommodate the range of outdoor temperatures identified for the project (−27° to 110°F).

The 105KW Annex also is required to withstand internal and external fires where failure of the structure could result in damage to safety-significant SSCs. This requirement was met by specifying UL and FM-rated components and designs, or equivalent, for the appropriate 105KW Annex structural components. In addition, intumescent coatings are provided for the appropriate bare steel structural column and supports.

The 105KW Annex and certain other structures are designed to seismic, wind, and snow and ashfall requirements as discussed above.

See the “Conservative Design Features” section for a full discussion.
Support Systems—The construction of the 105KW Annex and the features of construction called out in the functional design requirements do not require any support systems for performance of their credited safety functions.

Interface Design—The 105KW Basin superstructure is designed to PC-2 seismic requirements for an existing structure, and the existing FTS Annex has been designed to PC-3 seismic requirements with the exception of the new north wall, which has been designed to SDC-3 requirements. The potential for seismic interactions have been evaluated in PRC-STP-00454, Sludge Treatment Project Engineered Container Retrieval and Transfer System Seismic Interactions. At a distance of 40 ft, the 105KW Annex is outside the zone-of-influence of any 105KW Basin structural failures. Interactions between the Horizontal Shielded Hose Chase and the 105KW Basin superstructure and the FTS Annex have also been evaluated and no mitigation is required.

Specific Criteria—Requirements documents ensure the design of the 105KW Annex structure to the appropriate criteria for resistance to the effects of natural phenomena, including seismic events, wind, snow, and ashfall.

The requirements pertaining to SDC-1 seismic design of the 105KW Annex and Mezzanine, and other listed SSCs, are provided by PRC-PRO-EN-097, Table 1, “Seismic Design Category and Performance Category Correlation and Corresponding Seismic Design Criteria,” which requires design in accordance with ASCE/SEI 7-05.

The requirements pertaining to PC-2 wind design for the 105KW Annex are provided by PRC-PRO-EN-097, Section 2.5.4, “Wind Loads,” which requires design in accordance with ASCE/SEI 7-05 and DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities.

The requirements pertaining to PC-2 design for snow and ash loading for the 105KW Annex are provided by PRC-PRO-EN-097, Sections 2.5.3, “Snow Loads,” and 2.5.6, “Ashfall Loads,” respectively.

4.4.13.5 Controls (Technical Safety Requirements)

The 105KW Annex is a passive SSC not subject to change by Operations personnel. The 105KW Annex is therefore addressed in the TSRs as a design feature as described in Section 5.6.4, “105KW Annex and Associated Structures, Systems, and Components.”

One SAC has been identified to ensure the 105KW Annex can perform its safety functions. A Combustible Material Control Requirements SAC has been established to preclude structurally endangering fires as described in Section 4.5.14, “Combustible Material Control Requirements.”

4.4.14 SCS-CON-230 Divider Plate

4.4.14.1 Safety Function

The SCS-CON-230 divider plate is safety-significant because a hydrogen explosion in an STSC or STS Cask can result in facility worker serious injury or death. The safety function of the SCS-CON-230 divider plate is to protect initial conditions assumed in the safety basis analyses regarding the quantity of uranium metal in an STSC containing Settler Tank sludge. These

4.4.14.2 System Description

The ECRTS design includes a passive, engineered feature called the divider plate (ECRT-ME-230), which is installed into the north end of SCS-CON-230. The divider plate is shown in drawing H-1-92177, *STP ECRTS Retrieval System EC Divider Plate Assembly*. Figure 4-10 depicts the divider plate inserted into the sludge mound in SCS-CON-230.

![Divider Plate Installation in SCS-CON-230](image-url)
Video inspection of the Settler Tank sludge that was transferred into SCS-CON-230 showed that the sludge was generally uniformly distributed throughout the tank with the exception of a large mound under the north distributor head. As described in PRC-STP-CN-CH-00545, Sludge Treatment Project Engineered Container Retrieval and Transfer System Safety Basis Uranium Metal Concentration Derivation for Sludge in Engineered Container SCS-CON-230, the mound is approximately 18 in. in height with a top radius of approximately 9 in. and a bottom-radius of approximately 30 in. The mound is centered over the four egg crate sections in the north end of SCS-CON-230.

The uranium metal concentration in the sludge within this mound is predicted to be higher than sludge in the surrounding area. Analyses of the four core samples of the sludge in Engineered Container SCS-CON-230 show the uranium metal concentration increased the closer the sample was obtained to the north distributor head (i.e., closer to the center of the mound). A model, based on the physical properties, characterization results, and distribution of sludge, was developed to derive the safety basis value for the uranium metal concentration in settler sludge in Engineered Container SCS-CON-230 (PRC-STP-CN-CH-00545). The model predicts a safety basis average uranium metal concentration in the north half of SCS-CON-230 of 0.144 g/ml, while the peak metal concentration in the innermost ring (9-in. radius from the center of the mound) is 0.840 g/ml of settled sludge.

The thermal and gas analyses used a slightly larger volumetric average uranium metal concentration (0.163 g/ml) than the safety basis concentration (0.144 g/ml) in the north section of SCS-CON-230 of settled sludge based on retrieving 0.4 m$^3$ of the highest metal concentration material in a given north end quadrant as analyzed in PRC-STP-CN-CH-00712, Evaluation of Sludge Leakage from Divider Panel in SCS-CON-230.

PRC-STP-CN-CH-00712 develops a conservative model for the withdrawal of sludge from any one of the four quadrants defined by the divider plate in the north half of SCS-CON-230. The model assumes that the highest uranium metal concentration material is removed first, followed by the next highest, etc., until the total quantity of sludge to be removed is achieved. Application of this model is illustrated in Section 5.8.8.b and Table 13 of the calculation for a case assuming the withdrawal of 0.4 m$^3$ of material and concluding that the material would contain 65.1 kg of uranium metal.

Separately, PRC-STP-CN-CH-00712 develops a model for leakage past the divider plate based on experiments conducted at MASF with wet sand. The model concludes that when the first selected quadrant is emptied (a total volume of 0.49 m$^3$), cumulative leakage past the divider plate could contribute no more than 0.1229 m$^3$ of sludge containing no more than 11.6 kg of additional uranium metal.

The sludge quantity setpoints discussed in Section 4.5.6 derive a SAC limit to protect the 0.4 m$^3$ volume assumption based on the design basis sludge density of 2000 kg/m$^3$ versus the safety basis sludge density 2800 kg/m$^3$ as assumed in thermal and gas analyses. This conservative approach means that only a fraction of the allowed 0.4 m$^3$ would be loaded at the SAC limit for the density modeled in the thermal and gas analyses. The maximum loaded volume would be approximately 0.334 m$^3$ (PRC-STP-00754). This volume represents approximately 55 percent of the available material had the quadrant been emptied.
In order to protect the thermal and gas analysis assumption regarding the quantity of uranium metal in a layered STSC, it is important to ensure the sludge is not transferred or slumped from the mound area in other quadrants into the egg crate section being retrieved in a manner that would permit too much of the high concentration material to be loaded in a single STSC. Accordingly, the final design incorporates a divider plate that separates the four north-end egg crates from each other.

4.4.14.3 Functional Requirements

Table 4-16 below identifies the functional requirement and associated performance criterion for the engineered container divider plate (ECRT-ME-230).

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Limit the inleakage of sludge from the center of the sludge mound in adjacent quadrants when retrieving sludge from a given quadrant.</td>
<td>The maximum uranium metal content that can be loaded into an STSC from the north half of SCS-CON-230 with the divider plate installed and layered with KE sludge shall not exceed the 72.5 kg assumed in thermal and gas analyses.</td>
</tr>
</tbody>
</table>

4.4.14.4 System Evaluation

The performance criterion identified in Table 4-16 characterizes the specific capability necessary for the engineered container divider plate to meet its functional requirement. The following sections evaluate the capabilities of the engineered container divider plate to meet the identified performance criteria.

Conservative Design Features—STP ECRTS has conducted testing of the engineered container divider plate using the half-engineered container at MASF as reported in PRC-STP-TR-00724, Test Report for Sludge Treatment Project Engineered Container Divider Plate Assembly Test. The divider plate was installed in the half-sized engineered container, which was located underwater in the 105KW Basin mockup. The half-sized engineered container was filled with sand as a simulant for Settler Tank sludge in a configuration to approximate the Settler Tank sludge configuration in the north half of Engineered Container SCS-CON-230. The test results were evaluated in PRC-STP-CN-CH-00712 and included in the conservative model that demonstrates the performance criterion has been met as discussed above (Section 4.4.14.2). The divider plate affords a robust means of ensuring that too much of the uranium-metal-rich material in the center of the mound will not be loaded into a single STSC.

Safe Failure Modes—The engineered container divider plate is a passive design feature. The SCS-CON-230 divider plate was procured, inspected/accepted, and verified in accordance with PRC-MP-QA-599 requirements for Quality Level 2 items and has been installed into SCS-CON-230.

Environmental Design—The engineered container divider plate made of Type 304 stainless steel components can perform its function over the identified temperature range for ECRTS interior spaces of 40° to 100°F. Any temperature-driven expansion or contraction of the material
of construction will be consistent with the engineered container itself and could not affect performance. This is particularly true for the narrow range of temperature changes that can be anticipated in the basin (59° to 77°F). The materials of construction are not sensitive to the radiation environment associated with the contained sludge.

Support Systems—The engineered container divider plate is a passive design feature and does not rely on support systems to perform its safety function.

Interface Design—The engineered container divider plate interfaces with the general service engineered container, including the egg crate dividers. The test data for the divider plate are judged to represent the gaps that may exist at this interface.

Specific Criteria—The engineered container divider plate is fabricated of Type 304 stainless steel components (sheet metal, tubing, eye bolts, and bar stock) fabricated and inspected to American Society of Testing and Materials standards. Welding was performed per AWS D1.6, *Structural Welding Code – Stainless Steel*, with visual test of final pass on all welds.

4.4.14.5 Controls (Technical Safety Requirements)

The engineered container divider plate is a passive, engineered component that is not subject to change by Operations personnel. Therefore the divider plate is addressed in the TSRs as a design feature as described in Section 5.6.8, “SCS-CON-230 Divider Plate.”

4.4.15 Hoist Chain Stops

4.4.15.1 Safety Function

The hoist chain stops are safety-significant because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The safety function of the hoist chain stops is to protect the accident analysis assumption regarding the MAR during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container.

To provide an additional layer of defense-in-depth, RL has directed that administrative controls be established controlling the XAGO location and Basin water motive force (see Section 4.5.16, “XAGO Pre-Operational Testing and Operational Readiness Controls”). These controls ensure that sludge will not be transferred should too much chain be deployed and the hoist chain stop fail.

4.4.15.2 System Description

A hoist chain stop is simple mechanical device attached to the chain used to raise and lower a XAGO. The chain stop consists of a polyurethane stop block setting on a two-piece carbon steel casting. The chain stop is secured to the chain by two bolts and associated lock washers and nuts. The chain stop performs its safety function by physically preventing additional chain from being deployed by the hoist.

There are two hoists and associated chain stops, one located in Center Bay for retrieval from Engineered Containers SCS-CON-210, -220, and -230, and located in the East Bay for retrieval from Engineered Containers SCS-CON-240, -250, and -260.
4.4.15.3 Functional Requirements

Table 4-17 below identifies the functional requirement and associated performance criterion for the hoist chain stops.

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prevent a XAGO from being lowered into an engineered container by physically limiting</td>
<td>The hoist chain stop shall limit the length of chain deployed by the hoist to a maximum of 92 in.</td>
</tr>
<tr>
<td>the length of chain deployed by the hoist.</td>
<td></td>
</tr>
</tbody>
</table>

4.4.15.4 System Evaluation

Conservative Design Features—Operators lower the XAGO by depressing a hoist switch until the XAGO reaches the desired depth. The safety-significant chain stop will prevent the hoist from deploying more than 92 in. of chain which will ensure the XAGO remains approximately 6 in. above the top of an engineered container.

Safe Failure Modes—One failure mode has been identified for the chain stops. If the two bolts securing a chain stop to a chain were to loosen or fail, then additional chain could be deployed by the hoist. This failure mode is mitigated by the use of lock washers.

Environmental Design—The hoist chain stop materials of construction are polyurethane and carbon steel. These materials are not sensitive to ambient temperature and humidity conditions within the 105KW Basin superstructure.

Support Systems—The hoist chain stops are passive design features and do not rely on support systems to perform their safety function.

Interface Design—Hoist chain stops interface with the general service chain hoists and associated chains. There are no chain or hoist failure modes that can prevent a chain stop from performing its safety function. A failure of a chain, once deployed by the hoist, would result in the XAGO being dropped within the basin. Such an occurrence would be readily detected by Operators.

Specific Criteria—There are no specific criteria from industry codes and standards applicable to the chain stops.

4.4.15.5 Controls (Technical Safety Requirements)

The hoist chain stops are passive, engineered controls that are not subject to change by Operations personnel. Therefore the stops are addressed in the TSRs as a design feature as described in 5.6.9, “Hoist Chain Stops.” Following Readiness Review and RL Start-up Authorization the hoist chain stops will no longer be required to prevent sludge transfers.
4.5 Specific Administrative Controls

The following sections identify and describe the SACs selected to prevent and mitigate slurry spray releases, STSC/STS Cask hydrogen explosions, and STSC/STS Cask over-pressurizations. Table 4-18 provides a summary list of the SACs.
## Table 4-18. Summary List of Specific Administrative Controls

<table>
<thead>
<tr>
<th>Specific Administrative Control</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
</tr>
</thead>
</table>
| Sludge Source Verification      | • Operational Accident–STSC Hydrogen Explosion (3.4.2.2)  
• Operational Accident–STSC Over-Pressurization Release (3.4.2.4) | Protect initial conditions assumed in the STSC thermal and gas analyses regarding the type of sludge in an STSC. | Prior to starting Booster Pump ECRT-P-101A/B, verify the XAGO is placed in the correct engineered container for the planned transfer. |
| Basin Water Level               | Operational Accident–ECRTS Spray Releases (3.4.2.1) | Protect the hazard analysis assumption that slurry transfer line failures underwater in the 105KW Basin do not result in airborne releases. | Prior to starting Booster Pump ECRT-P-101A/B, verify the basin water level is greater than or equal to 15 ft above the basin floor. |
| Personnel Access Prohibition    | • Operational Accident–ECRTS Spray Releases (3.4.2.1)  
• Operational Accident–105KW Annex Fire (3.4.2.5)  
• Natural Phenomenon–Seismic Event (3.4.2.6)  
• Natural Phenomenon–Snow and Ashfall (3.4.2.8)  
• Natural Phenomenon–Low Temperatures (3.4.2.9)  
• External Events–Vehicle Impact (3.4.2.11)  
• External Events–Range Fire (3.4.2.12) | Mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer. | Prior to starting Booster Pump ECRT-P-101A/B, verify that:  
• No personnel are in the Sludge Loading Bay  
• Doors 103 and 109 are closed and locked |
| Vehicle Access Control          | External Events–Vehicle Impacts (3.4.2.11) | Prevent the spray release of slurry during sludge retrieval and transfer by prohibiting vehicular traffic in the vicinity of the 105KW Annex. | Prior to starting Booster Pump ECRT-P-101A/B, verify that “Road Closed” signs are posted on Wakefield Loop at a distance of 25 yards or greater from the 105KW Annex. |
| Slurry Settling Duration        | Operational Accident–ECRTS Spray Releases (3.4.2.1) | Protect accident analysis assumptions regarding the composition of decanted STSC supernate. | Prior to starting Decant Pump ECRT-P-201/201S, verify it has been a minimum of 2 hr since Booster Pump ECRT-P-101A/B was de-energized. |
Table 4-18. Summary List of Specific Administrative Controls

<table>
<thead>
<tr>
<th>Specific Administrative Control</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
</tr>
</thead>
</table>
| Sludge Buoyant Weight Limits                    | • Operational Accident–STSC Hydrogen Explosion (3.4.2.2)  
    • Operational Accident–STSC Over-Pressurization Release (3.4.2.4) | Protect initial conditions assumed in the STSC thermal and gas analyses regarding the quantity of sludge in an STSC.                                                                                           | The buoyant weight of sludge in an STSC shall be less than or equal to the associated limits as shown in Table 4-20.                                                                                                  |
| STSC Final Liquid Level Limits                   | Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Prevent a hydrogen explosion in an STSC during long-term storage at T Plant by limiting the liquid level in an STSC.                                                                                         | Verify that the final liquid level in an STSC is less than or equal to the applicable level as shown in Table 4-21.                                                                                                  |
| Gas Composition Verification                     | Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Prevent a hydrogen explosion in an STSC or STS Cask by verifying that the Auxiliary Ventilation System and Inert Gas System are supplied with nitrogen.                                                   | Prior to receipt at the 105KW Annex, verify that the nitrogen gas purity is greater than or equal to 99.9 percent and has a moisture content of 3 ppm or less.                                                                     |
| STSC Inerting Limit                              | Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Prevent a hydrogen explosion in an STSC by verifying that an inert atmosphere has been established in the STSC headspace.                                                                                 | The STSC shall be inerted to less than 0.5 vol% oxygen.                                                                                                                                                   |
| STS Cask Lid Critical Lift                      | Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Prevent a hydrogen explosion in an STSC by preventing an STS Cask Lid drop.                                                                                                                                 | 1. STS Cask Lid installation shall be performed in accordance with the requirements of DOE/RL-92-36, Chapter 3.0, “Critical Lifts.”  
    2. If sludge is present in an STSC, removal of the STS Cask Lid, if required, shall be performed in accordance with the requirements of DOE/RL-92-36, Chapter 3.0, “Critical Lifts.” |
Table 4-18. Summary List of Specific Administrative Controls

<table>
<thead>
<tr>
<th>Specific Administrative Control</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
</tr>
</thead>
</table>
| STS Cask Inerting and Pressurization Limits | • Operational Accident–STSC Hydrogen Explosion (3.4.2.2)  
• Natural Phenomenon–Lightning (3.4.2.9) | • Prevent a hydrogen explosion in an STS Cask by verifying that an inert atmosphere has been established in the STS Cask headspace.  
• Prevent a hydrogen explosion in the STS Cask by verifying that the STS Cask is properly pressurized thereby preventing air ingress.  
• Protect initial conditions assumed in the thermal and gas analyses for transportation regarding the initial STS Cask pressure. | The STS Cask shall be inerted to less than 1.2 vol% oxygen and pressurized to between 3 and 15 psig within 24 hr of terminating the STSC nitrogen purge. |
| STS Cask Leak Rate Limit | Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Prevent a hydrogen explosion by verifying that the STS Cask leak rate is less than or equal to 9.0E-4 standard cm³/s air. | The STS Cask leak rate shall be less than or equal to 9.0E-4 standard cm³/s air prior to shipment to T Plant. |
| STS Cask Staging Limit | • Operational Accident–STSC Hydrogen Explosion (3.4.2.2)  
• Operational Accident–STSC Over-Pressurization Release (3.4.2.4) | • Protect initial conditions assumed in staging and transportation analyses regarding STSC temperatures and pressures.  
• Prevent a hydrogen explosion by limiting the rate at which hydrogen would be released should the STS Cask need to be vented in the Sludge Loading Bay.  
• Prevent STS Cask over-pressurization by venting the cask. | The STS Cask shall exit the 105KW Annex en route to T Plant within 240 hr of completing STS Cask pressurization. |
Table 4-18. Summary List of Specific Administrative Controls

<table>
<thead>
<tr>
<th>Specific Administrative Control</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
</tr>
</thead>
</table>
| Combustible Material Control Requirements | • Operational Accident–105KW Annex.Fire (3.4.2.5)  
• Natural Phenomenon–Lightning (3.4.2.9)  
• External Events–Range Fire (3.4.2.12) | • Prevent a fire of sufficient size to initiate a spray release of slurry during sludge retrieval and transfer by controlling combustible materials.  
• Prevent a fire of sufficient size to initiate a hydrogen explosion by controlling combustible materials. | 1. In the Sludge Loading Bay, the fuel package size is limited to 645 kW as the default fire exposure. Larger fuel packages may be present provided the fuel package and associated separation distances have been analyzed and documented in a fire hazards analysis.  
2. In the Sludge Loading Bay, a minimum distance of 5 ft shall be maintained between a default fuel package and other fuel packages.  
3. In the Sludge Loading Bay, a minimum distance of 5 ft shall be maintained between a default fuel package and process transfer lines.  
4. On the Sludge Loading Bay Mezzanine, a minimum distance of 3 ft shall be maintained between a default fuel package and structural columns.  
5. Unattended vehicles containing ≤ 100 gal of fuel shall not be parked within 15 ft of the 105KW Annex.  
6. Unattended vehicles containing > 100 gal of fuel shall not be parked within 50 ft of the 105KW Annex.  
7. A 30-ft defensible space around the 105KW Annex shall be free of transient combustibles and accumulations of windblown vegetation. |
### Table 4-18. Summary List of Specific Administrative Controls

<table>
<thead>
<tr>
<th>Specific Administrative Control</th>
<th>Chapter 3 Accident Analysis Cross Reference (Section)</th>
<th>Safety Functions</th>
<th>Functional Requirements</th>
</tr>
</thead>
</table>
| Auxiliary Ventilation System Actuation Notification | • Operational Accident–STSC Hydrogen Explosion (3.4.2.2)  
• Operational Accident–105KW Annex Fire (3.4.2.5)  
• Natural Phenomenon–Seismic Event (3.4.2.6)  
• Natural Phenomenon–Wind (3.4.2.7)  
• Natural Phenomenon–Snow and Ashfall (3.4.2.8)  
• Natural Phenomenon–Lightning (3.4.2.9)  
• External Events–Vehicle Impact (3.4.2.11)  
• External Events–Range Fire (3.4.2.12) | Prevent a hydrogen explosion in an STSC by ensuring a 96-hr Auxiliary Ventilation System nitrogen supply. | STSC normal ventilation indicator lights shall be “on” when an STSC containing sludge is connected to the Process/Exhaust Ventilation System. |
| XAGO Pre-Operational Testing and Operational Readiness Controls | • Operational Accident–ECRTS Spray Releases (3.4.2.1)  
• Operational Accident–STSC Hydrogen Explosion (3.4.2.2) | Protect the accident analysis assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container | 1. The XAGO tool shall be placed away from the area above the engineered container when using Basin water to simulate sludge transfer to the 105KW Annex using the XAGO tool  
2. Positive control shall be maintained on the Basin water motive force to the XAGO tool to prevent Basin water transfers to the 105KW Annex when the XAGO tool is allowed above the engineered containers. |
4.5.1 Sludge Source Verification

4.5.1.1 Safety Function

The Sludge Source Verification administrative control is designated as a SAC because a hydrogen explosion in an STSC or STS Cask, or the over-pressurization of an STSC or STS Cask, can result in facility worker serious injury or death. The safety function of the Sludge Source Verification SAC is to protect initial conditions assumed in the STSC thermal and gas analyses regarding the type of sludge in an STSC. The hydrogen generation rate depends, in part, on the quantity of uranium metal present in the sludge, which varies between the engineered containers.

4.5.1.2 Specific Administrative Control Description

There are six engineered containers in the 105KW Basin. Engineered Containers SCS-CON-210, -220, and -230 are located in the East Bay. Engineered Container SCS-CON-210 contains KW Basin floor and pit sludge; SCS-CON-220 contains KW Basin floor and pit sludge and a small volume of segregated settler material; and SCS-CON-230 contains settler tank sludge. Engineered Containers SCS-CON-240, -250, and -260 are located in the Center Bay and contain sludge transferred from the KE Basin.

Different buoyant weight limits have been established for the different sludge types to protect initial conditions assumed in the STSC thermal and gas analyses. If sludge was retrieved from the wrong engineered container, then a buoyant weight limit could unknowingly be exceeded. To prevent such an occurrence, this SAC requires verification that the XAGO is placed in the correct engineered container for the planned transfer. The verification will be performed by visually observing the position of the XAGO tool and documenting the corresponding engineered container number. There are no practical engineered controls that can perform the intended safety function.

4.5.1.3 Functional Requirements

One functional requirement is identified for this SAC:

1. Prior to starting Booster Pump ECRT-P-101A/B, verify the XAGO is placed in the correct engineered container for the planned transfer.

4.5.1.4 Specific Administrative Control Evaluation

As discussed in Chapter 2.0, Section 2.5.2.5, “Sludge Retrieval,” there are two sludge retrieval lines: one in the East Bay and one in the Center Bay. Each line includes a XAGO, an Instrument Spool, a Booster Pump Skid, and an In-Basin Flocculant Addition Skid. For a given retrieval line, the XAGO is positioned north and south using a deployment beam on the overhead monorail system; and is positioned east and west using a trolley on the deployment beam. The XAGO is positioned vertically using a hoist on the trolley. This configuration allows placing the XAGO tool in each of the egg crates of a given container.

It is noteworthy that a XAGO cannot be placed in an incorrect container by a simple error of commission. Moving a XAGO from one container to another within a given bay is a multi-person, multi-step task that involves disconnecting the XAGO from the booster pump, draining and disconnecting three IXM water lines from the XAGO, using jumpers to bridge to
a different set of monorails, using two different transfer cranes to simultaneously move both the XAGO and Instrument Skid, and re-making process connections.

Verifying the XAGO is placed in the correct engineered container is a preventive control, as such there are no accident environment conditions to consider.

The location of the containers in the basin is indicated by labels on the lids of the engineered containers. Verifying that the XAGO is placed in the correct engineered container is judged to be a task of low difficulty.

The 105KW Basin may be posted as an Airborne Radioactivity Area. Respiratory protection may therefore be required while verifying the location of the XAGO. Operators performing work in the 105KW Basin are routinely required to wear respiratory protection. This induces a low level of stress.

4.5.1.5 Controls (Technical Safety Requirements)

The Sludge Source Verification SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.1, “Administrative Control 5.6.1–Sludge Source Verification.”

4.5.2 Basin Water Level

4.5.2.1 Safety Function

The Basin Water Level administrative control is designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The safety function of the SAC is to protect the hazard analysis assumption that slurry transfer line failures underwater in the 105KW Basin do not result in airborne releases.

4.5.2.2 Specific Administrative Control Description

The ECRTS hazard analysis assumed that slurry transfer line failures between the booster pump and the Ingress/Egress Assembly during sludge retrieval and transfer do not result in airborne spray releases because the associated transfer line is located underwater. To protect this assumption, operators will verify that the basin water level is greater than or equal to 15 ft above the basin floor prior to initiating a transfer.

The 105KW Basin water level verification is typically performed using a bubbler system. Alternatively, the water level can be verified using manual tools (e.g., measuring tapes or measuring rods). Based on the diversity of techniques available, the measuring devices are classified as general service SSCs and their usage is controlled in accordance with HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Programs, Chapter 10, “Initial Testing, In-Service Surveillance, and Maintenance,” Key Attribute 10-3. This attribute requires that instruments and equipment used for verifying conformance to requirements, monitoring processes, or collecting data are controlled, calibrated at specific intervals, and maintained to required accuracy limits. For this safety function, engineered controls versus a SAC could have been selected. For example, basin water level instrumentation could be interlocked to prevent the operation of Booster Pump ECRT-P-101A/B if the water level fell below a set value. A SAC was chosen instead to simplify system design by relying on direct operator verification and control.
4.5.2.3 **Functional Requirements**

One functional requirement is identified for this SAC.

1. Prior to starting Booster Pump ECRT-P-101A/B, verify the basin water level is greater than or equal to 15 ft above the basin floor.

4.5.2.4 **Specific Administrative Control Evaluation**

Verifying the basin water level is a preventive control, as such there are no accident environment conditions to consider.

Verifying basin water level has historically been a TSR control and is judged to be a task of low difficulty.

Operators performing work in the 105KW Basin are routinely required to wear respiratory protection. This induces a low level of stress.

4.5.2.5 **Controls (Technical Safety Requirements)**

The Basin Water Level SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.2, “Administrative Control 5.6.2–Basin Water Level.”

4.5.3 **Personnel Access Prohibition**

4.5.3.1 **Safety Function**

The Personnel Access Prohibition administrative control is designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The safety function of the SAC is to mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer.

4.5.3.2 **Specific Administrative Control Description**

Prior to initiating a slurry transfer, Operations will verify that the 105KW Annex is unmanned and that doors 103 and 109 are closed and locked.

The verification will be performed as a concurrent dual verification. As defined in DOE-STD-1036-93, *Guide to Good Practices for Independent Verification*, concurrent dual verification is a method of checking an operation in which the verifier independently observes and/or confirms the operation.

If the doors have remained closed and locked since the previous transfer, re-verification for a subsequent transfer is not required.

There are five doors into the Sludge Loading Bay doors: Doors 104, 106 and 109 on the main level, and Doors 201 and 202 on the mezzanine level. Doors 104 and 201 provide access to the Sludge Loading Bay from the Interior Stair and Change Room. Access to these doors is controlled by closing and locking Door 103. Locking Door 103 prevents access to Doors 104 and 201 while allowing access to the Change Room where remote readouts for Radiological Control instrumentation are located.
Door 109 is the Sludge Loading Bay roll-up door located on the east wall of the 105KW Annex, which must be closed and locked. Doors 106 and 202 are egress-only doors provided to comply with the emergency egress requirements of NFPA 101, Life Safety Code. These doors are self-closing and have no exterior hardware with which to open them.

For this safety function, engineered controls versus a SAC could have been selected. For example, door switches could be interlocked to prevent energizing Booster Pump ECRT-P-101A/B if a door is open. However, engineered controls have already been selected to prevent operational, fire, natural phenomena hazard, and external event-initiated spray releases in accordance with the control selection hierarchy. This control was selected as a SAC as it is a major contributor to defense-in-depth.

4.5.3.3 Functional Requirements
One functional requirement is identified for this SAC.

1. Prior to starting Booster Pump ECRT-P-101A/B, verify that
   a. No personnel are in the Sludge Loading Bay
   b. Doors 103 and 109 are closed and locked

4.5.3.4 Specific Administrative Control Evaluation
The Personnel Access Prohibition SAC is a mitigative administrative control. It is performed prior to the initiating of a slurry transfer. Therefore, there are no accident environment conditions to consider during its performance.

Verifying the Sludge Loading Bay is unmanned will be accomplished by performing a walkdown of the bay. Subsequent to the walkdown, Doors 103 and 109 will be closed and locked thus preventing access. The keys to Doors 103 and 109 will be placed in the key-controlled lock box located in the 105KW Shift Office. These activities are judged to be of low difficulty.

The 105KW Annex Sludge Loading Bay is environmentally controlled, and respiratory protection is not normally required.

4.5.3.5 Controls (Technical Safety Requirements)
The Personnel Access Prohibition SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.3, “Administrative Control 5.6.3–Personnel Access Prohibition.”

4.5.4 Vehicle Access Control
4.5.4.1 Safety Function
The Vehicle Access Control administrative control is designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. The safety function of the SAC is to prevent the spray release of slurry during sludge retrieval and transfer by prohibiting vehicular traffic in the vicinity of the 105KW Annex.
4.5.4.2 Specific Administrative Control Description

A vehicle impact was identified as an external event that could result in a slurry spray release. This SAC prohibits vehicular traffic in the vicinity of the 105KW Annex during sludge retrieval and transfers thereby preventing vehicle impact-initiated spray release. Prior to starting Booster Pump ECRT-P-101A/B, Operations will verify that “Road Closed” signs are posted on Wakefield Loop at a distance of 25 yards or greater from the 105KW Annex.

This SAC does not apply to emergency response vehicles. Restrictions on vehicles parking adjacent to the 105KW Annex are addressed by the Combustible Material Control Requirements SAC.

For this safety function, engineered controls are not practical. The 105KW Annex at grade level, and the horizontal shielded hose chase, are constructed of 15-in. reinforced concrete and provide a robust engineered barrier for vehicle impacts. However, the 16 ft-tall, 14-ft wide Sludge Loading Bay roll-up door is vulnerable to vehicle impacts. Routine vehicle access to this door is required for STS Trailer transport. Therefore, a SAC was selected. This selection takes into consideration the low time-at-risk for a vehicle impact/fire-induced spray release, existing 105KW Annex fire-related design features (see Section 3.4.2.5, “Operational Accident—105KW Annex Fire”), and facility experience in implementing TSR-level vehicle access controls.

4.5.4.3 Functional Requirements

One functional requirement is identified for this SAC.

1. Prior to starting Booster Pump ECRT-P-101A/B, verify that “Road Closed” signs are posted on Wakefield Loop at a distance of 25 yards or greater from the 105KW Annex.

4.5.4.4 Specific Administrative Control Evaluation

The Vehicle Access Control SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying compliance with vehicle access control requirements is judged to be a task of low difficulty.

Operators will be exposed to ambient environmental conditions while posting “Road Closed” signs.

4.5.4.5 Controls (Technical Safety Requirements)

The Vehicle Access Control SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.4, “Administrative Control 5.6.4–Vehicle Access Control.”

4.5.5 Slurry Settling Duration

4.5.5.1 Safety Function

The Slurry Settling Duration administrative control is designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the
PAC-3 SOF. The safety function of the SAC is to protect accident analysis assumptions regarding the composition of decanted STSC supernate.

4.5.5.2 Specific Administrative Control Description

The decant and ECRTS Sand Filter backwash spray release accident consequences documented in PRC-STP-CN-N-00947 are below evaluation guidelines for the selection of safety-significant controls. The solids fraction values used in the analyses were calculated in PRC-STP-CN-CH-00693, Sludge Treatment Project – Engineered Container Retrieval and Transfer System – Supporting Process Calculations for PDSA Accident Analysis, using a hindered terminal settling velocity model and assuming a 2-hour settling duration. Longer settling times will result in increased settling and thus a reduced solids concentration and a reduced MAR. In contrast, shorter settling times will result in decreased settling and thus a higher solids concentration and an increased MAR.

This SAC protects the accident analysis MAR assumptions by ensuring a minimum settling time of 2 hours prior to STSC decant. Prior to starting Decant Pump ECRT-P-201/201S, Operations will verify it has been a minimum of 2 hours since Booster Pump ECRT-P-101A/B was de-energized.

For this safety function, engineered controls versus a SAC could have been selected. For example, a timer could be interlocked to prevent operation of Decant Pump ECRT-P-201 prior to a 2-hour settling duration. A SAC was chosen instead to simplify system design by relying on direct operator control.

4.5.5.3 Functional Requirements

One functional requirement is identified for this SAC.

1. Prior to starting Decant Pump ECRT-P-201/201S, verify it has been a minimum of 2 hours since Booster Pump ECRT-P-101A/B was de-energized.

4.5.5.4 Specific Administrative Control Evaluation

The Slurry Settling Duration SAC protects accident analysis MAR assumptions; therefore, there are no accident environment conditions to consider.

Verifying that the slurry transferred into an STSC has settled for a minimum of 2 hours prior to decanting the supernate is judged to be a task of low difficulty.

Initiating a supernate decant will be authorized by a specifically authorized individual located in the EOC. There are no environmental conditions associated with this location that would result in elevated stress levels.

4.5.5.5 Controls (Technical Safety Requirements)

The Slurry Settling Duration SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.5, “Administrative Control 5.6.5–Slurry Settling Duration.”
4.5.6 Sludge Buoyant Weight Limits

4.5.6.1 Safety Function

The Sludge Buoyant Weight Limits administrative control is designated as a SAC because a hydrogen explosion in an STSC or STS Cask, or the over-pressurization of an STSC or STS Cask, can result in facility worker serious injury or death. Thus the SAC has two safety functions. The first is to prevent an STSC/STS Cask hydrogen explosion by protecting initial conditions assumed in STSC thermal and gas analyses regarding the quantity of sludge in an STSC. The second is to prevent an STSC/STS Cask over-pressurization by protecting initial conditions assumed in STSC thermal and gas analyses regarding the quantity of sludge in an STSC.

4.5.6.2 Specific Administrative Control Description

Thermal and gas analyses have been performed for an STSC during sludge retrieval and transfer (PRC-STP-CN-N-00935), during preparation for, and transportation to, T Plant (PRC-STP-CN-N-00819, PRC-STP-CN-N-00989), and during unloading and long-term storage at T Plant (PRC-STP-00241). The analyses demonstrate that under certain conditions sufficient hydrogen for flammability exists in an STSC or STS Cask headspace, and that sufficient gas can be generated to over-pressurize either an STSC or STS Cask.

Initial conditions assumed in the thermal and gas analyses that must be protected include the quantity of sludge in the STSC and the STSC dimensions. This SAC protects sludge quantity assumptions. STSC dimensions are addressed as a design feature of the STSC.

Table 4-19 provides the sludge quantity limits expressed as both volumes and buoyant weights. Table 4-19 also provides the process instrumentation buoyant weight setpoints selected to ensure that the limits are not exceeded.

The buoyant weight limits shown in Table 4-19 were derived using safety basis sludge densities consistent with the thermal and gas analysis assumptions. In contrast, the process instrumentation buoyant weight setpoints were derived using design basis densities. This conservative approach provides a significant design margin that greatly reduces the likelihood of a buoyant weight limit being exceeded. For example, the buoyant weight setpoint for SCS-CON-230 is 330 kg based on the design basis density. As shown in PRC-STP-00754, Appendix A, “Setpoint Analysis for STSC Buoyant Weight,” the setpoint would be 650 kg if it were instead based on the safety basis density. As shown in HNF-41051, Table 5-20, “Number of STSCs Produced Using STSC Buoyant Load Weight Setpoints,” the estimated number of STSCs is estimated to range from 18 (if filled to 100 percent of the setpoint) to 25 (if filled to 70 percent of the setpoint).
Table 4-19. Sludge Limits and Instrumentation Setpoints

<table>
<thead>
<tr>
<th>STSC Sludge Composition</th>
<th>Volume Limit (m³)</th>
<th>Corresponding Buoyant Weight Limit (kg)</th>
<th>Process Instrumentation Buoyant Weight Setpoint (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCS-CON-230</td>
<td>0.4</td>
<td>≤ 720</td>
<td>330</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>1.6</td>
<td>≤ 960</td>
<td>770</td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>1.6</td>
<td>≤ 1056</td>
<td>370</td>
</tr>
<tr>
<td>SCS-CON-220</td>
<td>1.0</td>
<td>≤ 789</td>
<td>650</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>2.1</td>
<td>≤ 1260</td>
<td>980†</td>
</tr>
</tbody>
</table>

Notes:
- a. HNF-41051, Table 2-2.
- b. PRC-STP-00754, Table 6-1.
- c. Derived using safety basis densities.
- d. Derived using design basis densities.
- e. Based on controlling the direct dose rate at the top of the STSC.

As shown in Table 4-19, the buoyant weight setpoint for an STSC containing only SCS-CON-240, -250, -260 sludge is 980 kg. This value represents a reduction of approximately 30 kg of sludge from what would otherwise be allowed. This reduction allows more water to be added to the STSC for radiation shielding purposes.

Process control engineers will use the data from the safety-significant liquid level and truck scale instrumentation (see Section 4.4.12, “Sludge Quantity Instrumentation”) to calculate the sludge buoyant weight after each slurry transfer and verify that the buoyant weight limits are not exceeded. Thus the sludge quantity instrumentation is a support SSC to this SAC.

Three sets of level and weight data are used in this calculation: the high tare weight and level for the STSC filled with water, the low tare weight and level for the STSC after the initial decant, and the final weight and level of the STSC ready for transportation. The high and low tare measurements are performed before any sludge is transferred into the STSC. A description of the buoyant weight calculation and associated equations are provided in PRC-STP-00358, Operating Sequence and Interlock Definition Document for the Sludge Treatment Project Engineered Container Retrieval and Transfer System.

For this safety function, engineered controls versus a SAC could have been selected. For example, additional liquid level and truck scale instrumentation, differential weight instrumentation, Normal Process Flush Interlock I-5, and Normal Process Shutdown Interlock I-4 could be classified as safety SSCs. A SAC was chosen instead to simplify design and for compliance with HNF-40475, which states that distributed control systems, including computer or software based systems, should not be used to perform safety-significant functions.
4.5.6.3 Functional Requirements

One functional requirement is identified for this SAC.

   1. The buoyant weight of sludge in an STSC shall be less than or equal to the applicable limits as shown in Table 4-19.

4.5.6.4 Specific Administrative Control Evaluation

The STSC Sludge Buoyant Weight Limits SAC protects thermal and gas analysis assumptions, as such there are no accident environment conditions to consider.

Verifying the sludge buoyant weight is within limits is judged to be a task of low difficulty. The liquid level and truck scale instrumentation is mounted on Safety Instrument Panel ECRT-PNL-401 located on the Mezzanine level of the 105KW Annex. The panel is the same panel used in MPAT during which the quantity of sludge simulant loaded into an STSC was successfully determined. The level and scale instrumentation can also be read remotely by camera.

The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no environmental conditions associated with this task that would result in elevated stress levels.

4.5.6.5 Controls (Technical Safety Requirements)

The Sludge Buoyant Weight Limits SAC has been developed in LCO format as described in Section 5.5.2.3, “Limiting Condition for Operation 3.3–Sludge Buoyant Weight Limits.”

4.5.7 Sludge Transport and Storage Container Final Liquid Level Limits

4.5.7.1 Safety Function

The STSC Final Liquid Level Limits administrative control is designated as a SAC because a hydrogen explosion in an STSC during long-term storage at T Plant can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion at T Plant by limiting the liquid level in an STSC.

4.5.7.2 Specific Administrative Control Description

A hydrogen explosion in an STSC during long-term storage at T Plant is prevented by passive ventilation. At T Plant, a 2-ft vent pipe is installed on Nozzle F2, and Nozzle S2 is left open to the storage cell atmosphere. The difference in elevation between these two points establishes a passive ventilation flow rate adequate to control the hydrogen hazard. Sludge expansion during long-term storage at T Plant has the potential to raise the supernate level in an STSC to the point it blocks the ventilation flow path at Nozzle S2.

As documented in HNF-15280, Technical Safety Requirements for the Solid Waste Operations Complex, a TSR has been established at T Plant to limit the maximum STSC fill volume to the values shown in Table 4-20. Compliance with these setpoints ensures that the level of supernate and expanded sludge remains approximately 1.5 in. below Nozzle S2.
Table 4-20. STSC Maximum Liquid Level

<table>
<thead>
<tr>
<th>STSC Sludge Composition</th>
<th>Process Instrumentation Setpoint (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCS-CON-230 layered with SCS-CON-240, -250, -260</td>
<td>72</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>74</td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>77</td>
</tr>
<tr>
<td>SCS-CON-220</td>
<td>73</td>
</tr>
</tbody>
</table>

*Level in inches relative to STSC interior bottom.

The final liquid level is measured by safety-significant radar level element/transmitter LE/LIT/-740-401. The level is indicated by safety-significant level indicator LI-740-401. Thus these instruments are support SSCs to this SAC. Prior to performing STSC process disconnects, Operations will verify that the liquid level in an STSC is within the limits shown in Table 4-21. If the level is greater than the limits, supernate will be decanted from the STSC.

For this safety function, engineered controls versus a SAC could have been selected. Specifically, additional level detectors could be interlocked to terminate IXM water addition when the requisite level was reached. A SAC was chosen instead to simplify system design by relying on safety-significant LE/LIT/-740-401, safety-significant LI-740-401, and direct operator control.

### 4.5.7.3 Functional Requirements

One functional requirement is identified for this SAC.

1. Verify that the final liquid level in an STSC is less than or equal to the applicable level as shown in Table 4-20.

### 4.5.7.4 Specific Administrative Control Evaluation

The STSC Final Liquid Level Limits SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying the STSC final liquid level is within limits is judged to be a task of low difficulty.

Level indicator LI-740-401 is mounted on Safety Instrument Panel ECRT-PNL-401 located on the Mezzanine level of the 105KW Annex. The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no conditions associated with this task that would result in elevated stress levels.

### 4.5.7.5 Controls (Technical Safety Requirements)

The STSC Final Liquid Level Limits SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.6, “Administrative Control 5.6.6–Sludge Transport and Storage Container Final Liquid Level.”
4.5.8 Gas Composition Verification

4.5.8.1 Safety Function

The Gas Composition Verification administrative control is designated as a SAC because a hydrogen explosion in an STSC or STS Cask can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion in an STSC or STS Cask by verifying that the Auxiliary Ventilation System and Inert Gas System are supplied with nitrogen.

4.5.8.2 Specific Administrative Control Description

Explosions in the STSC and STS Cask are credible events due to the hydrogen generated by the reaction between uranium metal and water and by radiolysis. In preparation for shipment to T Plant, the STSC and STS Cask are inerted with nitrogen. A safety-significant Oxygen Analyzer (see Section 4.4.7) is used to verify that the STSC and STS Cask have been inerted in accordance with the requirements of NFPA 69, Chapter 7, “Deflagration Prevention by Oxidant Concentration Reduction.”

This SAC ensures the effectiveness of the inerting activity by verifying the composition and purity of the gas provided by the nitrogen Cylinder Cradles. The verification is performed by reviewing gas sampling results provided by the vendor. A SAC was selected because there are no practical engineered controls that can perform the verification.

4.5.8.3 Functional Requirements

One functional requirement is identified for this SAC:

1. Prior to receipt at the 105KW Annex, verify that the nitrogen gas purity is greater than or equal to 99.9 percent and has a moisture content of 3 ppm or less.

4.5.8.4 Specific Administrative Control Evaluation

Verifying nitrogen purity is a preventive control; therefore, there are no accident environment conditions to be considered.

The associated level of difficulty and stress levels are low.

4.5.8.5 Controls (Technical Safety Requirements)

The Gas Composition Verification SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.7, “Administrative Control 5.6.7–Gas Composition Verification.”

4.5.9 Sludge Transport and Storage Container Inerting Limit

4.5.9.1 Safety Function

The STSC Inerting Limit administrative control is designated as a SAC because a hydrogen explosion in an STSC can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion in an STSC by verifying that an inert atmosphere has been established in the STSC headspace.
4.5.9.2  Specific Administrative Control Description

An explosion in an STSC is a credible event due to the hydrogen generated by the reaction between uranium metal and water and by radiolysis. A hydrogen explosion cannot occur if there is insufficient oxygen present to support combustion. This SAC requires verification that the STSC headspace oxygen concentration is less than 0.5 vol%.

The requirement to inert to the STSC to less than 0.5 vol% oxygen is based on NFPA 69, Chapter 7, “Deflagration Prevention by Oxidant Concentration Reduction.” In situations where the oxygen concentration is not being continuously monitored, NFPA 69 requires the oxygen concentration to be no more than 40 percent of the limiting oxygen concentration (LOC) when the LOC is below 5 vol%. Per NFPA 69, Appendix C, “Limiting Oxygen Concentrations,” the LOC for a hydrogen-nitrogen-air mixture is 3.0 vol%. Thus, per NFPA 69, the oxygen concentration in the STSC must be less than 1.2 vol%. Reducing the oxygen concentration to less than 0.5 vol% protects against exceeding the 1.2 vol% limit due to potential air inleakage during the time it takes to place the STSC Cask Lid and inert the STS Cask.

The oxygen concentration during STSC inerting is measured by safety-significant Oxygen Analyzer ECRT-CAB-601 (see Section 4.4.7). Thus the Oxygen Analyzer is a support SSC to this SAC. The oxygen concentration is displayed locally on the Oxygen Analyzer. Operators monitor the local display and terminate the STSC inerting process when the 0.5 vol% oxygen concentration limit is met.

An 8-hour time limit has been established for the STSC inerting activity. Under normal operating conditions it takes less than 1 hour to inert the STSC. If greater than 8 hours is required, then a significant off-normal condition exists and corrective actions are required.

For this safety function, engineered controls versus a SAC could have been selected. For example, the oxygen analyzer could be interlocked to terminate nitrogen flow only after the oxygen concentration was reduced below 0.5 vol%. A SAC was chosen instead to simplify system design by relying on safety-significant Oxygen Analyzer ECRT-CAB-601 and direct operator control.

4.5.9.3  Functional Requirements

One functional requirement is identified for this SAC:

1. The STSC shall be inerted to less than 0.5 vol% oxygen.

4.5.9.4  Specific Administrative Control Evaluation

The STSC Inerting Limit SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying the STSC oxygen concentration is less than 0.5 vol% is judged to be a task of low difficulty.

Oxygen Analyzer ECRT-CAB-601 is located in 105KW Annex Sludge Loading Bay. The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no conditions associated with this task that would result in elevated stress levels.
4.5.9.5 Controls (Technical Safety Requirements)

The STSC Inerting Limit SAC has been combined with other TSR requirements and developed in LCO format as described in Section 5.5.2.4, “Limiting Condition for Operation 3.4–STSC and STS Cask Inerting and Shipment Preparation.”

4.5.10 STS Cask Lid Critical Lift

4.5.10.1 Safety Function

The STS Cask Lid Critical Lift administrative control is designated as a SAC because a hydrogen explosion in an STSC can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion in an STSC by preventing an STS Cask Lid drop.

4.5.10.2 Specific Administrative Control Description

The 5-ton bridge crane in the 105KW Annex Sludge Loading Bay is used to place the STS Cask Lid on the cask after the STSC has been inerted. If the lid were to drop, the STSC boundary could be damaged resulting in a loss of the inert atmosphere which could eventually result in a hydrogen explosion.

Under abnormal conditions, it may be necessary to remove the STS Cask Lid once installed. If the lid were to drop, the STSC boundary could be damaged resulting in a loss of the inert atmosphere and loss of the ability to re-inert the STSC.

This SAC requires that installation of the STS Cask Lid be performed as a critical lift. As described in DOE/RL-92-36, Hanford Site Hoisting and Rigging Manual, critical lift designation implements administrative and physical controls to minimize the possibility of equipment failure or human error to a hoisting or forklift operation involving a load that poses unacceptable consequences if mishandled. Critical lift designation provides:

- Documented step-by-step instructions
- Sign-off approvals for technical, management, safety, and engineering
- Independent pre-identification of load weight, load center of gravity, lift attachment points, and lifting hardware minimum capabilities
- Independent pre-identification of crane(s) or fork lift(s) with minimum capabilities identified for the configuration to be used
- Evaluation of hazards associated with the lift
- Pre-identified special limiting or stop-work conditions

This SAC also requires that removal of the cask lid when sludge is present in an STSC, if required, be performed as a critical lift.

A SAC was selected as there are no SSCs capable of performing the above-identified tasks.
4.5.10.3 Functional Requirements

Two functional requirements are identified for this SAC.

1. STS Cask Lid installation shall be performed in accordance with the requirements of DOE/RL-92-36, Chapter 3.0, “Critical Lifts.”

2. If sludge is present in an STSC, removal of the STS Cask Lid, if required, shall be performed in accordance with the requirements of DOE/RL-92-36, Chapter 3.0, “Critical Lifts.”

4.5.10.4 Specific Administrative Control Evaluation

The STS Cask Lid Critical Lift SAC is a preventive control, as such there are no accident environment conditions to consider.

Critical lifts are routinely performed at the 105KW Basin, and is judged to be a task of low difficulty. STS Cask Lid installation is performed in the 105KW Annex Sludge Loading Bay. The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no environmental conditions associated with this task that would result in elevated stress levels.

4.5.10.5 Controls (Technical Safety Requirements)

The STS Cask Lid Critical Lift SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.8, “Administrative Control 5.6.8–STS Cask Lid Critical Lift.”

4.5.11 STS Cask Inerting and Pressurization Limits

4.5.11.1 Safety Function

The STS Cask Inerting and Pressurization Limits administrative control is designated as a SAC because a hydrogen explosion in an STS Cask can result in facility worker serious injury or death. The safety functions of the SAC are:

1. Prevent a hydrogen explosion in an STS Cask by verifying that an inert atmosphere has been established in the STS Cask headspace.

2. Prevent a hydrogen explosion in the STS Cask by verifying the STS Cask is properly pressurized thereby preventing air ingress.

3. Protect initial conditions assumed in the thermal and gas analyses for transportation regarding the initial STS Cask pressure.

4.5.11.2 Specific Administrative Control Description

An explosion hazard exists in the STS Cask until it is inerted because hydrogen generated within the STSC will periodically be released into the cask headspace via the Transport Vent Assemblies installed on STSC Nozzles S2 and F2.

A hydrogen explosion cannot occur if there is insufficient oxygen present to support combustion. As discussed above in Section 4.5.9.2, per NFPA 69 the oxygen concentration is to be no more than 40 percent of the LOC for a hydrogen-nitrogen-air mixture. Given an LOC of 3 vol%, the corresponding limit is 1.2 vol%.
The oxygen concentration during STS Cask inerting is measured by safety-significant Oxygen Analyzer ECRT-CAB-601 (see Section 4.4.7). Thus the Oxygen Analyzer is a support SSC to this SAC. The oxygen concentration is displayed locally on the Oxygen Analyzer. Operators monitor the local display and terminate the STS Cask inerting process when the 1.2 vol% oxygen concentration limit is met.

Once an inert atmosphere is established in the STS Cask, it must be maintained until received at T Plant. Pressurizing the STS Cask to greater than 3 psig, combined with a verified low leak rate, ensures there is no air inleakage during staging and transportation to T Plant.

PRC-STP-CN-N-00989, Thermal and Gas Analyses for a Sludge Transport and Storage Container (STSC) During Transportation to T Plant with KW Annex Staging, calculates hydrogen generation rates and STS Cask pressures for various sludge loading scenarios and staging periods in the 105KW Annex to determine an allowable shipping window to T Plant. PRC-STP-CN-N-00989 assumes an initial STS Cask pressure of 15 psig. At this initial pressure, the STS Cask pressure when received at T Plant will be less than the cask design pressure of 80 psig for a 5-day transportation time and up to a 30-day staging period.

The STS Cask is manually pressurized using nitrogen from the Inert Gas System. Once the STS Cask has been inerted, the STS Cask Vent Tool is closed and the purge outlet line is disconnected. Operators then pressurize the cask by opening a valve on the Inert Gas System and monitor the increase in pressure on safety significant pressure indicator ECRT-PI-760-606 (see Section 4.4.10). Thus pressure indicator ECRT-PI-760-606 is a support SSC to this SAC. A general service pressure control valve limits the cask pressurization to 10 psig. If the pressure should somehow increase above 15 psig, the pressure can be reduced by venting at ECRT-ME-601 through valve ECRT-V-612, and Filter ECRT-F-612, or by connecting the safety-significant STS Pressurization Check Tool to the STS Cask Vent Tool and venting the excess pressure through that device.

Inerting and pressurizing the STS Cask must be completed within 24 hours of terminating the STSC nitrogen purge. As previously discussed, the STSC is inerted using the Inert Gas System. Once an inert atmosphere is established in the STSC, the nitrogen purge is terminated by closing valve ECRT-V-611, which isolates the STSC from the Inert Gas System. Closing valve ECRT-V-611 starts the “STS Inerted and Isolated Clock,” which is used to track the 24-hour duration. The “STS Inerted and Isolated Clock” is stopped when the STS Cask pressure is verified to be between 3 and 15 psig. The “STS Inerted and Isolated Clock” start and stop times are then used to verify that the STS Cask was inerted and pressurized within the 24-hour time limit.

The 24-hour time limit is based on calculations in PRC-STP-CN-N-00989 which show that, after 24 hours, the hydrogen concentration in the STS Cask headspace is less than 25 percent of the LFL such that the STS Cask Lid can be safely removed and corrective actions taken.

After the STS Cask has been pressurized to within 3 to 15 psig, the pressure must be monitored until such time that cask leak rate testing has been initiated. Until the leak rate has been verified, the cask could potentially leak resulting in de-pressurization and an eventual loss of the inert atmosphere. The pressure can be monitored using pressure indicator ECRT-PI-760-606, or by connecting the STS Pressurization Check Tool to the Cask Vent Tool.
Relative to verifying the oxygen concentration and cask pressure, engineered controls versus a SAC could have been selected. For example, the Oxygen Analyzer could be interlocked to terminate nitrogen flow only after the oxygen concentration was reduced below 1.2 vol%. A SAC was chosen instead to simplify system design by relying on safety-significant SSCs and direct Operator control.

4.5.11.3 Functional Requirements
One functional requirement is identified for this SAC.
1. The STS Cask shall be inerted to less than 1.2 vol% oxygen and pressurized to between 3 and 15 psig within 24 hours of terminating the STSC nitrogen purge.

4.5.11.4 Specific Administrative Control Evaluation
The STS Cask Inerting and Pressurization Limits SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying the STS Cask oxygen concentration is less than 1.2 vol% and that the cask has been pressurized to between 3 and 15 psig within 24 hours of terminating the STSC nitrogen purge is judged to be a task of low difficulty.

Oxygen Analyzer ECRT-CAB-601 and pressure indicator ECRT-PI-760-606 are located in 105KW Annex Sludge Loading Bay. The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no conditions associated with this task that would result in elevated stress levels.

4.5.11.5 Controls (Technical Safety Requirements)
The STS Cask Inerting and Pressurization Limits SAC has been combined with other TSR requirements and developed in LCO format as described in Section 5.5.2.4, “Limiting Condition for Operation 3.4–STSC and STS Cask Inerting and Shipment Preparation.”

4.5.12 Sludge Transport System Cask Leak Rate Limit

4.5.12.1 Safety Function
The STS Cask Leak Rate Limit administrative control is designated as a SAC because a hydrogen explosion in an STS Cask can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion by verifying that the STS Cask leak rate is less than or equal to 9.0E-4 standard cm$^3$/s air.

4.5.12.2 Specific Administrative Control Description
In preparation for shipment to T Plant, the STS Cask is inerted to less than 1.2 vol% oxygen and pressurized to between 3 and 15 psig. Once an inert atmosphere is established in the STS Cask, it must be maintained until received at T Plant. Accordingly, the STS Cask pressure boundary is classified as a safety-significant SSC. The pressure boundary includes the STS Cask, STS Cask Lid, STS Cask Lid metal O-ring seals, and port seals. A leak test of the pressure boundary is performed using the safety-significant STS Cask Leak Tester (see Section 4.4.11).

Operators verify that the cask leak rate criterion is met using the Sludge Transport System Leak Tester (see Section 4.4.11). Thus the leak tester is a support SSC to this SAC. Up to four leak
tests are performed each time the STS Cask Lid is placed on the STS Cask following loading of the STSC. This includes leak tests of both vent port bolts, the drain port bolt, and the closure lid seal. The results from the four leaks tests are summed to verify that the cask leak rate is less than 9.0E-4 standard cm$^3$/s air. Typically only one of the two vent ports will be used. If a vent port has been leak tested and not subsequently used, the previously recorded leak rate may be applied to the summation.

4.5.12.3 Function Requirements

One functional requirement has been identified for this SAC.

1. The STS Cask leak rate shall be less than or equal to 9.0E-4 standard cm$^3$/s air prior to shipment to T Plant.

4.5.12.4 Specific Administrative Control Evaluation

The STS Cask Leak Rate Limit SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying the STS Cask leak rate is less than 9.0E-4 standard cm$^3$/s air prior to shipment to T Plant is judged to be a task of low difficulty.

The STS Cask Leak Tester is located on the ground floor of the 105KW Annex Sludge Loading Bay. The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no environmental conditions associated with this task that would result in elevated stress levels.

4.5.12.5 Controls (Technical Safety Requirements)

The STS Cask Leak Rate Limit SAC has been combined with other TSR requirements and developed in LCO format Section 5.5.2.4, “Limiting Condition for Operation 3.4–STSC and STS Cask Inerting and Shipment Preparation.”

4.5.13 Sludge Transport System Cask Staging Limit

4.5.13.1 Safety Function

The STS Cask Staging Limit administrative control is designated as a SAC because a hydrogen explosion in an STS Cask, or the over-pressurization of an STS Cask, can result in facility worker serious injury or death. The safety functions of this SAC are:

1. Protect initial conditions assumed in the STS Cask staging and transportation analyses regarding STSC temperatures and pressures.
2. Prevent STS Cask over-pressurization by venting the cask.
3. Prevent a hydrogen explosion by limiting the rate at which hydrogen would be released should the STS Cask need to be vented in the Sludge Loading Bay.

4.5.13.2 Specific Administrative Control Description

PRC-STP-CN-N-00989 calculates hydrogen generation rates and STS Cask pressures for various sludge loading scenarios and staging periods in the 105KW Annex to determine an allowable shipping window to T Plant. Factoring a staging period into the shipping window calculations
provides Operations a degree of flexibility in coordinating the shipment with T Plant and allows for potential delays due to cask leak rate verification issues, inclement weather, or other unforeseen circumstances. Staging periods of 1, 4, 10, and 30 days are analyzed. For all staging periods, the maximum hydrogen generation rate and STS Cask pressure are such that the STS Cask can be safely processed at T Plant with an appropriate margin of safety given a 5-day transportation time.

PRC-STP-CN-N-00989 also analyzes the venting of an STS Cask and STSC at the 105KW Annex. Such venting is not a part of normal operations but could be required if it were not possible to ship the STSC to T Plant. The analysis, which assumes the cask is vented using the STS Pressurization Check Tool after a 10-day staging period, shows that the cask is reduced from approximately 25 psig to atmospheric pressure in approximately 1 hour. During that time the hydrogen release rate varies from an initial value of 0.25 scfm to a final value of approximately 5E-3 scfm. The maximum release rate during venting is 0.5 scfm, which occurs after 0.45 hour. Given these hydrogen release rates, the cask can be safely vented by positioning Rad Con Hood ventilation hose ECRT-H-505 adjacent to the STS Pressurization Check Tool. This hose draws approximately 600 scfm, which would rapidly dilute the hydrogen vented from the cask to below 25 percent of the LFL. If the lid is removed after the STS Cask has been vented, hydrogen will continue to be released from the STSC via the two Transport Vent Assemblies at a maximum rate of 3E-3 scfm. This low release rate does not pose a hydrogen explosion hazard. Accordingly, the STS Staging Limit SAC requires venting the cask within 240 hours of completing STS Cask pressurization.

In addition to protecting initial conditions assumed in PRC-STP-CN-N-00989, the 240-hour staging limit prevents over-pressurization of the STS Cask while in the 105KW Annex. As calculated in PRC-STP-CN-N-00819, it takes greater than 70 days to reach the 80 psig design pressure of the STS Cask for the bounding STSC sluice loading.

There are no practical engineered controls that can perform the intended safety function as related to the STS Cask staging limit.

4.5.13.3 Functional Requirements

One functional requirement has been identified for this SAC.

1. The STS Cask shall exit the 105KW Annex en route to T Plant within 240 hours of completing STS Cask pressurization.

4.5.13.4 Specific Administrative Control Evaluation

The STS Cask Staging Limit SAC is a preventive control, as such there are no accident environment conditions to consider.

Monitoring the time between STS Cask pressurization and when the STS Trailer exits the Sludge Loading Bay is judged to be a task of low difficulty. Verifying that the 240-hour time limit has been met is performed by using an “STS Cask Staging Period Clock.” This clock starts when the cask pressure has been verified to be within limits and ends when the STS Trailer exits the Sludge Loading Bay.
4.5.13.5 Controls (Technical Safety Requirements)
The STS Cask Staging Limit SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.9, “Administrative Control 5.6.9–STS Cask Staging Limit.”

4.5.14 Combustible Material Control Requirements

4.5.14.1 Safety Function

The Combustible Material Control Requirements administrative control is designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF. In addition, the Combustible Material Control Requirements administrative control is designated as a SAC because a hydrogen explosion can result in facility worker serious injury or death. The SAC has the following two safety functions:

1. Prevent a fire of sufficient size to initiate a spray release of slurry during sludge retrieval and transfer by controlling combustible materials.
2. Prevent a fire of sufficient size to initiate a hydrogen explosion by controlling combustible materials.

4.5.14.2 Specific Administrative Control Description

A fire that results in structural damage to the 105KW Annex was identified as a potential initiator of a slurry spray release. A fire that damages the Process/Exhaust Ventilation System, or causes structural damage that in turn damages the STSC Boundary or STS Cask Pressure Boundary after being inerted was identified as a potential initiator for a hydrogen explosion. This SAC limits the quantities and locations of transient combustible materials in the 105KW Annex. This control minimizes the probability of a fire that could cause facility structural damage.

There is no plausible SSC(s) that can perform the intended safety function.

4.5.14.3 Functional Requirements

Seven functional requirements are identified for this SAC.

1. In the Sludge Loading Bay, the fuel package size is limited to 645 kW as the default fire exposure. Larger fuel packages may be present provided the fuel package and associated separation distances have been analyzed and documented in a fire hazards analysis.
2. In the Sludge Loading Bay, a minimum distance of 5 ft shall be maintained between a default fuel package and other fuel packages.
3. In the Sludge Loading Bay, a minimum distance of 5 ft shall be maintained between a default fuel package and process transfer lines.
4. On the Sludge Loading Bay Mezzanine, a minimum distance of 3 ft shall be maintained between a default fuel package and structural columns.
5. Unattended vehicles containing less than or equal to 100 gal of fuel shall not be parked within 15 ft of the 105KW Annex.
7. Unattended vehicles containing greater than 100 gal of fuel shall not be parked within 50 ft of the 105KW Annex.

8. A 30-ft defensible space around the 105KW Annex shall be free of transient combustibles and accumulations of windblown vegetation.

4.5.14.4 Specific Administrative Control Evaluation

The Combustible Material Control Requirements SAC is a preventive control, as such there are no accident environment conditions to consider.

Verifying compliance with combustible material controls is judged to be a task of moderate difficulty. The 645 kW fuel package size is the default transient combustible material fire analyzed in HNF-SD-SNF-FHA-001, Fire Hazards Analysis for the 105 KW Facility. The 645 kW value is associated with a fire involving 5 standard loads of combustible material. A standard load of combustible material is defined in WHC-SD-WM-TRP-233, Analytical and Experimental Evaluation of Solid Waste Drum Fire Performance, as a mix of rubber, plastic, paper, and cotton weighing 57 pounds. Thus a 5 standard load fire involves 285 pounds of combustible material.

Verification of compliance will be accomplished by performing a walkdown of the Sludge Loading Bay and 105KW Annex exterior.

The 105KW Annex is environmentally controlled, and respiratory protection is not normally required. Therefore, there are no external environmental conditions associated with this task that would result in elevated stress levels.

4.5.14.5 Controls (Technical Safety Requirements)

The Combustible Material Control Requirements SAC has been developed in LCO format as described in Section 5.5.2.5, “Limiting Condition for Operation 3.5–Combustible Material Control Requirements.”

4.5.15 Auxiliary Ventilation System Actuation Notification

4.5.15.1 Safety Function

The Auxiliary Ventilation System Actuation Notification administrative control is designated as a SAC because a hydrogen explosion in an STSC can result in facility worker serious injury or death. The safety function of the SAC is to prevent a hydrogen explosion in an STSC by ensuring a 96-hour Auxiliary Ventilation System nitrogen supply.

4.5.15.2 Specific Administrative Control Description

The Auxiliary Ventilation System has a 48-hour installed nitrogen capacity and a 48-hour reserve nitrogen capacity. Based on 100K Area operational history with loss of power events and ventilation system equipment failures, 96 hours is judged to be an adequate time period to detect actuation of the Auxiliary Ventilation System and to restore normal process ventilation.

This SAC requires that the Auxiliary Ventilation System be surveilled for actuation at least once per day when an STSC containing sludge is connected to the Process/Exhaust Ventilation System. Surveillances are performed by a Stationary Operating Engineer (SOE). Stationary Operating Engineers are present in the 100K Area every day of the year and routinely
perform surveillances when facilities are both manned and unmanned. A minimum shift complement administrative control has been established in support of this surveillance.

If the Auxiliary Ventilation System is actuated, the SOE will contact either the SOM or on-call SOM who will ensure the timely switch-over from the installed to the reserve nitrogen capacity such that the Auxiliary Ventilation System has a minimum 96-hour nitrogen supply, and initiate actions to restore normal process ventilation. The switch-over to the reserve capacity must be performed before the pressure in the installed capacity reaches 150 psig. The 150 psig value is based on the required minimum pressure to sustain flow through the Auxiliary Ventilation System.

For this safety function, an SSC versus a SAC could have been selected (i.e., an auto-dialer interlocked to ventilation flow). A SAC was chosen instead to simplify system design and rely on direct observation of the system status.

4.5.15.3 Functional Requirements

One functional requirement is identified for this SAC:

1. STSC normal ventilation indicator lights shall be “on” when an STSC containing sludge is connected to the Process/Exhaust Ventilation System.

4.5.15.4 Specific Administrative Control Evaluation

The Auxiliary Ventilation System Actuation Notification SAC is a preventive control, as such there are no accident environment conditions to consider.

Actuation of the Auxiliary Ventilation System is readily discernable by observing the status of safety-significant indicator lights ECRT-IL-651 and -652 located outside of the 105KW Annex adjacent to Auxiliary Ventilation Control Panel ECRT-PNL-602.

Performing the required surveillance is judged to be tasks of low difficulty.

Environmental conditions are those associated with ambient weather conditions.

4.5.15.5 Controls (Technical Safety Requirements)

The Auxiliary Ventilation System Actuation Notification SAC has been combined with the TSR requirements related to Auxiliary Ventilation System operability and developed in LCO format as described in Section 5.5.2.2, “Limiting Condition for Operation 3.2–Auxiliary Ventilation System.”

4.5.16 XAGO Pre-Operational Testing and Operational Readiness Controls

4.5.16.1 Safety Function

XAGO pre-operational testing and operational readiness controls are designated as a SAC because the facility worker radiological consequences of a slurry spray release are not clearly above or below 100 rem, and because the facility worker toxicological consequences are greater than the PAC-3 SOF; and because a hydrogen explosion in an STSC can result in facility worker serious injury or death. The safety function of the SAC is to protect the accident analysis
assumption regarding the material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container.

4.5.16.2 Specific Administrative Control Description

The consequences of a spray release during pre-operational testing and operational readiness activities are low to all receptors based on the assumption that the material-at-risk is limited to basin water and a small quantity of sludge. To protect the assumption that sludge will not be retrieved from an engineered container during pre-operational testing and readiness review activities, a safety-significant chain stop is installed on each of the chain hoists used raise and lower a XAGO that ensures the XAGO cannot be lowered into an engineered container (see Section 4.4.15). Preventing sludge retrieval and slurry transfer into an STSC also eliminates the STSC hydrogen explosion hazard.

To provide an additional layer of defense-in-depth, RL has directed that administrative controls be established controlling the XAGO location and Basin water motive force (letter 17-NSD-0037_RL). These controls ensure that sludge will not be transferred should too much chain be deployed and the hoist chain stop fail.

4.5.16.3 Functional Requirements

Two functional requirement are identified for this SAC:

1. The XAGO tool shall be placed away from the area above the engineered container when using Basin water to simulate sludge transfer to the 105KW Annex using the XAGO tool
2. Positive control shall be maintained on the Basin water motive force to the XAGO tool to prevent Basin water transfers to the 105KW Annex when the XAGO tool is allowed above the engineered containers.

4.5.16.4 Specific Administrative Control Evaluation

Verifying the XAGO location and positive control on the Basin water motive force are preventive controls, as such there are no accident environment conditions to consider. These verifications are judged to be tasks of low difficulty.

The 105KW Basin may be posted as an Airborne Radioactivity Area. Respiratory protection may therefore be required. Operators performing work in the 105KW Basin are routinely required to wear respiratory protection. This induces a low level of stress.

4.5.16.5 Controls (Technical Safety Requirements)

The XAGO pre-operational testing and operational readiness controls SAC has been developed as a Directive Action SAC as described in Section 5.5.3.1.10, “Administrative Control 5.6.10–XAGO Pre-Operational Testing and Operational Readiness Review Controls.”
Chapter 5.0

Derivation of Technical Safety Requirements
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5.0 Derivation of Technical Safety Requirements

5.1 Introduction


This chapter provides summaries and references to pertinent sections of this document that describe the design and administrative features selected for the prevention and mitigation of design basis accidents. The associated Limiting Conditions for Operation (LCOs), Surveillance Requirements (SRs), SMPs, Specific Administrative Controls (SACs), and Design Features (DFs) discussed herein form the basis for PRC-STP-00992 and provide the logical link between the TSR controls and the DSA.

This chapter includes the following information:

- A table that links the Chapter 3.0 design basis accidents to their associated TSRs
- Derivation of facility modes and associated minimum shift complements
- Derivation of LCOs and associated SRs
- Derivation of SMPs
- Derivation of directive action SACs
- Identification of DFs
- Identification of TSR interfaces with T Plant

5.2 Requirements

Design codes, standards, regulations, and DOE Orders required for establishing the facility safety basis specific to this chapter include the following:

- 10 CFR 830
- DOE G 423.1-1A, Implementation Guide for Use in Developing Technical Safety Requirements
- DOE-STD-1186-2004, Specific Administrative Controls

5.3 TSR Coverage

Safety-significant controls are required for three design basis accident categories: slurry spray releases, hydrogen explosions, and over-pressurizations. As discussed in Chapter 3.0, these accidents can be initiated by operational upsets, NPHs, and external events.
Table 5-1 identifies the major features relied on to prevent or mitigate slurry spray releases, hydrogen explosions, and over-pressurizations, the associated TSR coverage, and cross-references to the Chapter 3.0 and Chapter 5.0 subsections where additional information can be found.

**Table 5-1. Major Features for Hazard Protection**

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Notes:
105KW Annex 105-K West Basin Annex
AC Administrative Control
STS Sludge Transport System
STSC Sludge Transport and Storage Container

5.4 Derivation of Facility Modes

5.4.1 Facility Modes

Modes distinguish between different facility conditions, as dictated by required equipment operability and needed parameter limits, and ensure the provision of an adequate level of safety while in each condition.

As identified in Chapter 3, safety-significant controls are required for three categories of accidents: a spray release of slurry during sludge retrieval and transfer; a hydrogen explosion in an STSC, STS Cask, or process enclosure; and the over-pressurization of an STSC or STS Cask. All three categories of accidents are related to ECRTS activities. Based on the safety structures,
systems, and components (SSCs) and SACs selected for the prevention and mitigating of these accidents, and the associated equipment operability and parameter limit requirements, two modes have been established for the 105-K West Facility (105KW Facility); a Pre-Operational Testing Mode and an Operations Mode. Two submodes have been established for the Operations Mode; a Transfer Submode and a Shipment Preparation Submode.

5.4.1.1 Pre-Operational Testing Mode

In the Pre-Operational Testing Mode the following activities are conducted:

- Operation of 105KW Facility services and utilities
- Operation of Basin water treatment systems
- Management of fuel fragments
- Retrieval, storage, movement, and containerization of sludge
- Removal of equipment no longer in use
- Packaging, handling, and interim storage of waste
- Routine operational activities (e.g., surveillances, equipment calibrations)
- Preventive and corrective maintenance and inspections
- Radiological Control surveillances and equipment service
- ECRTS Pre-Operational Testing as defined in PRC-STP-TPR-01001, K Basin
  Pre-Operational Acceptance Testing for the Sludge Treatment Project Engineered
  Container Retrieval and Transfer System
- ECRTS operational readiness preparations including Operational Acceptance Testing, procedure validation, and Readiness Review activities.

The key distinction between the Pre-Operational Testing Mode and the Operations Mode and its associated Transfer and Shipment Preparation submodes is that in the Pre-Operational Testing Mode only basin water or Ion Exchange Module (IXM) water will be transferred into an STSC. Because sludge is not transferred, there is no potential for a slurry spray release, hydrogen explosion, or STSC/STS Cask over pressurization.

In the Pre-Operational Testing Mode transfers of sludge are precluded by: (1) safety significant hoist chain stops that physically prevent a XAGO retrieval tool (XAGO) from being lowered into an engineered container, and (2) a SAC that ensures sludge cannot be transferred should too much chain be deployed and the hoist chain stop fail. The hoist chain stops are passive design features; as such, there are no associated equipment operability requirements. The SAC does not address safety-significant equipment operability requirements, but instead administratively controls the location of the general service XAGO and the configuration of general service motive water equipment.
5.4.1.2 Operations Mode

In the Operations Mode the following activities are conducted:

- Operation of 105KW Facility services and utilities
- Operation of Basin water treatment systems
- Management of fuel fragments
- Retrieval, storage, movement, and containerization of sludge
- Removal of equipment no longer in use
- Packaging, handling, and interim storage of waste
- Routine operational activities (e.g., surveillances, equipment calibrations)
- Preventive and corrective maintenance and inspections
- Radiological Control surveillances and equipment service
- Receipt of an STS Trailer at the 105KW Annex and preparation of an empty STSC for transfers (e.g., establishing process connections, electrical and valve line-up activities)

The key distinctions between the Operations Mode and its two associated submodes are: (1) an STSC, if present in the 105KW Annex, is empty, and (2) transfers into the empty STSC are not conducted. Because the STSC is empty and transfers are not conducted, there is no potential for a slurry spray release, hydrogen explosion in an STSC or STS Cask, or an STSC/STS Cask over-pressurization. A hydrogen explosion in a process enclosure could conceivably occur in the Operations Mode. However, such an event is extremely unlikely as this would require the failure of a safety-significant transfer line during a previous slurry transfer resulting in a spill within an enclosure, a failure to take corrective actions, and a coincident loss of ventilation.

There are no TSR equipment operability requirements in the Operations Mode. There is one applicable parameter limit requirement, i.e., Combustible Material Control Requirements. These requirements are applicable because a fire has the potential to damage safety-significant equipment subsequently relied upon to support operations conducted in the Transfer and Shipment Preparation Submodes.

5.4.1.2.1 Transfer Submode

In addition to the activities performed in the Operations Mode, the following activities are conducted in the Transfer Submode:

- IXM water is transferred into an STSC, decanted, and returned to the Basin
- Sludge is retrieved from an engineered container and transferred into an STSC
- Supernate is recirculated, decanted, filtered, and returned to the Basin
- The sand filter is backwashed into an STSC
• The Overfill Recovery Tool may be used to retrieve sludge from an STSC and return it to an engineered container.
• Slurry transfer and decant lines may be pigged.

The key distinction between the Transfer Submode and the Operations Mode and Shipment Preparation Submode is that transfers into and out of an STSC are conducted. Therefore, the potential exists for a slurry spray release and a hydrogen explosion in a process enclosure. In addition, because slurry transfers result in an STSC containing sludge, the potential exists for a hydrogen explosion in an STSC.

Equipment operability requirements applicable in the Transfer Submode are:
• Seismic shutdown switches and Safety Shutdown Interlock I-1
• Auxiliary Ventilation System
• STSC level and truck weight instrumentation

Parameter limit requirements in the Transfer Submode are:
• Basin water level
• Slurry settling duration
• Sludge buoyant weight
• STSC final fill limit
• Combustible material controls

5.4.1.3 Shipment Preparation Submode
In addition to the activities performed in the Operations Mode, the following activities are conducted in the Shipment Preparation Submode:
• The STSC is purged with nitrogen gas
• The STS Cask is purged with nitrogen gas, and pressurized
• The STS Cask is leak tested
• The STS Cask is staged pending shipment to T Plant.

The key distinctions between the Shipment Preparation Submode and the Transfer Submode are (1) within this submode the STSC is disconnected from the Process/Exhaust Ventilation System (i.e., the purge inlet and outlet lines are removed from Nozzles S2 and F2), and (2) the STS Cask lid is installed. Because the STSC is disconnected from the Process/Exhaust System, it must be inerted to prevent a hydrogen explosion. In addition, isolating the STSC introduces the potential for over-pressurization. Installing the lid on the STS Cask introduces the potential for a hydrogen explosion because hydrogen generated within the STSC is periodically released into the STS Cask headspace. Installing the cask lid also introduces the potential for over-pressurization.
Equipment operability requirements in the Shipment Preparation Submode are:

- Auxiliary Ventilation System
- Oxygen analyzer
- STS Cask Leak Tester

Parameter limits in the Transfer Submode are:

- Nitrogen gas purity
- STSC oxygen concentration
- STS Cask oxygen concentration and pressure
- STS Cask leak rate
- Combustible material controls
- STS Cask staging duration

5.4.2 Minimum Shift Complement

The minimum shift complement is that required to perform the minimum set of TSR surveillances and associated actions. A “manned” and “unmanned” minimum shift complement has been defined for each facility mode as shown in Table 5-2. The 105KW Facility is “manned” when staffed to allow performing physical work evolutions in the Basin operating areas and 105KW Annex.

5.4.2.1 Pre-Operational Testing Mode Minimum Shift Complement

There are no TSR surveillances and associated actions applicable in the Pre-Operational Testing Mode. Therefore, there is no minimum shift complement.

5.4.2.2 Operations Mode Minimum Shift Complement

LCO/SR 3/4.5, “Combustible Material Control Requirements,” (see Section 5.5.2.5) is the only TSR applicable when the 105KW Facility is in the Operations Mode. When the 105KW Facility is manned, SR 4.5 requires daily surveillances to verify: (1) that the 105KW Annex complies with separation distance requirements for unattended vehicles, and (2) that the 105KW Annex 30-ft defensible space is free of transient combustibles and accumulations of windblown vegetation. These surveillances are performed by an NCO. If an unattended vehicle is parked within the allowed separation distances, or if the defensible space is not free of transient combustibles and accumulations of windblown vegetation, the NCO will notify an SOM. The SOM then initiates the LCO actions. The associated minimum shift complement is therefore one NCO and one SOM when the facility is manned. There is no minimum shift complement when the facility is unmanned as SR 4.5 is not applicable.
Table 5-2. Minimum Shift Complement

<table>
<thead>
<tr>
<th>Facility Mode</th>
<th>Minimum Shift Complement*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manned</td>
<td>Unmanned</td>
</tr>
<tr>
<td>Pre-Operational Testing Mode</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Operations Mode</td>
<td>1 NCO</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>1 SOM</td>
<td></td>
</tr>
<tr>
<td>Transfer Submode</td>
<td>1 SOE</td>
<td>1 SOE</td>
</tr>
<tr>
<td></td>
<td>1 NCO</td>
<td>1 NCO</td>
</tr>
<tr>
<td></td>
<td>1 SOM</td>
<td>SOM (on-call)</td>
</tr>
<tr>
<td>Shipment Preparation Submode</td>
<td>1 SOE</td>
<td>1 SOE</td>
</tr>
<tr>
<td></td>
<td>1 NCO</td>
<td>1 NCO</td>
</tr>
<tr>
<td></td>
<td>1 RCT^2</td>
<td>1 RCT^b</td>
</tr>
<tr>
<td></td>
<td>1 SOM</td>
<td>SOM (on-call)</td>
</tr>
</tbody>
</table>

Notes:

a. Exempt personnel may replace bargaining unit personnel provided the substituting exempt personnel are trained and qualified to an equivalent or greater level than the personnel being replaced.

b. Required after the STS Cask has been pressurized to between 3 and 15 psig and until leak testing of the STS Cask is initiated.

N/A not applicable

NCO Nuclear Chemical Operator

RCT Radiological Control Technician

SOE Stationary Operating Engineering

SOM Shift Operations Manager

5.4.2.3 Transfer Submode Minimum Shift Complement

The Combustible Material Control Requirements LCO/SR is also applicable in the Transfer Submode. Therefore, an NCO and SOM are required when the 105KW Facility is manned.

One additional TSR must be considered in establishing the Transfer Submode minimum shift complement, i.e., LCO/SR 3/4.2, “Auxiliary Ventilation System” (see Section 5.5.2.2). When in the Transfer Submode, SR 4.2 requires daily surveillances to: (1) verify nitrogen gas cylinder cradle pressures are greater than 1357 psig, and (2) verify that the status lights on the outside wall of the 105KW Annex are illuminated. These surveillances are performed by an SOE whether the facility is manned or unmanned. If the pressure is less than 1357 in a credited cylinder cradle, or if one or both of the status lights are off, the SOE will notify an SOM if the 105KW Facility is manned, or an on-call SOM if the facility is unmanned. The SOM/on-call SOM then initiates the LCO actions.

Based on the above discussions, the Transfer Submode minimum shift complement is one SOE, one NCO, and one SOM when the facility is manned; and one SOE and one on-call SOM when the facility is unmanned.
5.4.2.4 Shipment Preparation Submode

The Combustible Material Control Requirements and Auxiliary Ventilation System LCOs/SRs are also applicable in the Shipment Preparation Submode. Therefore, the minimum shift complement is one SOE, one NCO, and one SOM when the facility is manned; and one SOE and one on-call SOM when the facility is unmanned.

One additional TSR must be considered in establishing the Shipment Preparation Submode minimum shift complement, i.e., LCO/SR 3/4.4, “STSC and STS Cask Inerting and Shipment Preparation” (see Section 5.5.2.4). Surveillance Requirement 4.4 requires the STS Cask pressure to be monitored daily after the cask has been pressurized to between 3 and 15 psig and until leak testing of the STSC Cask is initiated. This surveillance is performed by an NCO whether the facility is manned or unmanned. Monitoring the cask pressure requires entry into the Sludge Loading Bay, which is a radiological buffer area. Therefore, a Radiological Control Technician is required. If the STS Cask pressure has decreased by greater than 2 psig, the NCO will notify an SOM (if manned) or on-call SOM (if unmanned) who then initiates the LCO actions. Therefore, after the cask has been pressurized to between 3 and 15 psig and until leak testing of the STS Cask is initiated, the Shipment Preparation Submode minimum shift complement for the pressure monitoring surveillance is one NCO, one RCT, and one SOM/on-call SOM.

5.5 TSR Derivation

5.5.1 Safety Limits and Limiting Control Settings

Safety Limits are limits on process variables associated with those safety-class physical barriers that are necessary for the intended facility function and that are required to guard against the uncontrolled release of radioactive materials. Based on the design basis accident analyses in Chapter 3.0, there are no safety-class SSCs. Therefore, there are no Safety Limits or associated Limiting Control Settings.

5.5.2 Limiting Conditions for Operation and Surveillance Requirements

LCOs represent the lowest functional capability or performance level of safety SSCs required for safe operation of a facility. In accordance with DOE-STD-1186-2004, SACs that prevent or mitigate an accident scenario and have a safety function that would be safety-class or safety-significant if the function were provided by an SSC may be developed as LCOs.

SRs are requirements relating to test, calibration, or inspection to assure that the necessary operability and quality of safety SSCs is maintained.

The following sections provide information used in the derivation of LCOs and SRs documented in PRC-STP-00992.
5.5.2.1 Limiting Condition for Operation 3.1–Seismic Shutdown Switches and Safety Shutdown Interlock I-1

5.5.2.1.1 Background

Chapter 3.0, Section 3.4.2.6, “Natural Phenomenon–Seismic Event,” analyzes the consequences of a seismic-induced spray release. Safety-significant controls are required because the facility worker consequence is clearly above 100 rem and clearly above a Protective Action Criteria (PAC)-3 sum of fractions. Section 3.4.2.6 also analyzes the consequences of a seismic-induced hydrogen explosion in the Transfer Line Service Box (TLSB). Safety-significant controls are required due to the potential for facility worker serious injury or death. The TLSB analysis bounds a similar event in the In-Basin/Horizontal Shielded Hose Chase.

The control strategy for seismic-induced slurry spray releases during sludge retrieval and transfer is a pair of seismic shutdown switches interlocked to remove power from slurry transfer Booster Pump ECRT-P-101A/B via Safety Shutdown Interlock I-1.

The control strategy to prevent seismic-induced hydrogen explosions in the TLSB and In-Basin/Horizontal Shielded Hose Chase is to limit the volume of slurry leaks within the enclosures. Identical to a seismic-induced spray release, the control strategy is to credit the seismic shutdown switches interlocked to remove power from slurry transfer Booster Pump ECRT-P-101A/B. By terminating the transfer, only a small volume of slurry would accumulate in the enclosures if the transfer lines were to fail due to seismic forces.

There are two, redundant seismic shutdown switches; one in the Fuel Transfer System (FTS) Annex, and one in the 105KW Annex Sludge Loading Bay. Each switch receives three inputs from high sensitivity triaxial piezo-electric accelerometers. A switch activates the alarm relay when the signal from any axis exceeds the pre-set alarm level. The switches are set to activate at less than an acceleration of 0.2 g. This value is based on potential seismic interactions between the 105KW Reactor stack and safety-significant components located in the 105KW Basin, FTS Annex, and Horizontal Shielded Hose Chase. A detailed description of the seismic shutdown switches is provided in Section 4.4.4, “Seismic Shutdown Switches.”

Either seismic shutdown switch in alarm will actuate Safety Shutdown Interlock I-1. When actuated, Interlock I-1 opens redundant contactors to remove 480VAC power from the slurry transfer booster pump variable frequency drive (VFD) thus terminating the transfer. A detailed description of Safety Shutdown Interlock I-1 is provided in Section 4.4.5, “Safety Shutdown Interlock I-1.”

5.5.2.1.2 Limiting Condition for Operation

LCO 3.1 requires the seismic shutdown switches and Safety Shutdown Interlock I-1 to be operable. In order to be operable, the following limiting conditions must be met:

A. Seismic Shutdown Switches actuate Safety Shutdown Interlock I-1 within 2 seconds at an acceleration less than 0.2 g

B. Safety Shutdown Interlock I-1 removes power from the booster pump variable frequency drives
If either limiting condition is not met, and a seismic event were to occur coincident with a slurry transfer, then a seismic-initiated failure of an above-water slurry transfer line could result in a spray release or hydrogen explosion within a process enclosure.

LCO 3.1 is applicable in the Transfer Submode when sludge is being retrieved from an engineered container and transferred to an STSC. Transfers of IXM water and supernate into and out of an STSC are also performed in the Transfer Submode. LCO 3.1 is not applicable during these transfers because the radiological consequences of a spray release are low, and because the hydrogen generation rate associated with the supernate is low. Transfers of slurry out of an STSC may also be performed in the Transfer Submode if overfill recovery is required. LCO 3.1 is not applicable to such transfers based on likelihood of a seismic event occurring coincident with recovering sludge from an STSC.

5.5.2.1.3 Surveillance Requirements

Operability of the seismic shutdown switches is verified by an annual calibration and associated functional test. The functional test will verify the 2-second criterion is met. Calibration of the switches is performed by tilting the switch and measuring the trip angle, which correlates to an acceleration. The annual frequency is based on the failure modes and effects analysis (FMEA) (PRC-STP-CN-CS-00776, Failure Modes and Effects Analysis for the Sludge Treatment Project Engineered Container Retrieval and Transfer System Safety Instrument Systems), which assigns a 12-month test interval. The resulting average probability of failure on demand is 4.3E-3.

Operability of the seismic shutdown switch and Safety Shutdown Interlock I-1 circuitry is verified by performing a monthly functional test. The functional test is performed by simulating a signal from the seismic shutdown switches and verifying that power has been removed from the slurry transfer booster pump VFD. The monthly frequency is based on the seismic shutdown switch manufacturer’s recommendation.

5.5.2.1.4 Actions

If either of the seismic shutdown switches or Safety Shutdown Interlock I-1 are not operable, the required action and associated completion time is to stop and/or prohibit slurry transfers immediately. Stopping and/or prohibiting transfers is an eliminative action such that the Seismic Switches/Safety Shutdown Interlock I-1 safety functions are no longer required, i.e., there is no potential for a seismic-initiated spray release, or spill of slurry within a process enclosure, if slurry is not being transferred.

5.5.2.2 Limiting Condition for Operation 3.2–Auxiliary Ventilation System

5.5.2.2.1 Background

A hydrogen explosion in an STSC requires safety-significant controls due to the potential for facility worker serious injury or death. A hydrogen explosion in an STSC can be initiated by equipment failures and human errors, a fire in the 105KW Annex, NPH, and external events as described in the following Chapter 3.0 sections:

- Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion”
- Section 3.4.2.5, “Operational Accident–105KW Annex Fire”
- Section 3.4.2.6, “Natural Phenomenon–Seismic Event”
During sludge retrieval and transfer, the control strategy for the STSC is to prevent an explosion by maintaining the hydrogen concentration in the STSC headspace below 25 percent of the lower flammability limit (LFL) in air in accordance with the requirements of NFPA 69, Standard on Explosion Prevention Systems, Chapter 8, “Deflagration Prevention by Combustible Concentration Reduction.” Under normal operating conditions, the general service Process/Exhaust Ventilation System performs this function. Two flow elements mounted on the low pressure air purge inlet piping monitor the STSC inlet airflow rate to the STSC. If the general service Process/Exhaust Ventilation System fails to maintain a minimum air flow rate of 1 standard cubic foot per minute (scfm) through the STSC, the safety-significant Auxiliary Ventilation System automatically actuates. The Auxiliary Ventilation System uses pressurized nitrogen gas to provide a minimum flow rate of 0.5 scfm through the STSC.

Upon completion of sludge retrieval and transfer, the control strategy for the STSC is to prevent a hydrogen explosion by oxidant concentration reduction using nitrogen as the inerting agent. The STSC is inerted using the Inert Gas System. Nitrogen from the system is flowed through the STSC to reduce the oxygen concentration to less than 0.5 percent as measured by safety-significant Oxygen Analyzer ECRT-CAB-601. During STSC inerting, the Auxiliary Ventilation System remains connected to the STSC and is operable. If an Inert Gas System failure occurred such that no nitrogen was being provided by the system to the STSC, the Auxiliary Ventilation System would provide a flow rate through the STSC sufficient to maintain the headspace less than 25 percent of the LFL.

There are two redundant Auxiliary Ventilation trains (Train A and Train B), each capable of providing the requisite nitrogen flow rate. Nitrogen gas is supplied by two cylinder cradles, one each connected to Train A and Train B; spare cylinder cradles are installed but not connected. Each cylinder cradle contains 12 nitrogen cylinders. One connected cylinder cradle and one spare provides greater than 96 hours of nitrogen supply for a single train at a maximum flow rate of 0.8 scfm given the initial cylinder cradle pressures are greater than or equal to 1357 psig. A detailed description of the Auxiliary Ventilation System is provided in Section 4.4.6, “Auxiliary Ventilation System.”

It is important that actuation of the Auxiliary Ventilation System be detected so that nitrogen usage can be monitored and spare cylinder cradles connected when required in order to provide the requisite 96-hour supply. In addition, actions need to be initiated to restore normal process ventilation to the STSC. The status of the Auxiliary Ventilation System is indicated by two “STSC Normal Ventilation” indicator lights (one for Train A and one for Train B) located on the west outside wall of the 105KW Annex. These lights are energized (i.e., “on”) when the normal process ventilation flow rate is greater than 1 scfm. If the flow rate drops below 1 scfm, the Auxiliary Ventilation System will automatically actuate, and the lights are de-energized such that
they are “off.” A detailed description is provided in Section 4.5.16, “Auxiliary Ventilation System Actuation Notification.”

5.5.2.2.2 Limiting Condition for Operation

LCO 3.2 requires the Auxiliary Ventilation System to be operable. For the Auxiliary Ventilation System to be operable, the following limiting conditions must be met:

A. Train A and Train B each actuate at an STSC ventilation flow less than 1 scfm

B. Nitrogen flow rate from each train greater than or equal to 0.5 scfm and less than or equal to 0.8 scfm

C. Static pressure of greater than or equal to 1357 psig in two connected and two designated spare cylinder cradles.

Limiting condition A requires Train A and Train B each to actuate if the STSC ventilation flow rate is less than 1 scfm. If the system fails to actuate, then a flammable hydrogen explosion could form in the STSC headspace. The ventilation flow rate is measured by redundant air purge inlet flow elements. Associated low flow current switches actuate the Auxiliary Ventilation System if the flow rate is less than 1.0 scfm by removing power to the solenoid valves on the nitrogen supply thus switching them to the open position and initiating nitrogen flow.

Limiting condition B requires that, upon actuation, Train A and Train B each provide a nitrogen flow rate of 0.5 scfm to 0.8 scfm. The minimum flow rate of 0.5 scfm ensures that the headspace of the STSC remains below 25 percent of the LFL. Limiting the maximum nitrogen flow rate to 0.8 scfm ensures that each cylinder cradle can supply nitrogen for a minimum of 48 hours given an initial static pressure of 1357 psig.

Limiting condition C requires a static pressure of greater than or equal to 1357 psig in two connected and in two designated spare cylinder cradles. For a given train, one connected cradle and one designated spare, each at 1357 psig, provide a 96-hour nitrogen supply given a maximum flow rate of 0.8 scfm. Based on 100K Area operating history, 96 hours is judged to be an adequate time period to detect activation of the Auxiliary Ventilation System and to restore normal process ventilation.

LCO 3.2 is applicable in the Transfer Submode and the Shipment Preparation Submode. In the Transfer Submode the Process/Exhaust Ventilation System is connected to an STSC and transfers of sludge into the STSC are performed. Therefore the Auxiliary Ventilation System must be operable in the event the Process/Exhaust Ventilation System cannot maintain flow through the STSC after the initial slurry transfer.

In the Shipment Preparation Submode, there is sludge in an STSC and the Process/Exhaust Ventilation System remains connected to an STSC until an inert atmosphere has been verified. During the inerting process, the Auxiliary Ventilation System must be operable in the event there is a loss of nitrogen flow from the Inert Gas System. After an inert atmosphere is verified, the STSC purge inlet and STSC/STS purge outlet lines are disconnected from the STSC. In the event there are difficulties inerting, pressurizing, or leak testing the STS Cask, the STS Cask Lid may need to be removed and the STSC reconnected to the Process/Exhaust Ventilation System.
Limiting Condition C is not applicable if the Auxiliary Ventilation System actuates. By design, when the system actuates the connected cylinder cradle pressure will decrease as nitrogen gas flows from the cradle through the STSC.

### 5.5.2.2.3 Surveillance Requirements

The Auxiliary Ventilation System air purge inlet flow elements and low flow current switches are calibrated biennially. The calibration verifies that the Auxiliary Ventilation System actuates if the STSC ventilation flow rate is less than 1 scfm. The biennial surveillance frequency is based on PRC-STP-00754, *Sludge Treatment Project Engineered Container Retrieval and Transfer System Setpoint Determination Document*, which uses a 2 year calibration frequency to establish the instrument drift.

Verification that each train, when actuated, provides a minimum of 0.5 scfm and a maximum of 0.8 scfm of nitrogen to the STSC is accomplished by a functional test of the system. The functional test is performed by: (1) closing a valve on the low pressure air purge piping and verifying that the Auxiliary Ventilation System actuates, and (2) reading the nitrogen flow rate from Trains A and B as indicated by flow elements on each train. The functional test of the Auxiliary Ventilation System is performed bi-weekly. This frequency is based on the combined effects of instrument error and temperature deviation from the original setpoint. The uncertainty associated with the temperature deviation is based on a monthly temperature change of 68°F (PRC-STP-CN-M-00779). The flow elements used to measure and indicate the nitrogen flow rate are calibrated biennially. The biennial surveillance frequency is based on PRC-STP-00754, which uses a 2 year calibration frequency to establish the instrument drift.

Verification of a pressure greater than or equal to 1357 psig in two connected cylinder cradles and two designated spares is performed by reading the pressure gauge associated with each cylinder cradle. “Two connected cylinder cradles” refers to two cradles, one of which is connected to Train A, and one of which is connected to Train B. There may be up to a total of five spare cylinder cradles. “Two designated spares” refers to two cradles that are specifically designated as spares for the purposes of the LCO. Cylinder cradle pressure verification is performed daily. This surveillance frequency is based on engineering judgment and takes into consideration: (1) the safety-significant classification of the nitrogen supply components, and (2) that nitrogen gas used by Auxiliary Ventilation System is preferentially provided by the Inert Gas System.

The pressure gauges used to verify the cylinder cradle pressures are calibrated annually. This surveillance frequency is based on PRC-STP-00754, which uses a 1-year calibration frequency to establish the instrument drift.

Monitoring of the STSC Normal Ventilation indicator lights is performed daily. This frequency ensures that actuation of the Auxiliary Ventilation System is detected promptly such that actions are taken that ensure a minimum 96-hour nitrogen supply.

### 5.5.2.2.4 Actions

If either Train A or Train B of the Auxiliary Ventilation System does not actuate when the STSC ventilation flow rate less than 1 scfm, the required action is to restore the actuation setpoint. The associated completion time is immediately. This completion time minimizes the time-at-risk for a hydrogen explosion.
If either Train A or Train B of the Auxiliary Ventilation System does not provide a nitrogen flow rate of 0.5 to 0.8 scfm, the required action is to restore the nitrogen flow rate range. The associated completion time is immediately. This completion time minimizes the time-at-risk for a hydrogen explosion.

If the pressure in a connected or designated spare cylinder is less than 1357 psig, the actions taken are dependent upon when the non-conformance is identified.

If the static pressure is <1357 psig in any of two connected cylinder cradles or two designated spare cradles prior to the initial slurry transfer, then the required action is to prohibit slurry transfers. Prohibiting slurry transfers is an eliminative action such that the Auxiliary Ventilation System safety function is no longer required, i.e., if there is no sludge in an STSC, there is no potential for a hydrogen explosion. The associated completion time is immediately. This completion time minimizes the time-at-risk for a hydrogen explosion.

If the static pressure is <1357 psig in a connected or designated spare cylinder cradle subsequent to the initial slurry transfer into an STSC, the initial action is to verify Process/Exhaust Ventilation System service to the STSC. If the Process/Exhaust Ventilation System is servicing the STSC, then there is no hydrogen explosion hazard. Verification of Process/Exhaust Ventilation System service to the STSC is performed daily. This frequency is based on the likelihood of a loss of ventilation in a 24-hour interval, which is judged to be low given the Process/Exhaust Ventilation System is provided with redundant filter trains and exhaust fans. One train is normally in operation and the second train is in standby.

Two follow-on sets of actions may then be taken depending on the cause and location of the non-conformance. If the cause of the non-conformance is associated with a particular cylinder cradle, the action is to replace the cylinder cradle and verify that the replacement cylinder cradle pressure is ≥1357 psig. The associated completion time is immediately. This completion time minimizes the time-at-risk for a hydrogen explosion should the Process/Exhaust Ventilation System fail concurrent with low cylinder cradle pressure.

If the cause of the non-conformance is associated with a failed or damaged component downstream of the connected cylinder cradle, then a recovery plan is required to restore the cylinder cradle pressure to ≥1357 psig. The associated completion time is 5 days. This completion time is judged to be an adequate time period for Operations and Engineering to ascertain the cause of the low pressure, to define the work scope to repair the system, and restore the cylinder cradle pressure.

If monitoring determines that Process/Exhaust Ventilation System service is not being provided to the STSC, the Sludge Loading Bay is to be evacuated. Evacuating the Sludge Loading Bay facility worker. The associated completion is immediately. This completion minimizes the facility worker time-at-risk. A recovery plan is then required to restore the cylinder cradle pressure to ≥1357 psig. The associated completion time is 5 days. A recovery plan, separate from that previously discussed, is required to ensure that additional controls, if needed, are in place to protect facility workers re-entering the Sludge Loading Bay in support of restoring the cylinder cradle pressure.

If the Auxiliary Ventilation System has actuated (as indicated by an STSC Normal Ventilation Light being off) the initial action is to replace the connected cylinder cradle with a designated spare when the connected cylinder cradle pressure decreases to 150 psig. The associated
completion time is immediately. Replacing the connected cylinder with a designated spare ensures a flow rate of 0.5 scfm for a minimum of 96-hours. The 150 psig value is based on the required minimum pressure to sustain flow through the Auxiliary Ventilation System. The Process/Exhaust Ventilation System service to the STSC must then be restored. The associated completion time is 48 hours. Restoring Process/Exhaust Ventilation System service within 48 hours ensures there is sufficient nitrogen available to provide a flow rate of 0.5 scfm and thus maintain the hydrogen concentration to below 25% of the LFL. Lastly, depending on how long the Auxiliary Ventilation System was operating prior to restoring the Process/Exhaust Ventilation System, it may be necessary to connect compliant cylinder cradles and to identify compliant spares. The action is to perform a surveillance and verify a pressure of \( \geq 1357 \) psig in two connected cylinder cradles and two designated spares. The associated completion time is 1 hour, which is a reasonable duration for Operations to perform the surveillance. If the surveillance identifies a non-conformance, then the associated condition is entered and the associated actions taken.

5.5.2.3 Limiting Condition for Operation 3.3–Sludge Buoyant Weight Limits

5.5.2.3.1 Background

Chapter 3.0, Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion,” analyzes a hydrogen explosion in an STSC and STS Cask. Chapter 3.0, Section 3.4.2.4, “Operational Accident–STSC Over-Pressurization,” analyzes a high pressure venting of the STSC. In both accidents, safety-significant controls are required due to the potential for facility worker serious injury or death. For both accidents, the STSC analysis bounds the STS Cask analysis.

The hydrogen explosion and over-pressurization accident analyses and associated control strategies are based on a bounding STSC loading of 0.4 m\(^3\) of Settler Tank sludge layered with 1.6 m\(^3\) of 105-K East (KE) sludge. These bounding sludge volumes were also used in development of the T Plant safety basis and transportation safety analyses. Readings from the STSC level and truck weight instrumentation are used to calculate the buoyant weight of sludge in an STSC, and thus function to protect the bounding sludge volume assumption.

STSC level instrumentation includes a radar level element and associated level indicating transmitter, and a level indicator. A new level element/transmitter is provided with each STSC. The instrument remains installed on the STSC after sludge transfers are completed and the STSC is packaged and shipped to T Plant.

Truck weight instrumentation includes four load cells installed on a truck scale. This instrumentation measures the weight of the STS Trailer and its contents. All four load cells are inputs to a summation box that sums the load cell signals and outputs a single truck weight signal to a weight indicator. A detailed description of the STSC level and truck weight instrumentation is provided in Section 4.4.12, “Sludge Quantity Instrumentation.”

Level readings from the level indicator and truck weight readings from the weight indicator are used to calculate the buoyant weight of sludge in an STSC. The buoyant weight is verified to be within limits following each batch transfer of slurry. A detailed description is provided in Section 4.5.6, “Sludge Buoyant Weight Limits.” The STSC level instrumentation is also used to verify that the liquid level in an STSC is within limits established to prevent blocking STSC Nozzle S2 due to sludge expansion during long term storage at T Plant as described in Section 4.5.7, “Sludge Transport and Storage Container Final Liquid Level Limits.”

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5.5.2.3.2 Limiting Condition for Operation

LCO 3.3 requires that STSC sludge buoyant weight limits be in accordance with the limits shown in Table 5-3. If the buoyant weight of sludge in an STSC is greater than the bounding values assumed in thermal and gas analyses, then controls for the prevention of STSC/STS Cask hydrogen explosions and over-pressurizations may not be effective.

Table 5-3. Sludge Buoyant Weight Limits

<table>
<thead>
<tr>
<th>STSC Sludge Composition</th>
<th>Buoyant Weight Limit (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settler tank sludge layered with KE sludge</td>
<td>SCS-CON-230 ≤ 720</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-240, -250, -260 ≤ 960</td>
</tr>
<tr>
<td>SCS-CON-210</td>
<td>≤ 1056</td>
</tr>
<tr>
<td>SCS-CON-220</td>
<td>≤ 789</td>
</tr>
<tr>
<td>SCS-CON-240, -250, -260</td>
<td>≤ 1260</td>
</tr>
</tbody>
</table>

LCO 3.3 is applicable in the Transfer Submode and Shipment Preparation Submode. Buoyant weight measurements are made: (1) when IXM water is transferred into, and decanted out of, an STSC in order to establish the high and low tare weights, and (2) after slurry transfers. These transfers are only conducted in the Transfer Submode. Although transfers into or out of an STSC are not performed in the Shipment Preparation Submode, the limits must be met at all times after the initial transfer. Therefore, LCO 3.3 is also applicable in that submode.

5.5.2.3.3 Surveillance Requirements

Verification that the buoyant weight of sludge in an STSC is less than or equal to the applicable limit is performed after each batch transfer of slurry. Verifying the STSC is within limits after each slurry transfer reduces the likelihood that a sludge buoyant weight limit will be exceeded.

As previously stated, a new level element/transmitter is provided with each STSC. Each level/transmitter is calibrated by the manufacturer, re-calibrated prior to installation, and re-calibrated every 5 years thereafter as required. As documented in the FMEA, a 5-year frequency supports a Safety Integrity Level-2 designation, which provides an average probability of failure on demand of less than $1.0 \times 10^{-2}$ to greater than or equal to $1.0 \times 10^{-3}$. The associated level indicator is calibrated annually based on the manufacturer’s recommendation.

The truck weight instrumentation is calibrated annually based on the manufacturer’s recommendation.

5.5.2.3.4 Actions

If the buoyant weight of sludge in an STSC is greater than the applicable limit, the initial action is to verify Process/Exhaust Ventilation System service to the STSC. If the Process/Exhaust Ventilation System is operating, then there is no hydrogen explosion hazard. The verification is performed daily. This frequency is based on the likelihood of a loss of ventilation in a 24-hour interval, which is judged to be low given the Process/Exhaust Ventilation System is provided with redundant filter trains and exhaust fans. The follow-on action is to develop a
facility-approved recovery plan to reduce the STSC sludge buoyant weight. The associated completion time is 5 days. This completion time is adequate to reconfigure equipment in the 105KW Basin and 105KW Annex and to remove sludge from the STSC and transfer it to an engineered container using the overfill recovery tool.

If the verification action determines that Process/Exhaust Ventilation System service is not being provided to the STSC, the Sludge Loading Bay is to be evacuated. If the Process/Exhaust Ventilation System is not operating, then the Auxiliary Ventilation System will automatically actuate. However, if the sludge buoyant weight limit is exceed, then the Auxiliary Ventilation System flow rate of 0.5 scfm may not be adequate to maintain the hydrogen concentration below 25% of the LFL. Evacuating the Sludge Loading Bay protects the facility worker. The associated completion is immediately. This completion minimizes the facility worker time-at-risk. A recovery plan is then required to reduce the sludge buoyant weight to within the applicable limit. The associated completion time is 5 days. A recovery plan, separate from that previously discussed, is required to ensure that additional controls, if needed, are in place to protect facility workers re-entering the Sludge Loading Bay in support of overfill recovery activities.

5.5.2.4 Limiting Condition for Operation 3.4–STSC and STS Cask Inerting and Shipment Preparation

5.5.2.4.1 Background

Chapter 3.0, Section 3.4.2.2, “Operational Accident–STSC Hydrogen Explosion,” analyzes a hydrogen explosion in an STSC and STS Cask. Safety-significant controls are required due to the potential for facility worker serious injury or death.

STSC Inerting Limit. A hydrogen explosion cannot occur in the STSC headspace if there is insufficient oxygen present to support combustion. To inert the STSC, nitrogen gas from the Inert Gas System is used to purge the STSC to reduce the oxygen concentration to less than 0.5 vol% oxygen. The requirement to inert to the STSC to less than 0.5 vol% oxygen is based on NFPA 69, Chapter 7, “Deflagration Prevention by Oxidant Reduction Concentration.” In situations where the oxygen concentration is not being continuously monitored, NFPA 69 requires the oxygen concentration to be no more than 40 percent of the limiting oxygen concentration (LOC) when the LOC is below 5 vol%. Per NFPA 69, Appendix C, “Limiting Oxygen Concentrations,” the LOC for a hydrogen-nitrogen-air mixture is 3.0 vol%. Thus, per NFPA 69, the oxygen concentration in the STSC must be less than 1.2 vol%. LCO 3.5 requires verification that the oxygen concentration in the STSC headspace is less than 0.5 vol%. Reducing the concentration to less than 0.5 vol% protects against exceeding the 1.2 vol% limit due to potential air inleakage during the time it takes to place the STS Cask lid and inert the STS Cask.

To inert the STSC, the room air inlet to the STSC is isolated by closing valve ECRT-V-732. Closing valve ECRT-V-732 actuates the Auxiliary Ventilation System which, after approximately 5 minutes, begins a flow of nitrogen to the STSC. Closing valve ECRT-V-732 also starts the “STSC Inerting Clock.” Two inert gas supply valves (i.e., ECRT-V-605 and -611) are then opened to initiate a flow of nitrogen to the STSC from the Inert Gas System.

The oxygen concentration in the STSC headspace is measured and indicated by an Oxygen Analyzer that withdraws a gas sample from the STSC/STS purge outlet line. The reaction of
oxygen in the gas sample with lead in an oxygen sensor produces an electrical signal proportional to the oxygen concentration. A detailed description of the Oxygen Analyzer is provided in Section 4.4.7, “Oxygen Analyzer.”

Operators monitor the Oxygen Analyzer local display. Once the oxygen concentration has been verified to be less than 0.5 vol%, the STSC is isolated from the Inert Gas System by closing valves ECRT-V-605 and -611. Closing these valves stops the “STSC Inerting Clock.” The “STSC Inerting Clock” start and stop times are then used to verify that the STSC was inerted within the 8-hour time limit. The 8-hour time limit for inverting the STSC is based on engineering judgment. Under normal operating conditions it takes less than 1 hour to inert the STSC. If greater than 8 hours is required, then a significant off-normal condition exists and corrective actions are required.

Closing valves ECRT-V-605 and ECRT-V-611 also starts the “STSC Inerted and Isolated Clock,” which is used to track a 24-hour time limit for the performance of STS Cask inerting and pressurization as described in the following section.

**STS Cask Inerting and Pressurization Limits.** After the STSC has been isolated from the Inert Gas System, hoses and instruments are disconnected from the STSC. Transport Vent Assemblies are installed on Nozzles S2 and F2, and the lid is placed on the STS Cask. The Inert Gas System is then connected to the STSC using the STS Cask Drain Port Tool; and the STSC/STS Cask Purge Outlet line is connected to the cask using the STS Cask Vent Tool. Nitrogen flow is then initiated and the cask is inerteed untill Operators verify an oxygen concentration of less than 1.2 vol% as indicated by the Oxygen Analyzer.

Once an inert atmosphere is established in the STS Cask, it must be maintained until received at T Plant. Pressurizing the STS Cask to greater than 3 psig, combined with a verified low leak rate, ensures that there is no air inleakage for the duration of the shipping window.

PRC-STP-CN-N-00989, *Thermal and Gas Analyses for a Sludge Transport and Storage Container (STSC) During Transportation to T Plant with KW Annex Staging*, calculates hydrogen generation rates and STS Cask pressures for various sludge loading scenarios and staging periods in the 105KW Annex to determine an allowable shipping window. PRC-STP-CN-N-00989 assumes an initial STS Cask pressure of 15 psig. To protect this assumption, the STS Cask pressure must be less than 15 psig.

The STS Cask is manually pressurized using nitrogen from the Inert Gas System. Once the STS Cask has been inerted, the STS Cask Vent Tool is closed and the STSC/STS purge outlet line is disconnected. Operators then pressurize the cask by opening a valve on the Inert Gas System and monitor the increase in pressure on safety-significant Pressure Indicator PI-760-606. A general service pressure control valve limits the cask pressurization to 10 psig. If the pressure should somehow increase above 15 psig, the pressure can be reduced by venting through valve ECRT-V-612 and Filter ECRT-F-612, located on the Nitrogen Purge Panel, or by connecting the STS Pressurization Check Tool to the Cask Vent Tool and venting the excess pressure through that device.

The STSC “Inerted and Isolated Clock” is stopped when it is verified that the cask has been pressurized to between 3 and 15 psig as indicated on Pressure Indicator PI-760-606. The “STSC Inerted and Isolated Clock” start and stop times are then used to verify that the STS Cask was inerted and pressurized within the 24-hour time limit.
The 24-hour time limit is based on PRC-STP-CN-N-00989, which calculates that it takes approximately 70 hours to reach 25 percent of the LFL in the cask headspace. Requiring the inerting and pressurization to be completed within 24 hours provides sufficient time to take corrective actions as required.

**STS Cask Leak Rate Limit.** After the STS Cask has been inerted and pressurized, a leak test is performed to verify a leak rate of less than or equal to 9.0E-4 standard cm³/s air. This leak rate criterion is established in CHPRC-03111, *One-Time Request for Shipment for Sludge Transport from K West Basin to T Plant*.

The cask leak rate is measured using the STS Cask Leak Rate Tester. The tester includes a control panel, vacuum pump, three STS Cask Leak Test Adapters, venting manifold, volume check tool, and test/home ports for each leak test adapter.

The STS Cask vent, drain, and main seal closures must be tested. To leak test a closure, a leak test adapter is connected to its respective port. The isolation valve is opened, the vacuum pump turned on, and a process of vacuum conditioning is undertaken. Upon achieving adequate vacuum conditioning, leak testing is performed in a sequence of three periods of pressure logging. These three periods are the preliminary system calibration, leak detection and measurement, and final system calibration. A detailed description of the STS Cask Leak Tester is provided in Section 4.4.11, “Sludge Transport System Cask Leak Tester.”

The overall leak rate of the STS Cask is the sum of the individual leak rates of the STS Cask closures. The leak rate is required to be less than or equal to 9.0E-4 standard cm³/s air. STS Cask ports that have not been used since the previous test do not need to be re-tested, and the previously calculated leakage rate for that port can be included in the evaluation of the total STS Cask leakage rate.

The potential exists for multiple days to elapse between the time the STS Cask has been inerted and pressurized and the time leak testing of the STS Cask using the STS Cask Leak Tester is initiated. Air inleakage during this time period could result in a loss of the inert atmosphere within the cask. To ensure the inert atmosphere is being maintained, the LCO includes a requirement to measure the STS Cask pressure if it has been more than 1 day after the STS Cask pressure has been established. If the cask remains pressurized, then air inleakage cannot occur.

**5.5.2.4.2 Limiting Condition for Operation**

LCO 3.4 has the following limiting conditions:

A. The STSC headspace hydrogen concentration shall be less than 25% of the LFL until the oxygen concentration has been reduced to less than 0.5 vol%.

B. The STS Cask headspace hydrogen concentration shall be less than 25% of the LFL until the oxygen concentration has been reduce to less than 1.2 vol%.

For Limiting Condition A, the hydrogen concentration in the STSC headspace is controlled by the Auxiliary Ventilation System (see LCO 3.2). The Auxiliary Ventilation System remains connected to the STSC until such time that it has been verified that the oxygen concentration has been reduced to less than 0.5 vol%.

For Limiting Condition B, the hydrogen concentration in the STS Cask headspace is controlled by the 24-hour time limit to verify that the oxygen concentration has been reduced to less than...
1.2 vol% and pressure the STS Cask to prevent air inleakage. Once established, maintaining the inert atmosphere requires the STS Cask to be pressurized between 3 and 15 psig, and the cask leak rate to meet the leak rate criterion.

LCO 3.4 is applicable in the Shipment Preparation Submode.

5.5.2.4.3 Surveillance Requirements

Verification that the STSC has been inerted to less than 0.5 vol% oxygen is required to be performed before 8 hours has elapsed since initiating the nitrogen purge. As previously stated, under normal operating conditions it takes less than 1 hour to inert the STSC. If greater than 8 hours is required to inert the STSC, than a significant off-normal condition exists and the required actions are to be taken.

Verification that the STS Cask has been inerted to less than 1.2 vol% oxygen and pressurized to between 3 and 15 psig is required to be performed before 24 hours has elapsed since terminating the STSC nitrogen purge. As previously stated, the 24-hour time limit is based on PRC-STP-CN-N-00989, which calculates that it takes approximately 70 hours to reach 25 percent of the LFL in the cask headspace. Requiring the inerting and pressurization to be completed within 24 hours provides sufficient time to take corrective actions as required.

The oxygen sensor fuel cell is required to be replaced and calibrated semi-annually to ensure replacement prior to the manufacturer’s stated 8-month life expectancy in air is reached. A functional test of the Oxygen Analyzer is performed prior to each use. This ensures the oxygen analyzer is operable every time it is turned on and used to measure the oxygen concentration in an STSC or STS Cask.

The STS Cask pressure is monitored using Pressure Indicator PI-760-606, which is required to be calibrated annually. This frequency is based on PRC-STP-CN-CS-00776, which conservatively assigns a 12 month test interval. The resulting average probability of failure on demand is 6.0E-4.

Monitoring of the STS Cask Pressure Boundary for a 2 psig decrease from the initial fill pressure is performed “daily after the STS Cask has been pressurized to between 3 and 15 psig and until leak testing of the STS Cask has been initiated.” This surveillance frequency ensures that a significant cask leak, should it occur, is detected in a timely manner such that corrective actions can be taken. The daily frequency is based on PRC-STP-CN-M-00990, STS Cask Headspace Pressure Upon Arrival at T Plant. Given that the STS Cask has been pressurized to 3 psig (i.e., the lower bound of the acceptable pressure range), a leak rate of 3.35 cm³/sec would be required for the STS Cask to reach atmospheric pressure within 24 hours. Leaks of this magnitude, i.e., greater than 3700 times the leak rate criterion of 9.0E-4 cm³/s, are not expected based on the design of the STS Cask port and lid seals.

A functional test of the STS Cask Leak tester is performed before and after each use of the STS Cask Leak Tester. This frequency is in accordance with ANSI N14.5 requirements.

Verification that the STS Cask leak rate is less than or equal to 9.0E-4 standard cm³/s air is performed “prior to exiting the Shipment Preparation Submode.” This frequency ensures that each STS Cask meets the LCO requirement before it is shipped to T Plant.
5.5.2.4.4 Actions

If 8 hours after initiating the STSC nitrogen purge, the STSC headspace cannot be reduced to less than 0.5 vol% oxygen, the required action is to immediately restore Process/Exhaust Ventilation System service to the STSC. This is accomplished by opening valve ECRT-V-732 on the low pressure air purge inlet piping. Restoring the inlet airflow to the STSC ensures the hydrogen concentration in the STSC remains below 25 percent of the LFL.

If 24 hours after terminating the STSC nitrogen purge, either (1) the STS Cask cannot be inerted to less than 1.2 vol% hydrogen, or (2) if the STS Cask cannot be pressurized to between 3 and 15 psig, the required action is to immediately restore Process/Exhaust Ventilation System service to the STSC. This requires removing the STS Cask lid, reconnecting the Process/Exhaust Ventilation System to the STSC, and opening valve ECRT-V-732.

If STS Cask pressure monitoring indicates a 2 psig or greater pressure decrease, the required action is to immediately ensure the STS Cask pressure is between 3 and 15 psig. If the STS Cask is pressurized, air-leakage cannot occur. Thus, this action puts the STS Cask in a safe condition. The cask pressure is monitored using PI-760-606. If required, the cask is re-pressurized using nitrogen from the Inert Gas System. The cask pressure must then monitored daily and re-pressurized as required. A facility-approved recovery plan to repair the STS Cask Seals must then be developed. The associated completion time is 5 days. This completion time is judged to be an adequate time period for Operations and Engineering to prepare the associated recovery plan and obtain facility approval.

If the STS Cask leak rate is confirmed to be greater than 9.0E-4 standard cm³/sec air, then the STS Cask pressure must be monitored daily and re-pressurization as required. These actions place the STS Cask in a safe configuration. The follow-on action is to develop a facility-approved recovery plan to repair the STS Cask Seals. The associated completion time is 5 days.

5.5.2.5 Limiting Condition for Operations 3.5–Combustible Material Control Requirements

5.5.2.5.1 Background

Chapter 3.0, Section 3.4.2.5, analyzes fire-initiated spray releases and hydrogen explosions. Safety-significant controls are required for spray releases because the facility worker radiological consequences are not clearly above or below 100 rem, and the facility worker toxicological consequences are clearly above a PAC-3 sum of fractions. Safety-significant controls are required for hydrogen explosions due to the potential for facility worker serious injury or death.

The principal control strategy is to prevent the occurrence of a fire of sufficient magnitude to result in structural damage to the 105KW Annex. This is accomplished, in part, by controlling the quantity and location of combustible materials.

HNF-SD-SNF-FHA-001, Fire Hazards Analysis for the 105-KW Facility (FHA), analyzes a number of 105KW Annex fire scenarios. The process transfer line fire, transporter tire fire, and STSC hood, drape, and cover fire involve fixed quantities of combustible materials at fixed locations. Analyses of these fires demonstrate that they are not structurally-endangering.
The quantity of combustible materials associated with a step-off pad can vary depending on the operations being conducted and the housekeeping performed. The FHA analyzes a fire involving a step-off pad located on the tongue of the STS Trailer. The analysis conservatively assumes a total of 285 lb of combustible material is simultaneously burned. The corresponding peak heat release rate is 645 kW. Given a fuel package size of 645 kW, the FHA establishes separation distances from other fuel packages, from process transfer lines, and from structural columns.

The FHA analyzes multiple liquid fuel fires originating outside of 105KW Facility structures. The fires cover a range of pool fire areas for given amounts of fuel. Based on the analyses, separation distances were calculated to prevent damage to structural columns of the 105KW Basin superstructure. For a 100-gal pool fire, the minimum separation distance is approximately 10.5 ft. For implementation purposes, this is conservatively increased to 15 ft. For a 3255-gal pool fire, such as may be associated with a tanker truck, the minimum separation distance is approximately 45 ft. For implementation purposes, this is conservatively increased to 50 ft. Other liquid fuel volumes between 100 and 3255 gal are also analyzed. To simplify implementation, the separation distance for the 3255-gal volume is conservatively applied to volumes greater than 100 gal.

5.5.2.5.2 Limiting Condition for Operation

LCO 3.5 has the following requirements:

A.1 105KW Annex Sludge Loading Bay

1. The transient combustible fuel package size is limited to 645 kW as the default fire exposure.
2. A minimum distance of 5 ft shall be maintained between a default fuel package and other fuel packages.
3. A minimum distance of 5 ft shall be maintained between a default fuel package and process transfer lines.
4. On the mezzanine, a minimum distance of 3 ft shall be maintained between a default fuel package and structural columns.

A.2 105KW Annex Exterior

1. Vehicles containing ≤ 100 gallons of fuel shall not be left unattended within 15 ft of the 105KW Annex.
2. Vehicles containing > 100 gallons of fuel shall not be left unattended within 50 ft of the 105KW Annex.
3. A 30-ft defensible space around the 105KW Annex shall be free of transient combustibles and accumulations of windblown vegetation.

Limiting condition A.1.1 limits the transient combustible fuel package size to that analyzed in HNF-SD-SNF-FHA-001.

Limiting conditions A.1.2 through A.1.4 define minimum separation distances that must be maintained between a default fuel package and other fuel packages, process transfer lines, and structural columns. Failure to maintain these minimum separation distances could result in a structurally endangering fire.
Limiting conditions A.2.1 and A.2.2 define separation distances between unattended vehicles and the 105KW Annex as a function of fuel volume. Failure to maintain these separation distances could result in a structurally endangering fire.

Limiting condition A.2.3 requires a 30-ft defensible space around the 105KW Annex to be maintained free of transient combustible materials and accumulations of windblown materials. Ignition of such materials adjacent to the 105KW Annex could result in a structurally endangering fire or damage to outdoor components of the safety-significant Auxiliary Ventilation System.

A fire-initiated slurry spray release can only occur during a slurry transfer. A fire-initiated hydrogen explosion can only occur when an STSC contains sludge. However, a fire occurring at other times has the potential to damage safety-significant equipment that is subsequently relied upon to support operations. Therefore, LCO 3.5 is applicable in the Operations Mode, Transfer Submode, and the Shipment Preparation Submode.

5.5.2.5.3 Surveillance Requirements

Verification that the Sludge Loading Bay complies with the Fire Protection Combustible Control requirements is performed weekly. This surveillance frequency takes into account the routine nature of operations and activities performed when an STS Trailer is present in the Sludge Loading Bay. Maintenance activities, which have the potential to introduce significant quantities of combustible material, will typically be performed in the Operations Mode, but not in the associated submodes.

Verification that the 105KW Annex complies with separation distance requirements for unattended vehicles is performed daily when the 105KW Facility is manned. This frequency minimizes the time-at-risk for a structurally-endangering fire should a non-compliant condition exist. The surveillance is not required when the facility is unmanned (e.g., weekends and holidays) based on the very low volume of traffic in the 100K Area during such times.

Verification that the 105KW Annex 30-ft defensible space is free of transient combustibles and accumulations of windblown vegetation is performed daily when the 105KW Facility is manned. This frequency minimizes the time-at-risk for fire damage to the Auxiliary Ventilation System should a non-compliant condition exist. The surveillance is not required when the facility is unmanned based on the frequency of a rapid accumulation of a significant quantity of transient combustible materials/windblown vegetation occurring concurrent with an ignition source or range fire over a relatively short time period.

If combustible materials are not in compliance with the above-listed control requirements, then the required action is to immediately correct the non-compliance. The immediate completion time minimizes the time-at-risk of a potentially structurally-endangering fire or damage to the Auxiliary Ventilation System.

5.5.3 Administrative Controls

Administrative controls are provisions relating to organization and management, procedures, record-keeping, assessments, and reports necessary to ensure safe operation of a facility. As discussed in DOE G 423.1-1A, ACs can be programmatic or specific. A programmatic AC represents commitments to establish, implement, and maintain an SMP. A SAC is an
AC that provides a specific preventive or mitigative function for accident scenarios where the safety function has importance similar to, or the same as, the safety function of a safety SSC.

The following sections provide information used in the derivation of ACs documented in the PRC-STP-00992.

5.5.3.1 Directive Action Specific Administrative Controls

5.5.3.1.1 Administrative Control 5.6.1–Sludge Source Verification

The safety function of the Sludge Source Verification SAC is to protect initial conditions assumed in the STSC thermal and gas analyses regarding the type of sludge in an STSC. The SAC requires verifying that the XAGO is placed in the correct engineered container for the planned transfer prior to starting slurry transfer Booster Pump ECRT-P-101A/B.

Thermal and gas analyses have been performed for an STSC during sludge retrieval and transfer, preparation for transportation, transportation to T Plant, and long-term storage at T Plant. The analyses demonstrate that under certain conditions during filling, inerting, transportation, or storage, sufficient hydrogen for flammability can exist in an STSC headspace. The type and quantity of sludge in an STSC is an initial condition assumed in the thermal and gas analyses that must be protected. Assumptions regarding the type and quantity of sludge in an STSC are also used to calculate the rate at which the STSC/STS Cask pressurizes. The SAC ensures that sludge is retrieved from the intended engineered container. A detailed description of the SAC is provided in Section 4.5.1, “Sludge Source Verification.”

5.5.3.1.2 Administrative Control 5.6.2–Basin Water Level

The safety function of the Basin Water Level SAC is to protect the hazard analysis assumption that slurry transfer line failures underwater in the 105KW Basin do not result in an airborne release. The SAC requires verification that the basin water level is greater than or equal to 15 ft above the basin floor prior to starting slurry transfer Booster Pump ECRT-P-101A/B.

The ECRTS hazard analysis (PRC-STP-00687) assumed that slurry transfer line failures between Booster Pump ECRT-P-101A/B and the Ingress/Egress Assembly during sludge retrieval and transfer do not result in airborne spray releases because the associated transfer line is located underwater. To protect this assumption, the SAC ensures a minimum water level is maintained in the 105KW Basin. A detailed description of the SAC is provided in Section 4.5.2, “Basin Water Level.”

5.5.3.1.3 Administrative Control 5.6.3–Personnel Access Prohibition

The safety function of the Personnel Access Prohibition SAC is to mitigate facility worker consequences in the event of a spray release by prohibiting access to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer. Prior to starting the slurry transfer booster pump, the SAC requires verification that:

- No personnel are in the Sludge Loading Bay
- Doors 103 and 109 are closed and locked

Engineered controls have been selected to prevent operational, NPH, and external event-initiated spray releases (e.g., safety-significant above water slurry transfer lines). To provide an additional layer of defense-in-depth for facility worker protection, the Personnel Access
Prohibition SAC prohibits manned entry to the 105KW Annex Sludge Loading Bay during sludge retrieval and transfer. A detailed description of the SAC is provided in Section 4.5.3, “Personnel Access Prohibition.”

5.5.3.1.4 Administrative Control 5.6.4–Vehicle Access Control

The safety function of the Vehicle Access Control SAC is to prevent the spray release of slurry by prohibiting vehicular traffic in the vicinity of the 105KW Annex during sludge retrieval and transfer. Prior to starting the slurry transfer booster pump, the SAC requires “Road Closed” signs to be posted on Wakefield Loop in the vicinity of the 105KW Annex.

A vehicle impact was identified as an external event that could result in a slurry spray release. The SAC prohibits vehicular traffic in the vicinity of the 105KW Annex during sludge retrieval and transfers thereby preventing a vehicle impact-initiated spray release. A detailed description of the SAC is provided in Section 4.5.4, “Vehicle Access Control.”

5.5.3.1.5 Administrative Control 5.6.5–Slurry Settling Duration

The safety function of the Slurry Settling Duration SAC is to protect the accident analysis assumption regarding the composition of decanted supernate. Prior to starting Decant Pump ECRT-P-201/201S, the SAC requires verification that it has been 2 hours since the slurry transfer booster pump was de-energized.

The material-at-risk values used in consequence calculations for a spray release of STSC supernate and ECRTS Sand Filter backwash are based on a supernate solids volume fraction that assumes a 2-hour settling duration. In addition, flammable gas calculations for the Decant Pump Box and ECRTS Sand Filter Enclosure are based on a supernate composition given a 2-hour settling duration. A detailed description of the SAC is provided in Section 4.5.5, “Slurry Settling Duration.”

5.5.3.1.6 Administrative Control 5.6.6–Sludge Transport and Storage Container Final Liquid Level

The safety function of the STSC Final Liquid Level SAC is to prevent a hydrogen explosion in an STSC during long-term storage at T Plant by limiting the liquid level in an STSC. Prior to performing STSC process disconnects, the SAC requires verification that the liquid level in an STSC is less than or equal to the applicable limit shown in Table 4-20, “STSC Maximum Liquid Level.”

A hydrogen explosion in an STSC during long-term storage at T Plant is prevented by passive ventilation. At T Plant, a 2-ft vent pipe is installed on Nozzle F2, and Nozzle S2 is left open to the storage cell atmosphere. Sludge expansion during long-term storage at T Plant has the potential to raise the supernate level in an STSC to the point it blocks the ventilation flow path at Nozzle S2. Compliance with the maximum fill volume limits ensures that the volume of supernate and expanded sludge does not block the S2 vent flow path. A detailed description of the SAC is provided in Section 4.5.7, “Sludge Transport and Storage Container Final Liquid Level Limits.”

5.5.3.1.7 Administrative Control 5.6.7–Gas Composition Verification

The safety function of the Gas Composition Verification SAC is to prevent a hydrogen explosion in an STSC or STS Cask by verifying that the Auxiliary Ventilation System and Inert Gas
System are supplied with nitrogen. Prior to receipt at the 105KW Annex, the SAC requires verification that the nitrogen gas purity is greater than or equal to 99.9 percent and has a moisture content of 3 ppm or less.

Upon completion of sludge retrieval and transfer, the control strategy for the STSC and STS Cask is to prevent a hydrogen explosion by oxidant concentration reduction using nitrogen as the inerting agent. Nitrogen gas supplied by the Inert Gas System is used to inert the STSC and the STS Cask. The SAC verifies that the Inert Gas System nitrogen supply cylinders contain nitrogen gas of high quality versus a flammable gas or a gas that is an oxidizer (e.g., oxygen, chlorine). In addition, this SAC verifies a very low moisture limit. A detailed description of the SAC is provided in Section 4.5.8, “Gas Composition Verification.”

5.5.3.1.8 Administrative Control 5.6.8–STS Cask Lid Critical Lift

The safety function of the STS Cask Lid Critical Lift SAC is to prevent a hydrogen explosion by preventing an STS Cask Lid drop. The SAC requires that STS Cask Lid installation be performed in accordance with the requirements of DOE/RL-92-36, Hanford Site Hoisting and Rigging Manual, Chapter 3.0, “Critical Lifts.” In addition, if sludge is present in an STSC, the SAC requires that removal of the STS Cask Lid, if required, be performed in accordance with the requirements DOE/RL-92-36, Chapter 3.0.

A 5-ton bridge crane in the 105KW Annex is used to place the STS Cask Lid on the STS Cask after the STSC has been inerted, process disconnects performed, and the STSC Transport Vent Assemblies have been installed. If the lid were to drop, the STSC Boundary could be damaged resulting in a loss of the inert atmosphere which could eventually result in a hydrogen explosion. The SAC requires that installation of the STS Cask Lid be performed as a critical lift which reduces the likelihood of a drop.

Once an STSC containing sludge has been inerted and the STS Cask Lid put in place, the lid is normally not removed until the STS Cask is received at T Plant. However, the STS Cask Lid may need to be removed if there are difficulties with inerting, pressurizing, leak testing, or staging the STS Cask. In such situations, the SAC also requires that removal of the STS Cask Lid be performed as a critical lift. A detailed description of the SAC is provided in Section 4.5.10, “STS Cask Lid Critical Lift.”

5.5.3.1.9 Administrative Control 5.6.9–STS Cask Staging Limit

The STS Cask Staging Limit SAC has the following three safety functions:

1. Protect initial conditions assumed in the STS Cask staging and transportation analyses regarding STSC temperatures and pressures.
2. Prevent a hydrogen explosion by limiting the rate at which hydrogen would be released should the STS Cask need to be vented in the Sludge Loading Bay.
3. Prevent STS Cask over-pressurization by venting the cask.

The SAC requires the STS Cask to exit the 105KW Annex en route to T Plant within 240 hours of completing STS Cask pressurization.

PRC-SP-00989 calculates hydrogen generation rates and STS Cask pressures for various sludge loading scenarios and staging periods in the 105KW Annex to determine an allowable
shipping window. Factoring a staging period into the shipping window calculations provides Operations a degree of flexibility in coordinating the shipment with T Plant and allows for potential delays due to inclement weather or other unforeseen circumstances.

PRC-STP-CN-N-00989 also analyzes the venting of an STS Cask and STSC at the 105KW Annex. Such venting is not a part of normal operations but could be required if it were not possible to ship the STSC to T Plant. The analysis, which assumes the cask is vented using the STS Cask Vent Tool and the STS Cask Pressurization Check Tool after a 10 day staging period, shows that the cask is reduced from approximately 25 psig to atmospheric pressure in approximately 1 hour. The maximum hydrogen release rate during venting is 0.5 scfm, which occurs after 0.45 hour. This maximum release rate can be safely vented by positioning Rad Con Hood ventilation hose ECRT-H-505 adjacent to the STS Pressurization Check Tool.

In addition to protecting initial conditions assumed in PRC-STP-CN-N-00989, the 240-hour staging limit prevents over pressurization of the STS Cask while in the 105KW Annex. As calculated in PRC-STP-CN-N-00819, it takes greater than 70 days to reach the 80 psig design pressure of the STS Cask for the bounding STSC sludge loading. A detailed description of the SAC is provided in Section 4.5.13, “Sludge Transport System Cask Staging Limit.”

5.5.3.1.10 XAGO Pre-Operational Testing and Operational Readiness Controls

The safety function of the XAGO Pre-Operational Testing and Operational Readiness Controls SAC is to protect the accident analysis assumption regarding material-at-risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container. The SAC has two requirements. First, when using Basin water to simulate a sludge transfer to the 105KW Annex, the XAGO tool is to be placed away from the area above an engineered container. Second, when the XAGO is allowed above an engineered container, positive control is maintained on the Basin water motive force to the XAGO tool. These controls ensure that sludge will not be transferred to the 105KW Annex should too much chain be deployed and the safety-significant hoist chain stop (see Section 5.6.9) fail.

5.5.3.2 Programmatic Administrative Controls

5.5.3.2.1 Administrative Control 5.7.1–Safety Management Programs

The Safety Management Program AC provides a commitment to establish, implement, and maintain the following SMPs as described in HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Programs:

- Prevention of Inadvertent Criticality (Chapter 6.0)
- Radiation Protection (Chapter 7.0)
- Hazardous Material Protection (8.0)
- Radioactive and Hazardous Waste Management (Chapter 9.0)
- Initial Testing, In-Service Surveillance, and Maintenance (Chapter 10.0)
- Operational Safety (Conduct of Operations/Fire Protection Program) (Chapter 11.0)
- Procedures and Training (Chapter 12.0)
• Human Factors (Chapter 13.0)
• Quality Assurance (Chapter 14.0)
• Emergency Preparedness Program (Chapter 15.0)
• Provisions for Decontamination and Decommissioning (Chapter 16.0)
• Management, Organization, and Institutional Safety Provisions (Chapter 17.0)

Two key elements of the Fire Protection Program are specifically credited with preventing and mitigating design basis accidents: (1) a combustible control program as required by PRC-STD-FP-40404, *Fire Protection Program*, and (2) hot work controls as required by PRC-PRO-FP-40421, *Hot Work*.

### 5.6 Design Features

Design features are those features of a facility that, if altered or modified, would have a significant effect on safe operation. Design features are normally passive attributes of the facility not subject to significant alteration by Operations personnel, and that do not require, or infrequently require, maintenance or surveillance.

The following sections provide information used in the derivation of DFs documented in PRC-STP-00992.

#### 5.6.1 Above-Water Slurry Transfer Lines

Above-water slurry transfer lines have two safety functions:

1. Prevent the spray release of slurry by maintaining integrity during sludge retrieval and transfer.
2. Prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by maintaining integrity during slurry transfers.

Slurry transfer lines provide the primary containment for slurry transfers. The safety-significant portion of the ECRTS Transfer System includes only those system components that are above water. Slurry transfer line failures that occur under water in the 105KW Basin do not result in an airborne spray release.

Above-water slurry transfer lines include: (1) the inner pipe within the slurry transfer line Ingress/Egress Assembly, (2) the inner hose of the slurry transfer line hose-in-hose, (3) the inner pipe for the slurry transfer line coaxial connector, and (4) the slurry transfer line piping and hose in the TLSB. In addition, above-water slurry transfer lines include connections between lengths of hose and pipe including gaskets and fasteners, and any in-line equipment (e.g., isolation valves, pump housings, and instruments) that is part of the above-water slurry transfer line pressure boundary. A detailed description of above-water slurry transfer lines and associated functional requirements and performance criteria are provided in Section 4.4.1, “Above-Water Slurry Transfer Lines.”

The above-water slurry transfer lines are predominantly a passive engineered control. The passive components (e.g., hoses and piping) are not subject to change by Operations.
personnel. Characteristics of the passive components were ensured through design and procurement. The in-service inspection is that above-water slurry transfer lines shall be used within their design life. The above-water slurry transfer lines have a design life of 5 years.

The positioning of isolation valves, which define the above-water slurry transfer line boundary, is controlled by the Conduct of Operations key attribute of the Operational Safety SMP. Above-water slurry transfer line isolation valves shall be inspected annually to verify that the valves are closed when so indicated by the associated valve position indicators.

5.6.2 Slurry Transfer Line Rupture Disk

The slurry transfer line rupture disk has two safety functions. The first safety function is to prevent the spray release of slurry by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer. The second safety function is to prevent a hydrogen explosion in the TLSB and In-Basin/Horizontal Shielded Hose Chase by preventing over-pressurization of slurry transfer lines during sludge retrieval and transfer.

The slurry transfer line rupture disk is located between the slurry transfer booster pumps and the Ingress/Egress Assembly. It is mounted on a skid that rests on the basin floor. The rupture disk is designed to relieve at a pressure of 115 psig, plus or minus 5 percent to provide adequate pressure relief for the slurry transfer line. A detailed description of the rupture disk and associated functional requirements and performance criteria are provided in Section 4.4.2, “Slurry Transfer Line Rupture Disk.”

The rupture disk is a passive mechanical device that opens in response to system pressure. The disk is not subject to configuration changes by Operations personnel. Characteristics of the disk were ensured through design and procurement. The in-service inspection is that the rupture disk shall be used within its design life. The rupture disk has a design life of 5 years.

5.6.3 Double-Valve Isolation Check Valve ECRT-CV-105

The safety function of double-valve isolation check valve ECRT-CV-105 is to prevent the spray release of slurry by preventing backflow into the TLSB IXM water supply line during sludge retrieval and transfer.

Double-valve isolation is provided to protect the interface between the slurry transfer line in the TLSB and the IXM water supply line. The valve pair consists of air-operated isolation valve ECRT-AOV-104 followed by check valve ECRT-CV-105, which is a swing-type check valve. A detailed description of valve ECRT-CV-105 and its associated functional requirements and performance criteria are provided in Section 4.4.3, “Double-Valve Isolation.”

Valve ECRT-CV-105 is a passive mechanical device that opens and closes in response to system pressure. The valve is not subject to configuration changes by Operations personnel. Characteristics of the valve were ensured through design and procurement. The in-service inspection is that check valve ECRT-CV-105 shall be used within its design life. The check valve has a design life of 5 years.
5.6.4 105KW Annex and Associated Structures, Systems, and Components

The 105KW Annex and associated SSCs have multiple safety functions related to preventing a spray release or hydrogen explosion caused by fires or natural phenomena hazards. The safety functions are listed below.

1. Prevent: (a) a fire-induced spray release of slurry during sludge retrieval and transfer, and (b) a hydrogen explosion by maintaining structural integrity in a fire.

2. Prevent: (a) a fire-induced spray release of slurry during sludge retrieval and transfer, and (b) a hydrogen explosion by preventing vehicle fuel spills from entering the 105KW Annex.

3. Prevent a hydrogen explosion by maintaining structural integrity during a seismic event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary.

4. Prevent a wind-induced hydrogen explosion in the STSC or STS Cask by withstanding applicable wind loads thereby preventing damage to the Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary.

5. Prevent a spray release of slurry during sludge retrieval and transfer by maintaining structural integrity during a snow and ashfall event.

6. Prevent a hydrogen explosion by maintaining structural integrity during a snow and ashfall event thereby preventing damage to the safety-significant Auxiliary Ventilation System, STSC boundary, and STS Cask pressure boundary.

7. Prevent a lightning-induced hydrogen explosion by maintaining structural integrity in a fire.

The 105KW Annex consists of the Sludge Loading Bay, the Mechanical Equipment Room, the High-Efficiency Particulate Air (HEPA) Filter Room, and the Interior Stair/Personnel Change Room. Part of the north wall of the Mechanical Equipment Room, and the entire north walls of the HEPA Filter Room and the Interior Stair area are formed from the south wall of the Sludge Loading Bay (see Chapter 2.0, Figures 2-4 and 2-5). The 105KW Annex is constructed of noncombustible materials in accordance with its IBC, Type IIB classification.

The 105KW Annex, including the Mezzanine and external stairs on the west side of the building, are conservatively designed to Seismic Design Category-2 seismic criteria. The 105KW Annex Mezzanine; bridge crane and associated supports; 105KW Annex exhaust stack; fire protection sprinkler system supports; heating, ventilation, and air conditioning duct supports; cable tray supports; hose cradles; South Tool Tray, and the nitrogen cylinder storage awning are also seismically qualified due to the potential for seismic interaction with safety SSCs. The 105KW Annex is designed to Performance Category (PC)-2 wind criteria. The 105KW Annex and horizontal shielded hose chase are designed to PC-3 snow and ashfall criteria.

The 105KW Annex design includes a concrete monolithic truck stop located immediately west of the parking location for the STS Trailer. This concrete truck stop provides a physical barrier that prevents the transport tractor fuel tanks from entering the building while the STS Trailer is being positioned. The apron outside the roll-up door is sloped away from the building to ensure
that fuel spills occurring adjacent to the entrance will gravity-drain away from the building. A detailed description of 105KW Annex, associated SSCs, and associated functional requirements and performance criteria are provided in Section 4.4.13, “105KW Annex and Other Structures.”

In support of the NPH-related safety functions, the 105KW Annex and associated SSCs will be inspected annually for signs of structural degradation.

5.6.5 Sludge Transport and Storage Container

The STSC design features have the following safety functions:

1. STSC Dimensions: Prevent a hydrogen explosion by protecting initial conditions assumed in the STSC thermal and gas analysis regarding the STSC dimensions.

2. STSC Sloped Fin: Prevent a hydrogen explosion in the STSC by limiting the volume of a vessel spanning bubble.

3. STSC Boundary: Prevent a hydrogen explosion in the STSC by maintaining an inert atmosphere in the STSC.

4. STSC Transport Vent Assemblies: Prevent STSC over-pressurization by venting pressure.

An STSC is approximately 10 ft tall and 5 ft in diameter with semi-elliptical heads top and bottom. The following nominal dimensions are used in thermal and gas analyses:

- STSC inside diameter of 58 in.
- 2:1 radius semi-elliptical top and bottom heads
- The overall vessel length is 104 7/8 in. from the vessel bottom to the top flange

These dimensions suffice to establish the internal volume of the STSC and the headspace volume in a loaded STSC when the water level is controlled as planned.

An STSC includes an engineered feature called the sloped fin. The sloped fin is T shaped in cross-section. The fin extends out at the base, on the bottom head, tapering towards the vessel wall 5 degrees from vertical to a point above the maximum sludge height. The fin is constructed of stainless steel and is welded in its intended position. The capability of a sloped fin to disrupt a vessel-spanning bubble is documented in PNNL-19345, The Disruption of Vessel-Spanning Bubbles with Sloped Fins in Flat-Bottom and 2:1 Elliptical Bottom Vessels.

The STSC boundary is composed of the following components:

- STSC
- Man-way flange on Nozzle F
- Flange and associated Camlock fitting and cap on Nozzle F1
- Flange and associated Camlock fitting and cap on spare Nozzle S1
- Overfill Recovery Tool on Nozzle D
- Radar level element/transmitter connected at Nozzle C
• LSH-740-402 connected at Nozzle E
• Self-sealing Stäubli quick disconnects, Transport Vent Assembly check valves, and associated Camlocks connected at Nozzles S2 and F2
• Sludge and decant connector interface spool assemblies, leak detectors, and flush and drain lines connected at Nozzles A and B and associated flanges

Once an inert atmosphere is established in an STSC, the STSC boundary prevents significant air inleakage until such time as the STS Cask is inerted.

When installed, the Transport Vent Assemblies function as part of the STSC boundary. Additionally, the assemblies function to prevent STSC over-pressurization. The assemblies include a check valve that opens to vent pressure created by hydrogen generated within the sludge.

Detailed descriptions of the STSC dimensions, sloped fin, boundary, and transport vent assemblies and associated functional requirements and performance criteria are provided in Section 4.4.8, “Sludge Transport and Storage Container and Transport Vent Assemblies.”

The STSC nominal key dimensions and sloped fin are not subject to configuration changes by Operations personnel. These STSC design features were ensured through design and procurement. The in-service inspection is that the STSC shall be used within its design life. The STSC has a design life of 30 years.

The STSC boundary is leak tested prior to the STSC being placed into service. For sludge retrieval and transfer and STSC inerting operations, process connections are made at Nozzles A, B, F1, F2, and S2. Upon completion of the STSC inerting operations, the process connections are removed and the STSC boundary is re-established. The in-service inspection for the flanges on Nozzles A and B, and the Camlock cap on Nozzle F1, is that prior to installation the associated O-rings and mating surfaces shall be inspected for damage or foreign materials.

The self-sealing Stäubli quick disconnects attached at Nozzles F2 and S2 form the STSC boundary for the short time interval between removal of the process hoses and insertion of the transport vent assemblies. Characteristics of the Stäubli quick disconnects were ensured through design and procurement. The in-service inspection is that the Stäubli quick disconnects shall be used within their design life.

The transport vent assembly check valves are passive mechanical devices that open and close in response to system pressure. The check valves are not subject to configuration changes by Operations personnel. Characteristics of the valves were ensured through design and procurement. The in-service inspection is that the transport vent assemblies shall be used within their design life.

5.6.6 STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes

The safety function of the STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes is to protect initial conditions assumed in the development of seismic response spectra for the top of the STSC.
The model used to calculate the seismic response spectra assumed that the STSC and STS Cask move together as a single assembly. The STSC Seismic Wedges are devices designed to limit independent motion of the STSC and STS Cask. The model also assumed that STS Trailer Seismic Dampener Shoes are placed under each landing gear footing. The shoes are credited in the analysis with dampening the impact of the STS Trailer front landing gear during seismic events.

The STSC Seismic Wedges are designed to be placed between the STSC and the STS Cask. Eight sets of wedges are distributed around the circumference of the STSC to occupy space between the STSC and the STS Cask. This prevents the STSC from moving out of sync with, and thus potentially hitting, the cask during a seismic event. The wedges are installed prior to the initial transfer of IXM water into the STSC, and are removed prior to STSC shipment to T Plant.

The STS Trailer Seismic Dampener Shoes consists of a stack of safety-significant impact-absorbing pads. The pads are contained within a general service cylindrical aluminum holder for ease of placement under the STS Trailer front landing gear. The impact absorbing pads are made of Nitrile. Individual pads are 0.5 inch thick, and the total stack height is 3.5 in. Detailed descriptions of the wedges and shoes and their associated functional requirements and performance criteria are provided in Section 4.4.8, “Sludge Transport and Storage Container and Transport Vent Assemblies.”

The positioning of STSC Seismic Wedges and STS Trailer Seismic Dampener Shoes is controlled by the Operational Safety (Conduct of Operations) Safety Management Program. The in-service inspection is that the wedges and shoes shall be used within their 5-year design life.

### 5.6.7 Sludge Transport System Cask Pressure Boundary

The safety function of the STS Cask pressure boundary is to prevent a hydrogen explosion by maintaining an inert atmosphere in an STS Cask.

The STS Cask is a right circular cylinder approximately 11 ft high and 6 ft in diameter. The cask is constructed of a 1-in.-thick stainless steel inner shell and 1.5-in.-thick stainless steel outer shell. The inner and outer shells are welded to a 6-in.-thick stainless steel bottom forging. At the top, the inner and outer shells are welded to a stainless steel upper forging. The approximately 3-in. annulus between the two shells is filled with lead for gamma radiation shielding. The STS Cask Lid, fabricated from 5-in.-thick stainless steel, is secured to the STS Cask upper forging with twenty-four, 1.5-in. diameter bolts. The cask has a bottom drain port in the shell, and two vent ports and a test port in the lid.

The STS Cask pressure boundary consists of the following:

- Inner shell
- Lower end forging
- Upper end forging
- Closure lid
• Metallic inner O-ring seal (for lid closure)
• Closure bolts and associated flat washers
• Vent and drain port plugs and associated metallic sealing elements

A detailed discussion of the STS Cask pressure boundary and associated functional requirements and performance criteria are provided in Section 4.4.9, “Sludge Transport System Cask Pressure Boundary, STS Cask Vent Tool, and STS Pressurization Check Tool.”

The capability of the STS Cask to maintain an inert atmosphere will be verified each time a cask is used by the performance of a leak rate test as described in Section 4.5.12, “Sludge Transport System Cask Leak Rate Limit.”

5.6.8 SCS-CON-230 Divider Plate

The safety function of the SCS-CON-230 divider plate is to protect initial conditions assumed in the safety basis analyses regarding the quantity of uranium metal in an STSC containing Settler Tank sludge.

A divider plate has been installed in the north end of Engineered Container SCS-CON-230 where a mound was formed during sludge transfer from the Settler Tanks to the container (see Chapter 4.0, Figure 4-10). The uranium metal concentration in the sludge within the mound is predicted to be higher than sludge in the surrounding area.

The divider plate accomplishes its safety function by separating the four north-end egg crates thus limiting the amount of sludge retrieved from adjoining egg crates when retrieving sludge from a given egg crate. The divider plate was constructed with guide plates and center notches to properly locate it within the engineered container such that two of the plates rest below the crest of the engineered container egg crates.

Significant movement of the plate during sludge retrieval is prevented by the engineered container walls and stiffening bars, and by the north-south plates being below the crest of the egg crates along with the center notches. The in-service surveillance is that the divider plate shall be used within its design life. The divider plate has a design life of 5 years.

5.6.9 Hoist Chain Stops

The safety function of the hoist chain stops is to protect the accident analysis assumption regarding material at risk during pre-operational testing and operational readiness activities by preventing the XAGO from being lowered into an engineered container.

A hoist chain stop is a simple mechanical device attached to the chain used to raise and lower a XAGO. The chain stop consists of a polyurethane stop block setting on a two-piece carbon steel casting. The chain stop is secured to the chain by two bolts and associated lock washers and nuts. The chain stop performs its safety function by physically preventing additional chain from being deployed by the hoist. A detailed description of the chain stops and associated functional requirements and performance criteria are provided in Section 4.4.15, “Hoist Chain Stops.”
The hoist chain stops are passive mechanical devices that are not subject to configuration changes by Operations personnel. Characteristics of the chain locks were ensured through design and procurement. The in-service inspection is that the chain locks shall be used within their design life.

To provide an additional layer of defense-in-depth, RL has directed that administrative controls be established controlling the XAGO location and Basin water motive force (see Section 4.5.16, “XAGO Pre-Operational Testing and Operational Readiness Controls”). These controls ensure that sludge will not be transferred should too much chain be deployed and the hoist chain stop fail.

5.7 Interface with TSRs from Other Facilities

STSCs generated by ECRTS are shipped to T Plant for interim storage using the STS. T Plant TSRs are documented in HNF-15280. Administrative Control 5.7.9, “Waste Acceptance Program (AC) – SWOC,” includes specific elements related to the receipt, handling, and storage of STS Casks and STSCs. Table 5-4 correlates the T Plant AC 5.7.9 elements to the 105KW Facility TSRs that establish and verify the credited conditions.

<table>
<thead>
<tr>
<th>T Plant AC Element</th>
<th>T Plant AC 5.7.9 Requirement</th>
<th>Corresponding 105KW Facility TSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSC fill volume</td>
<td>Fill volumes for newly received STSCs shall not exceed the following limitations:</td>
<td>LCO 3.3, Sludge Buoyant Weight Limits</td>
</tr>
<tr>
<td></td>
<td><strong>Table 5.7.9-1. STSC Fill Limitations</strong></td>
<td>Directive Action SAC 5.6.6, STSC Final Fill Liquid Levels</td>
</tr>
<tr>
<td></td>
<td><strong>STSC Sludge Composition</strong></td>
<td>Buoyant Weight Limit (Max kg)</td>
</tr>
<tr>
<td></td>
<td>Settler tank sludge layered with KE Sludge</td>
<td>≤ 720 kg (1,588 lb)</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-230</td>
<td>≤ 720 kg (1,588 lb)</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-240, -250, -260</td>
<td>≤ 960 kg (2,117 lb)</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-210</td>
<td>≤ 1,056 kg (2,329 lb)</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-220</td>
<td>≤ 789 kg (1,740 lb)</td>
</tr>
<tr>
<td></td>
<td>SCS-CON-240, -250, -260</td>
<td>≤ 1,260 kg (2,778 lb)</td>
</tr>
</tbody>
</table>

*Level in inches relative to STSC interior bottom

<table>
<thead>
<tr>
<th>STSC sintered metal filter vents</th>
<th>STSC shall have sintered metal vent filter assembly installed on ports F2 and S2 prior to receipt at T Plant</th>
<th>Operational Safety (Conduct of Operations) SMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>STP Purge</td>
<td>STP purge activities (inerting) for the STSC and STS Cask are verified complete prior to receipt at T Plant.</td>
<td>LCO 3.5, STSC and STS Cask Inerting</td>
</tr>
<tr>
<td></td>
<td>1. STSC was purge and oxygen concentration was less than 0.5 percent.</td>
<td>LCO 3.6, STS Cask Shipment Preparation</td>
</tr>
<tr>
<td></td>
<td>2. STS Cask was purged and oxygen concentration was less than 1.2 percent</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 6.0

Prevention of Inadvertent Criticality
## Contents

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6.0 Design for the Prevention of Inadvertent Criticality

6.1 Introduction

This chapter provides the facility-specific details of the criticality safety program for the 105-K West Facility (105KW Facility). Chapter 6.0 of HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, provides the general CHPRC-wide details of the criticality safety program, including program Key Attributes 6-1 through 6-5. These key attributes are considered safety basis commitments. Key Attribute 6-6, for criticality alarm systems, is not applicable to the 105KW Facility.


The 105KW Facility is classified as an Exempt Facility in accordance with the requirements of HNF-7098, Critical Safety Program. An Exempt Facility may contain greater than three percent of a minimum critical mass but a criticality is determined to be incredible (beyond extremely unlikely) due to the physical form and distribution of the fissionable material and controls are not required to protect the physical form and distribution. For criticality safety for firefighting purposes, the 105KW Facility is a Category A facility per the requirements of HNF-7098, which means that there is no possibility of criticality due to firefighting activities, specifically if water is used to fight fires. Firefighting methods are not restricted by criticality safety.

The 105-K West Basin (105KW Basin) was previously used to store and handle irradiated fuel from the N Reactor and to a lesser extent irradiated fuel from the older Hanford single-pass reactors. All the fuel stored in the 105KW Basin has been removed from the basin and was processed at the CVDF (142-K) and shipped to the Canister Storage Building for storage. Only sludge and residual amounts of fuel in the form of fuel fragments remain. The small amount of fuel fragments that have been found in the basin will be removed for analysis at a future date and will not be returned to the basin. The floor and pit sludge in the Center, East, and West Bays of the 105KW Basin has been loaded into Sludge Containerization System (SCS) engineered containers located in the Center Bay. The sludge in the Integrated Water Treatment System (IWTS) particulate settlers (also referred to as the settler tanks) has been retrieved and transferred into an SCS container; however, some residual sludge remains in the particulate settlers. Sludge from the former 105-K East (KE) Fuel Storage Basin is also stored in SCS containers in the East Bay.

The 105KW Basin is currently authorized for the storage of sludge in the engineered containers and in various components of the basin water system. Criticality safety analysis has been performed to support the removal of the sludge from the engineered containers into Sludge Storage and Transport Containers (STSCs) using equipment installed in the 105KW Basin proper and in the 105KW Annex.

The sludge storage and removal operations, and the operation of the basin water systems including the IWTS, were evaluated in CHPRC-02459, CSER 14-006: Criticality Safety Evaluation Report for Limited Fissile Material Operations at the K West Basin. In addition to the sludge removal operations, CHPRC-02459 allows for planned maintenance and modification
operations associated with the engineered containers while they contain sludge, transfer of strainer material to the engineered containers, canisters, the recovery, handling, and storage of found fuel and scrap (assumed to be no more than 10 kg total), removal of found fuel fragments from the 105KW Basin, the handling and storage of debris in the basin, and cleanup of any spills associated with these activities.

6.2 Requirements

The requirements that form the basis for criticality safety at the 105KW Facility are specified in documents listed in HNF-11724, Section 6.2 and are additionally found in HNF-7098.

6.3 Criticality Concerns

CHPRC-02459 determined that a criticality accident is not credible at the 105KW Facility given the current inventory and type of fissile material present. Sampling indicates that the sludge in the six engineered containers has a maximum enrichment of 0.71 g $^{235}$U/g U. The maximum plutonium content is 5.9 g Pu/L, which is only 63 percent of the concentration required for a criticality in ANSI/ANS 8.1-1998, Nuclear Criticality Safety in Operations with Fissionable Materials outside Reactors. A homogenous mixture of uranium and plutonium of this enrichment and concentration cannot be made critical.

CHPRC-02459 examined cases where inhomogeneous collections of material at higher enrichments may occur; several very conservative accumulations of material were investigated and found to be subcritical. Many conservative assumptions were made in the analysis:

- All of the material is collected into compact geometries.
- The fissile material was separated from the non-fissile materials present in the sludge.
- The metal portion of the sludge particles were completely separated from the oxide portion of the sludge.
- The metal particles were then compacted into cylindrical or hemispherical geometries.
- Optimal spacing was provided between metal particles to provide near optimal moderation.
- The fissile material densities far exceeded that of actual sludge characterization.
- The fissile material mass far exceeded the current inventory.

The above conservatisms were applied to the following basin activities to determine that there are no criticality concerns (i.e., a criticality accident is incredible):

- Storage, handling, and processing of sludge, including transfer of the sludge from the engineered containers to the STSCs via ECRTS.
- Sludge sampling, in which various probes or sampling devices may be inserted into sludge accumulations within the basin. This may apply to sludge in the engineered containers, to sludge that is loose in the basin, or to sludge contained in canisters.
- Recovery of sludge spilled during transfer, sampling, or other operations. Recovered sludge may be returned to an engineered container or placed into other containers including vacuuming into the IWTS.
- Handling of basin debris (e.g., abandoned equipment) which may contain small amounts of fissile material holdup.
- Handling of fuel fragments. Approximately 1 kg of such material is known to be in the basin. It is possible that additional fuel fragments will be found in the future. It is not considered credible for the total amount of fuel fragments to exceed 10 kg. The existing fragments are stored in canisters and any additional fragments that are found will be stored in canisters; however, the type of storage container is not important to criticality safety. The storage canisters may be moved and/or staged anywhere in the basin.
- Ion Exchange Module operation and disposal.
- Operation of the Basin Recirculation Cooling and Cleanup System and the IWTS. Note that the Basin Recirculation Cooling and Cleanup System has not been used for cooling basin water since the spent fuel was removed from the basin and may be deactivated. The cooling equipment is out of service and there are no plans to return it to service.

6.4 Criticality Controls

6.4.1 Engineering Controls
There are no engineering controls identified for criticality safety.

6.4.2 Administrative Controls
There are no direct administrative controls identified for criticality safety. It is assumed that no fissile material will be brought into the 105KW Basin, and introduction of fissile material into the basin is not allowed by this DSA.

6.4.3 Application of Double Contingency Principle
CHPRC-02459 demonstrated that a criticality accident, given the fissile material configuration and inventory in the 105KW Facility, is incredible. Therefore, double contingency does not apply.

6.5 Criticality Safety Program
The Criticality Safety Program is described in HNF-11724, Section 6.5, and its subsections:
- Section 6.5.1, “Criticality Safety Organization”
- Section 6.5.2, “Criticality Safety Implementation”
- Section 6.5.3, “Criticality Safety Training”
- Section 6.5.4, “Determination of Operational Nuclear Criticality Limits”
- Section 6.5.5, “Criticality Safety Inspections and Assessments”
- Section 6.5.6, “Criticality Nonconformance Reporting and Follow-up”

### 6.6 Criticality Instrumentation

HNF-11724, Section 6.6, “Criticality Alarm System,” describes the requirements for alarm systems at fissionable material facilities. The 105KW Facility is currently classified as an Exempt Facility and therefore a criticality alarm system is not required.
Chapter 7.0

Radiation Protection
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7.0 Radiation Protection

7.1 Introduction

This chapter provides the facility-specific, safety-related details of the Radiological Control Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 7.0, provides the general company-wide, safety-related details of the Radiological Control Program, including program Key Attributes 7-1 through 7-9. Together, this chapter and HNF-11724, Chapter 7.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 7.0. Key Attributes 7-1 through 7-9 are applicable to the 105KW Facility therefore, all Key Attributes of the Radiological Control Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

This chapter describes the safety policies, procedures, designs, and other considerations relative to radiation protection that maintain radiation exposures ALARA at the 105KW Facility. Credible radiological hazards are identified in Chapter 3.0 and are not described in this chapter. The Radiological Control Program elements described in this chapter are designed to minimize occupational exposures resulting from normal operations, as well as from accidents.

In those cases where policies, programs, and practices important to safe operation are described in detail in other documents, the information is summarized in this chapter and the documents are referenced. The detailed programs and procedures described in referenced documents supporting the authorization basis may be changed without further U.S. Department of Energy approval, to the extent that the changes do not constitute an Unreviewed Safety Question.

7.2 Requirements

The requirements that form the basis of the Radiological Control Program are identified in HNF-11724, Section 7.2.

7.3 Radiation Protection Program and Organization

The 105KW Facility Radiological Control Program and its organization, including safety management policies and philosophies, are described in HNF-11724, Section 7.3.

7.4 As Low as Reasonably Achievable Policy and Program

A summary discussion of the ALARA policy and program is provided in HNF-11724, Section 7.4.

7.5 Radiological Protection Training

Requirements and criteria for radiological protection training are described in HNF-11724, Section 7.5.
7.6 Radiation Exposure Control

Details of radiation exposure control measures are provided in HNF-11724, Section 7.6 and its subsections (Section 7.6.1, “Administrative Limits;” Section 7.6.2, “Radiological Practices;” Section 7.6.3, “Dosimetry;” and Section 7.6.4, “Respiratory Protection”).

7.7 Radiological Monitoring

The radioactive material sampling and monitoring programs conducted within Hanford facilities are addressed in HNF-11724, Section 7.7. The Radiological Control Program requires that radiological monitoring be performed to demonstrate compliance with radiological program requirements, document radiological conditions, detect changes in radiological conditions, detect gradual buildup of radioactive material, verify the effectiveness of controls, and identify and control potential sources of radiation.

7.8 Radiological Protection Instrumentation

A summary of the requirements for radiological protection instrumentation selection and placement criteria, calibration, and quality assurance for calibration and maintenance of radiation protection instrumentation is provided in HNF-11724, Section 7.8.

7.9 Radiological Protection Record Keeping

A summary of the radiological control record keeping requirements is provided in HNF-11724, Section 7.9.

7.10 Occupational Radiation Exposures

A summary discussion of the historic Hanford Site collective occupational dose and the calculated environmental exposure to the hypothetical maximally-exposed individual is provided in HNF-11724, Section 7.10.
Chapter 8.0

Hazardous Material Protection
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8.0 Hazardous Material Protection

This chapter provides the facility-specific, safety-related details of the Hazardous Material Protection Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 8.0, provides the general company-wide, safety-related details of the Hazardous Material Protection Program, including program Key Attributes 8-1 through 8-9. Together, this chapter and HNF-11724, Chapter 8.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 8.0. Key Attributes 8-1 through 8-9 are applicable to the 105KW Facility, therefore, all Key Attributes of the Hazardous Material Protection Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

8.1 Introduction

The hazardous materials present in the 105KW Facility and support facilities include both radiological hazardous materials and toxicological hazardous materials. However, hazardous substances or materials referred to in this chapter are those nonradioactive materials that pose a hazard to workers or to the public because of their chemical properties. Radiological controls and protection are covered in other chapters.

A basic response to hazardous chemicals is included in HNF-IP-0263-SNF, Building Emergency Plan for the 100 K Area.

8.2 Requirements

The requirements that form the basis for the hazardous materials protection program are identified in HNF-11724, Section 8.2. Requirements specific to the 105KW Facility are included in this chapter, as applicable.

8.3 Hazardous Material Protection Program and Organization

The 100K health and safety plan is implemented at the operable unit level by company and facility specific policies and procedures. A summary description of the Hazardous Material Protection Program is described in HNF-11724, Section 8.3.

The 100K Area Safety Organization facilitates the Chemical Management Program.

The 100K Area tool crib attendant and 100K Area facility personnel control the hazardous materials used and stored by 105KW Facility personnel.

8.4 As Low as Reasonably Achievable Policy and Program

While no established formal ALARA Program existed for nonradiological hazardous materials, the classic concept of ALARA (i.e., minimization of radiological exposures) has been expanded
to the application of exposure minimization for hazardous substances and conditions. This ALARA policy is described in HNF-11724, Section 8.4.

8.5 **Hazardous Material Training**

All 100K Area employees receive hazards communication or material training appropriate to their job functions. Plans and procedures for training 100K Area workers regarding hazardous materials are summarized in HNF-11724, Section 8.5.

8.6 **Hazardous Material Exposure Control**

Controls for hazardous materials include engineered controls and operational controls. The 105KW Facility has been designed/modified to incorporate engineered controls for contamination control, confinement, and barriers for personnel safety.

The 100K Area Industrial Safety and Industrial Hygienist organizations evaluate the health and safety hazards as part of the job hazard analysis process. They determine if engineering controls and work practices are feasible for protecting employees from the hazards they are likely to encounter.

CH2M HILL Plateau Remediation Company Occupational Safety and Health Programs and Policies contain standards for employee exposure to specific chemical hazards. The standards define management and personnel requirements and responsibilities for the safe handling of these chemicals. Further, they provide information on training, safe handling, concentration and contamination limits, medical surveillance programs, personal protective equipment, and emergency procedures.

8.6.1 **Hazardous Material Identification Program**

A summary description of the Hazardous Material Identification Program is provided in HNF-11724, Section 8.6.1. Nonradioactive material hazards are identified during work planning and analysis to determine if engineering controls and work practices are feasible for controlling exposure. The list of hazards is included in HNF-IP-0263-SNF. Materials are controlled through the warehouse and tool crib. The facility manager is responsible for maintaining an inventory listing of all hazardous material within the specific facility.

8.6.2 **Administrative Limits**

A summary discussion of the administrative limits to hazardous materials is provided in HNF-11724, Section 8.6.2. Workplace monitoring is performed before and during work activities when conditions can be reasonably expected to result in employee exposures equal to or greater than the prescribed action level.

Action level means a concentration calculated as an 8-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.
8.6.3 Occupational Medical Programs
A summary discussion of the occupational medical program is provided in HNF-11724, Section 8.6.3.

8.6.4 Respiratory Protection
A summary discussion of the respiratory protection program is provided in HNF-11724, Section 8.6.4.

8.7 Hazardous Material Monitoring
A summary discussion of the Hazardous Material Monitoring Program is provided in HNF-11724, Section 8.7. The 100K Industrial Hygienist evaluates job hazards, selects appropriate workplace monitoring instruments, and identifies appropriate air monitoring strategies for hazardous substances. The Industrial Hygienist establishes a program for monitoring individual employee exposure levels with other approved methods where direct reading instruments are not available.

8.8 Hazardous Material Protection Instrumentation
The 105KW Basin area has no routine chemical operations requiring alarm instrumentation.

The safety-significant Oxygen Analyzer used to prevent hydrogen explosions by measuring the oxygen concentration in the Sludge Transport and Storage Containers and Sludge Transport system Cask is described in Section 4.4.9, “Sludge Transport System Cask Pressure Boundary, STS Cask Vent Tool, and STS Pressurization Check Tool.”

The potential for nitrogen gas used by the Inert Gas System and Auxiliary Ventilation System to create an oxygen deficient atmosphere in the 105KW Annex Sludge Loading Bay is analyzed in PRC-STOP-CN-CH-00730, STP ECRTS - Nitrogen Leak and Oxygen Depletion Calculation for the Inert Gas System and Auxiliary Ventilation System. For a worst-case pipe break scenario wherein all of the nitrogen from 12 high pressure gas cylinders is released into the Sludge Loading Bay, the final oxygen concentration is 20.6 percent, which is greater than the Occupational Safety and Health Administration minimum requirement of 19.5 percent. Therefore, alarm instrumentation is not required.

The 105KW Basin area has no routine chemical operations requiring alarm instrumentation.

8.9 Hazardous Material Protection Recordkeeping
A summary discussion of Document Control and the Records Management Program is provided in HNF-11724, Section 8.9.

8.10 Hazard Communication Program
A summary discussion of the Hazard Communication Program is provided in HNF-11724, Section 8.10.
100K management, along with the appropriate work function groups, is responsible for developing, implementing, and maintaining a facility or group specific written Hazard Communication Program for the work areas, as necessary to fully implement requirements.

### 8.11 Occupational Chemical Exposures

A summary description of the Occupational Chemical Exposure Program is provided in HNF-11724, Section 8.11.
Chapter 9.0

Radioactive Hazardous Waste Management
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9.0 Radioactive and Hazardous Waste Management

9.1 Introduction

The capabilities for safely controlling, handling, and processing radioactive and hazardous wastes produced or encountered during normal operations and remedial actions at the 105-K West Facility (105KW Facility) are addressed in this chapter. Descriptions are also provided of the radioactive, hazardous, and mixed wastes, the applicable requirements and controls, and the 105KW Facility waste management program.

This chapter provides the facility-specific, safety-related details of the Radioactive and Hazardous Waste Management Program. HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 9.0, provides the general company-wide safety-related details of the Radioactive and Hazardous Waste Management Program, including program Key Attributes 9-1 through 9-6. Together, this chapter and HNF-11724, Chapter 9.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 9.0. Key Attributes 9-1 through 9-6 are applicable for the 105KW Facility therefore, all key attributes of the Generic Program are considered safety basis commitments. There are no additional key attributes required to address 105KW Facility specific hazards.

In addition to CHPRC implementing procedures for the key attributes, Key Attributes 9-2 and 9-6 are implemented by the following facility-specific procedures.

- 100K-PRO-WM-52463, Establishing/Modifying CERCLA Waste Management Area
- 100K-PRO-OP-50729, CERCLA Waste Staging Area Surveillance and Inspections
- 100K-PRO-OP-50939, Processing Contaminated Waste for ERDF Disposal K Basins and 142K
- 100K-PRO-OP-50944, CERCLA Waste Inventory Control

Radioactive wastes are solid, liquid, or gaseous materials of no or low economic value that contain radionuclides. Hazardous wastes are nonradioactive wastes that pose a hazard to workers or the public due to their chemical properties. Hazardous wastes are defined as solid wastes that exhibit any of the characteristics of hazardous waste identified in 40 CFR 261, “Identification and Listing of Hazardous Waste.” Mixed wastes contain both radioactive and hazardous components, as defined by the Atomic Energy Act of 1954 and the Resource Conservation and Recovery Act of 1976 (RCRA). In Washington State, the RCRA Program is administered through the Washington State Department of Ecology, and the requirements are specified in WAC 173-303, “Dangerous Waste Regulations.” Radioactive, hazardous, and mixed wastes occasionally are generated as part of a maintenance activity or decontamination and decommissioning, and at all 100K facilities, including the 142-K Building.

As wastes from the operation of the 105KW Facility are generated, they are managed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as specified by the CERCLA process, only the substantive requirements of the regulations cited in the previous paragraph apply.
HNF-4747, 100K West Basin Deactivation Health and Safety Plan, provides a description of general work in and around the basin and describes industrial hazard mitigation and control.

9.2 Requirements

The requirements and basis for the Radioactive and Hazardous Waste Management Program are identified in HNF-11724, Section 9.2.

9.3 Radioactive and Hazardous Waste Management Program and Organization

The facility administrative procedures for solid waste management contain the procedural guidance for the planning, generation, and disposal of generated waste in compliance with applicable requirements. The administrative procedures cover characterization, preplanning, designation, containerization, disposal, and programmatic requirements. A summary of the Waste Management Program is provided in HNF-11724, Section 9.3.

9.4 Radioactive and Hazardous Waste Streams and Sources

The liquid, gaseous, and solid wastes produced by 105KW Facility operations are addressed in the following subsections. Additional programmatic details are discussed in HNF-11724, Section 9.4, and its subsections.

9.4.1 Liquids

9.4.1.1 105KW Basin Liquid Leaks

No radioactive liquid is deliberately discharged from the basin. An asphalt membrane was installed beneath the 105KW Basin during the original construction. This membrane was intended to collect any basin leakage and divert it to a tile drainage field. The diversion line has been intercepted and connected to a sump. Any leakage collected will be pumped from the sump back into the basin.

Periodic basin water level trending is used to provide an indication of basin water loss. Seven groundwater monitoring wells located around the 105KW Basin provide a means to determine if any of the monitored constituents have increased.

Discharges to the Columbia River have ceased and the National Pollutant Discharge Elimination System permit has been cancelled.

9.4.1.2 Other Radioactive Liquid Wastes

Radioactive liquid wastes other than contaminated water (e.g., potentially contaminated oil) are packaged and disposed of in accordance with approved procedures at site disposal facilities. Waste handling activities at the 100K Area may include inspection, sampling, and other activities needed to characterize the waste. Waste may be repackaged as needed to meet radiological and environmental requirements associated with waste acceptance criteria of the receiving facility.
9.4.2 Gaseous Waste

Gaseous waste is exhausted from the 105KW Basin through operating roof vents, a vent from the IWTS, and from the Sand and garnet filters. The radiological emissions for a year are not to exceed a dose of 10 mrem to the maximally exposed individual. Emissions are primarily of $^{60}$Co, $^{137}$Cs, $^{90}$Sr, $^{241}$Am, and plutonium isotopes. Offsite and onsite doses are within all limits of DOE O 458.1, *Radiation Protection of the Public and the Environment*, and 40 CFR 61, “National Emission Standards for Hazardous Air Pollutants.”

Table 9-1 shows the airborne radioactive material releases from the 105KW Basin for calendar year 2013.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Release (Ci)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{90}$Sr</td>
<td>2.9E-6</td>
</tr>
<tr>
<td>$^{137}$Cs</td>
<td>3.4E-6</td>
</tr>
<tr>
<td>$^{154}$Eu</td>
<td>2.4E-8</td>
</tr>
<tr>
<td>$^{238}$Pu</td>
<td>2.5E-7</td>
</tr>
<tr>
<td>$^{239/240}$Pu</td>
<td>1.6E-6</td>
</tr>
<tr>
<td>$^{241}$Pu</td>
<td>1.0E-5</td>
</tr>
<tr>
<td>$^{241}$Am</td>
<td>1.5E-6</td>
</tr>
</tbody>
</table>


Gaseous waste is exhausted from the 105KW Annex Exhaust Stack. An exhaust stack monitoring system will be used for securing representative samples of the facility’s emissions in accordance with 40 CFR 61, and WAC 246-247, “Radiation Protection – Air Emissions.” The Air Monitoring Plan for the 105KW Annex is DOE/RL-2010-63-ADD1, *Remedial Design/Remedial Action Work Plan for the K Basins Interim Remedial Action: Removal of K Basins Sludge from the River Corridor to the Central Plateau; and Removal of Knock-Out Pot Contents from the K Basins.*

9.4.3 Solids

9.4.3.1 Spent Ion Exchange Modules

Spent Ion Exchange Modules are disposed of in accordance with approved procedures at site disposal facilities.

9.4.3.2 Low-Level Radioactive Solid Waste

Low-level waste is packaged and disposed of in accordance with approved procedures at the site disposal facilities, in accordance with the waste acceptance criteria of the receiving facility. Hazardous and mixed (hazardous and radioactive) wastes that are managed under CERCLA are addressed in Section 9.4.3.3. Hazardous and mixed (hazardous and radioactive) wastes that are not managed under CERCLA (non-CERCLA waste) are addressed in Section 9.4.3.5.
9.4.3.3 Hazardous and Mixed Waste (CERCLA)

In accordance with the waste acceptance criteria of the receiving facility, mixed waste (per HNF-EP-0063, Hanford Site Solid Waste Acceptance Criteria, Section 4.0) is transferred in a timely manner to a treatment, storage, and disposal facility authorized under CERCLA. Typically this waste is sized to fit in a 55-gal drum for disposal. The 105KW Facility historically does not generate a large volume of mixed waste.

9.4.3.4 Transuranic Waste

Transuranic (TRU) wastes require specialized information for disposal. These wastes also require more rigorous packaging for TRU waste to be stored at the Central Waste Complex or T Plant. K Basin sludge, including fuel particles up to 0.25 in. in diameter, is considered remotely-handled TRU waste. K Basin sludge is designated a Toxic Substances Control Act of 1976-regulated TRU waste because of the presence of polychlorinated biphenyl.

9.4.3.5 Non-Regulated Waste

Most bulk oils at the 105KW Facility are non-regulated, and small quantities are recycled if possible or disposed of.
Chapter 10.0

Initial Testing, In-Service Surveillance, and Maintenance
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10.0 Initial Testing, In-Service Surveillance, and Maintenance

10.1 Introduction
This chapter provides the facility-specific, safety-related details of the Initial Testing, In-Service Surveillance, and Maintenance Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 10.0, provides the general company-wide safety-related details of the Initial Testing, In-Service Surveillance, and Maintenance Program, including program Key Attributes 10-1 through 10-6. Together, this chapter and HNF-11724, Chapter 10.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 10.0. Key Attributes 10-1 through 10-6 are applicable to the 105KW Facility; therefore, all Key Attributes of the Initial Testing, In-Service Surveillance, and Maintenance Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

10.2 Requirements
The requirements that form the basis for the Initial Testing Program, the Operational Readiness Review Program, the In-Service Surveillance Program, and the Maintenance Program are identified in HNF-11724, Section 10.2.

10.3 Initial Testing Program
The 105KW Facility Initial Testing Program ensures the operability of equipment and facilities before facility operation. A summary discussion of the initial testing program is provided in HNF-11724, Section 10.3.

All cranes and hoists are inspected, maintained, and tested in accordance with DOE/RL-92-36, Hanford Site Hoisting and Rigging Manual.

Nonconforming items are documented and corrected via quality assurance nonconformance records. Records of the test program are kept in accordance with the guidance of PRC-PRO-IRM-10588, Records Management Processes.

As part of the normal facility operation, equipment is inspected and maintained according to practices outlined in the 105KW Facility operating and surveillance procedures. The design for projects included acceptance test procedures that demonstrate the ability of the project to function as designed. As part of the normal facility operation, equipment is inspected and maintained according to practices outlined in the 105KW Facility operating and surveillance procedures.

The overall testing and demonstration strategy for Sludge Treatment Project Engineered Container Retrieval and Transport System entail six major activities.

1. Integrated process optimization demonstration (IPOD) and Mux IPOD
2. Risk Reduction Activities
3. Operator Training and Procedure Development
4. Factory Acceptance Testing (FAT)
5. Pre-Operational Acceptance Testing (PAT), which includes MPAT, Construction Acceptance Testing (CAT) and KPAT which will include an integrated systems acceptance test
6. Operational Acceptance Testing (OAT)

Descriptions of each major activity are provided in PRC-STP-00777, *Test and Demonstration Strategy for the Sludge Treatment Project Engineered Container Retrieval and Transfer System*.

### 10.4 In-Service Surveillance Program

The 105KW Facility In-service Surveillance Program is designed to maintain the integrity of the 105KW Facility systems to ensure that the systems perform their function of protecting the health and safety of the public, workers, and facility staff. Some facility equipment and system in-service surveillances are performed to ensure that performance requirements are met, as defined in the facility Technical Safety Requirements discussed in Chapter 5.0 of this document. A summary discussion of the In-service Surveillance Program is provided in HNF-11724, Section 10.4. Facility records, including in-service surveillance programs, inspections, disposition of degraded conditions, procedures and qualifications, are retained in accordance with the guidance of CH2M HILL Plateau Remediation Company Management Systems. Personnel performing in-service surveillances are to meet the requirements of the appropriate industry standard (SNT-TC-1A, *Recommended Practice)*.

### 10.5 Maintenance Program

A summary discussion of the Maintenance Program is provided in HNF-11724, Section 10.5.
Chapter 11.0

Operational Safety
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11.0 Operational Safety

11.1 Introduction

This chapter provides the facility-specific, safety-related details of the Operational Safety Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 11.0, provides the general company-wide, safety-related details of the Operational Safety Program, including program Key Attributes 11-1 through 11-8. Together, this chapter and HNF-11724, Chapter 11.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 11.0. Key Attributes 11-1 through 11-7 are applicable to the 105KW Facility); therefore, all Key Attributes of the Operational Safety Program are considered safety basis commitments.

The following additional Key Attributes are required to address 105KW Facility specific hazards:

- 105KW Annex Key Attribute 11-10: Maintain a 30-ft defensible space (firebreak) around the 105KW Annex.

11.2 Requirements

The requirements that form the basis for conduct of operations and general aspects of operational safety are identified in HNF-11724, Section 11.2.

11.3 Conduct of Operations

“Conduct of Operations” is a set of principles that establishes an overall philosophy for achieving excellence in the operation of 100K Area Decontamination & Decommissioning Project facilities. A summary of “Conduct of Operations” is provided in HNF-11724, Section 11.3.

Elements of the conduct of operations principles that are major contributors to safety performance at the 105KW Facility are summarized in the following subsections or elsewhere in this Documented Safety Analysis (e.g., control of procedures and training is addressed in Chapter 12.0, and the operating contractor’s process for handling events is discussed in Chapter 17.0). The U.S. Department of Energy, Richland Operations Office-approved Conduct of Operations Graded Approach Applicability Matrix identifies the aspects of each principle that apply and the corresponding operating or administrative procedure that implements the principle [CHPRC-00192, Decommissioning Waste, Fuels, and Remediation Services (DWF&RS) Conduct of Operations Applicability Matrix]. The matrix is developed and approved by DOE in accordance with PRC-PRO-OP-696, Conduct of Operations.
11.4 Fire Protection

A summary of the Fire Protection Program applicable to the 105KW Facility is provided in this section and in subsequent subsections of HNF-11724. The 105KW Facility Fire Protection Program is implemented by 100K-PRO-FP-50757, Fire Protection Program, and 105KW Facility administrative procedures. The results of the analyses pertinent to nuclear safety identified by HNF-SD-SNF-FHA-001, Fire Hazards Analysis for the 105-KW Facility (FHA), are addressed in Chapter 3.0 of this document and are summarized in the following subsections.

11.4.1 Fire Hazards

The FHA documented in HNF-SD-SNF-FHA-001 was developed in accordance with applicable DOE guidelines, as well as, site-wide requirements. The FHA addresses fire hazards or fire-related concerns in accordance with Contractor Requirements Document (CRD) O 420.1C, Facility Safety, for the 105KW Facility. It is intended to comprehensively assess the risk from fire to ensure that there are no undue fire hazards to site personnel, the public, and the environment, that the potential for the occurrence of a fire is minimized, that process control and safety systems are not damaged by fire or related perils, and that property damage from fire and related perils does not exceed an acceptable level.

The FHA is structured in accordance with CRD O 420.1C and evaluates the K Basins’ facilities to ascertain that the objectives of this CRD are met.

An analysis of the consequences of fire scenarios for the 105-KW Building concludes that there are two bounding maximum possible fire loss events. The first fire would occur in and be confined to the Transfer Bay area. This event could occur from either a diesel-fuel fire or a fire involving combustible waste. The second event is a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste staging area fire. The splash/splatter release initiated fire produces the largest potential monetary loss in the 105KW Annex. This fire although largest potential monetary loss, does not represent the largest potential fire event. The largest potential fire in the 105KW Annex in terms of fire size is the transporter tire fire.

A discussion of the scenarios is provided in Chapter 7.0 of the FHA (HNF-SD-SNF-FHA-001).

11.4.2 Fire Protection Program and Organization

The CHPRC Fire Protection Program is described in PRC-STD-FP-40404. This program implements the requirements of CRD O 420.1C.

The objectives of the Fire Protection Program include minimizing the potential for:

- Occurrence of a fire or related event.
- Fires that cause an unacceptable onsite or offsite release of hazardous or radiological material that could impact the health and safety of employees, the public, or the environment.
- Unacceptable interruption of vital RL programs as a result of fire and related hazards.
- Property loss from fire exceeding the limits established by RL.
• Fire damage to critical process controls and safety-class SSCs (as documented by appropriate safety analysis).

Additionally, the Fire Protection Program protects:

• The safety of workers commensurate with the nature of the work that is performed complete with appropriate facility and sitewide systems for fire suppression, fire alarm notification, and life safety features.

• Property to include the fire protection and fire suppression capabilities sufficient to minimize losses from fire and related hazards consistent with highly protected risk status in private industry.

Implementation of the Fire Protection Program by CHPRC includes employing a qualified fire protection engineering staff to ensure that requirements of the Fire Protection Program are incorporated and documented in site operations, including present and future missions. The staff may function both as Deputy Fire Marshals to govern statutory requirements as well as engineering consultants to assist CHPRC Projects in creating and maintaining a fire safe environment through minimization (or elimination) of hazards, provision of appropriate engineered controls, use of safe practices, and implementation of compensatory measures, as required.

The Fire Protection Program for the 105KW Facility, as documented in 100K-PRO-FP-50757, meets the requirements identified in CRD O 420.1C, and is structured and implemented in accordance with CHPRC’s safety management policies, philosophies, and criteria identified in the 105KW Facility administrative procedures. CRD O 420.1C requires an administrative program that provides a level of fire protection that fulfills the requirements for the best-protected class of industrial risks.

The 100K Fire Protection Program is managed by the 100K Area Engineering Organization. A qualified fire protection engineer is maintained on staff. The fire protection engineer is responsible for developing the Fire Protection Program in accordance with CRD O 420.1C. The fire protection engineer is also responsible for performing fire protection document reviews, providing technical assistance to the 100K Area projects and facilities for fire protection program implementation, and performing fire protection facility assessments and FHAs.

The Mission Support Alliance Fire Protection Systems Inspection and Maintenance Group is responsible for fire protection systems testing, inspection, and repair services. The Hanford Fire Department is responsible for fire suppression, emergency rescue, and medical response.

A wet-pipe sprinkler system is installed in the 105KW Facility administrative areas. The 105KW Annex is fully protected by a wet-pipe automatic fire suppression system. The normal water supply to the facility fire protection systems is the service water system. The 100K fire water utilities system provides an acceptable degree of protection and reliability in accordance with the appropriate guidance. A part of this system includes a 750,000-gal tank that is located near the 189-K Water Treatment Facility in the southwest corner of the 100K Area. This tank is sized to provide water for fire suppression (360,000 gal), emergency basin make-up (180,000 gal), and up to 24 hours of potable water demand at a nominal rate of 50 gal/min. The fire protection alarm system is part of the Hanford Fire Department Radio Fire Alarm Reporter.
reporting system. Further information on the fire protection system is provided in Section 2.7.4 of this document.

For the 105KW Facility, life-safety criteria are met as required by NFPA 101, *Life Safety Code*\(^{30}\), except that the egress emergency lighting requirements of NFPA 101 are not fully implemented in the basement areas of the 105-KW Building because these areas are not normally occupied. However, fire extinguishers are available and positioned and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

### 11.4.3 Combustible Loading Control

Hazards associated with flammable and combustible materials are discussed in HNF-SD-SNF-FHA-001, Chapter 7.0. Relatively small amounts of combustible materials, plus varying amounts of transient combustibles, will be present during normal operational activities. Fire retardant wood is used when required. Consistent with sound fire protection practice, combustibles will be controlled and limited to quantities ALARA. The primary concern is associated with combustibles in the immediate vicinity of certain structural members. In order to keep the combustibles within the bounds of the analysis done for the FHA, the 100K Area Fire Protection Program includes controls for combustibles (including separation distances) and describes methods for determining the maximum combustible loads that can be introduced without compromising structural integrity. A fire that damages the Process/Exhaust Ventilation System is a potential initiator for a hydrogen explosion. Combustible controls are in place to minimize the probability of such a fire.

The 100K Area Fire Protection Program also includes combustible controls (including separation distances) for the exterior CERCLA Waste Staging Areas to limit the number of waste packages potentially involved in a fire.

The office area contains amounts and types of combustibles consistent with an office occupancy. Based on operation of the office-area sprinkler system, fires associated with these combustibles do not have a significant impact on building structural integrity.

### 11.4.4 Vehicle Separation Distance

The Fire Protection Program specifies separation distances for vehicles external to the 105KW Facility to prevent structural damage from an external fire as documented in HNF-SD-SNF-FHA-001. Separation distances are established for the 105KW Annex, the north exterior wall of the 105KW Basin, and the north exterior wall of the Transfer Bay. As an alternative to separation, installation of a physical barrier (e.g., berm or grade slope away from the wall) to maintain minimum separation of 1 m (3.28 ft) between the perimeter of a spill pool and the north exterior wall of the Transfer Bay and/or Basin superstructure is acceptable.

### 11.4.5 Firefighting Capabilities

A fire alarm system that meets the applicable requirements of NFPA 72, *National Fire Alarm and Signaling Code*, has been installed throughout the normally occupied areas of the

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105KW Building. Manual pull stations are provided at primary exits and along the paths of egress. The fire alarm features include transmission of signals to the HFD via a radio fire alarm reporter box. Fire alarm annunciating devices are provided for occupant notification.

A fire brigade is not required at the 105KW Facility due to the nearby presence of the HFD. The standard response to an alarm condition in the 100K Area is by the HFD from the 100 Area Fire Station. The HFD response time from the 100 Area Fire Station to the 105KW Facility is approximately 5 to 10 minutes. A crew from the 200 Area Fire Station can be dispatched simultaneously, with an estimated response time of 15 to 20 minutes. These are the response times and the responder locations assumed in HNF-SD-SNF-FHA-001. Vehicle access to the 105KW Facility is provided by a paved access road. The HFD is fully staffed, trained, and equipped for emergency response.

The HFD is responsible for training its employees, including response personnel, test and services fire fighters, and system maintenance craft personnel. These training programs have been designed to meet National Fire Protection Association and CRD O 420.1C criteria. HFD members are trained to respond to events that occur in radiological and hazardous material environments.

11.4.6 Firefighting Readiness Assurance

Facility personnel are trained on the expected actions to be taken in case of a fire. Personnel are expected to notify the HFD, evacuate the facility, and follow approved fire response plans specific to the facility.

A pre-incident plan for the 105KW Facility has been prepared by the HFD.

11.4.6.1 Fire Prevention

The Hanford Site Fire Marshal is responsible for preparing and managing a fire prevention program in accordance with the requirements of NFPA 1, Fire Code. This program includes a requirement for periodic facility tours and inspections, performed by the HFD, to help ensure that emergency responders have current information on the conditions at the site as they might impact emergency response and access and helps ensure that adequate fire prevention and life safety conditions are being maintained to identify potential fire hazards. The tours and inspections are intended to accomplish the following:

- Familiarize incident responders of facility/area conditions, processes, and hazards to help ensure a safe, effective emergency response.
- To verify/validate the accuracy and adequacy of the facility/area Pre-incident Plans.
- To identify fire safety issues that may need correction to facility management personnel for proper action.
- To verify emergency access for response personnel.

Written inspection findings are provided to the facility manager, who is assigned responsibility for identifying and implementing corrective actions.
11.4.6.2 Fire Protection Recordkeeping

Records of fire protection system testing, inspection, and maintenance performed by the HFD are maintained by the HFD Manager, Fire Protection Systems Administration and Testing. Other fire protection records for activities that are the Building Manager’s completion responsibility (i.e., fire extinguisher inspections, fire barrier inspections, fire surveillance logs) are maintained by facility management.
Chapter 12.0

Procedures and Training
## Contents

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12.0 Procedures and Training

12.1 Introduction

This chapter provides the facility-specific safety-related details of the Procedures and Training Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 12.0, provides the general company-wide safety-related details of the Procedures and Training Program, including program Key Attributes 12-1 through 12-6. Together, this chapter and HNF-11724, Chapter 12.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 12.0. Key Attributes 12-1 through 12-6 are applicable to the 105KW Facility; therefore, all Key Attributes of the Procedures and Training Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

12.2 Requirements

The requirements that form the basis for the 105KW Facility procedures and training programs are identified in HNF-11724, Section 12.2. The documents and standards that form the basis for the Procedures and Training Program are found in DOE O 422.1, Conduct of Operations, and DOE O 426.2, Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities. Other more specific requirements are referenced as applicable in this chapter.

12.3 Procedure Program

105KW Facility activities are conducted in accordance with written procedures. A summary of the Facility Procedures Program, including development and maintenance of procedures, is provided in HNF-11724, Section 12.3, and its subsections and additionally in PRC-PRO-MS-589, CH2M HILL Plateau Remediation Company Procedures.

All 105KW Facility Managers are responsible for the content and accuracy of the administrative and technical procedures that support their organization. The 105KW Facility Procedures Organization will develop, control, and maintain the procedures used at the 105KW Facility.

12.3.1 Development of Procedures

HNF-11724, Section 12.3.1, provides a summary of the development of procedures.

12.3.2 Maintenance of Procedures

HNF-11724, Section 12.3.2, provides a general discussion of the maintenance of procedures.

12.3.3 Training Program

The objective of the Personnel Training Program is to provide and maintain a qualified work force for safe and efficient facility operations. A summary of the training program is provided in HNF-11724, Section 12.4, and its subsections.
PRC-STD-TQ-40201, *CH2M Hill Plateau Remediation Company Training Implementation Matrix*, per DOE O 426.2 for the 105KW Facility, has been approved by DOE.
Chapter 13.0

Human Factors
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13.0 Human Factors

13.1 Introduction

This chapter provides the facility-specific safety-related details of the Human Factors Program for the 105-K West Facility (105KW Facility). HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Program*, Chapter 13.0, provides the general company-wide safety-related details of the Human Factors Program, including program Key Attributes 13-1 and 13-2. Together, this chapter and HNF-11724, Chapter 13.0, meet the requirements of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chapter 13.0. Key Attributes 13-1 and 13-2 are applicable to the 105KW Facility); therefore, all Key Attributes of the Human Factors Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

Human factors engineering (HFE) is important in assuring the safe operation of the 105KW Facility. This chapter identifies appropriate HFE requirements and describes the process used to incorporate these requirements into the 105KW Facility.

Assessment teams have conducted hazard analyses (HA) to identify potential hazards to the facility operator, collocated personnel, the public, and the environment. Hazardous conditions associated with basin operations are identified in DD-53838, *105-KW Basin Streamline Hazards Analysis*. The hazardous conditions associated with ECRTS are identified in PRC-STP-00687, *Sludge Treatment Project Engineered Container Retrieval and Transfer System Hazard and Operability Study*, and PRC-STP-00697, *Sludge Treatment Project Engineered Container Retrieval and Transfer System Hazard Analysis Supplement 1*. Hazards were analyzed based on energy source and material, and established “defense-in-depth (DID) or worker safety features” were presented. The HA included an analysis of hazards during normal and abnormal operation (e.g., human errors and equipment failures) and accident conditions that potentially could occur. Chapter 3.0 of this DSA describes the HA methodology and summary of results.

This chapter shows that human factors were considered throughout the design process for the 105KW Facility and other subprojects. Human factors issues identified during these evaluations and have been resolved. The formality and the extent of the systematic inquiry into the human factors associated with the 105KW Facility were determined based on the extent of human interaction, the system design effort, and the risk associated with human performance failures.

13.1.1 Description of Facility Purpose

The 105KW Basin Sludge Treatment Project Engineered Container Retrieval and the ECRTS subprojects have been evaluated for HFE requirements.

ECRTS will be used to retrieve sludge from the engineered containers in multiple batches and pumped through HIH transfer line to a Sludge Transport and Storage Container (STSC) located in the 105KW Annex.

Additional details of ECRTS are provided in Chapters 2.0, 3.0, and 4.0 of this DSA.
13.2 Requirements
The requirements that establish the basis for HFE are identified in HNF-11724, Section 13.2.

13.3 Human Factors Processes
See HNF-11724, Section 13.3, for a description of the human factors process applicable to the 105KW Facility. The 105KW Basin was originally designed and constructed in the early 1950s for K Reactor spent nuclear fuel (SNF) storage. The basin was modified in the 1970s to store N Reactor spent fuel elements. No formal HFE program review was required; however, HFE program elements were applied to design and operation aspects. Graded approach factors applicable to the 105KW Basin prior to modifications for SNF removal are as follows:

- Facility structure is more than 40 years old
- Basin systems are 8 to 23 years old
- Support systems are 20 to 40 years old
- Pre-existing quantity, form and location of hazardous material (sludge in engineered containers)

13.3.1 Process Background
105KW Basin HFE considerations are commensurate with the following:

- Planned 105KW Facility mission
- Hazard Category 2 Nuclear Facility classification
- Complexity of the 105KW Basin SSCs
- Level and type of human interfaces with the SSCs and the 105KW Basin processes

The ECRTS process was reviewed from the Human Factors perspective as documented in PRC-STP-00506, STP ECRTS Human Factors Value Management Study. Detailed comments were captured in the project database for resolution. These comments were resolved during design development and full scale concept testing at the MASF.

13.4 Identification of Human–Machine Interfaces
A process for identifying human-machine interface (HMI) is provided in HNF-11724, Section 13.4. This section of the DSA summarizes the SSCs that require HMI to function. Significant HMIs that are pertinent to the operation of the 105KW Facility are also discussed. The intent during design was to reduce the HMI as much as possible at the 105KW Facility. The systems are designed to run very efficiently in either manual or automated state; however, operator input (e.g., providing permission for the system to move from one process to the next process) ensures that the system is maintained under operator control through all processes and keeps the operator involved at critical stages of the process operation. The operator will also monitor system operation. When there is an off-normal occurrence, the operator physically checks the discrepant part of the system. Periodic inspection of the system and routine periodic maintenance will also be required.
The structured approach to human factors engineering for ECRTS is described in PRC-STP-00506. As part of this study, the project conducted a human-factors review using guidance from DOE-HDBK-1140-2001, *Human Factors/Ergonomics Handbook for the Design for Ease of Maintenance*. This review included a facilitated session attended by representatives from Sludge Treatment Project (STP) ECRTS Engineering, Design, STP Radiological Control, Basin Nuclear Chemical Operators, STP Industrial Safety, MASF Testing, and STP Nuclear Safety.

PRC-STP-00506 documented the results of this session. Review comment records were used to document comments that were addressed during the final design phase. These comments fell into the following broad categories:

- Revised control panel arrangement and control parameters and relocated controls
- Improved access for operations and maintenance
- Enhanced contamination control
- Facilitation of maintenance and repair
- Easier determination of valve operation and positioning and flow within boxes.

### 13.5 Optimization of Human–Machine Interfaces

A general discussion on the Human Factors Program is provided in HNF-11724. In considering the optimization of HMI, human involvement was reduced to the minimum levels necessary to ensure complete facility safety. The staffing levels, training, special tools required, human-computer interface, and response to equipment failures all consider human interfaces. Optimized alarms allow the human operators to quickly and accurately identify the condition generating the alarm and to determine the next course of action.

The layout and design of controls, instruments, and provisions for labeling that apply the principles of ergonomics and human engineering were evaluated using the applicable INEL-95/0117, *Human Factors Engineering Checklists for Application in the SAR Process*, checklists. With input from the checklists and interviewing operators, the HMI process provides for effective design.

Consideration is given to minimum staffing levels, training, and periodic maintenance; these considerations are described in Section 13.5.2.

The work environments meet general operating HFE environmental design criteria, based on available calculated engineering design requirements and comparison of the results to existing criteria found in the HFE standards and checklist.

Temperature, humidity, and other environmental conditions are discussed in Chapter 2.0 of this DSA and in the system design description for the HVAC system. The available calculated values and available design information from system design descriptions were compared to DOE-STD-1062-94, *Ergonomics and Human Factors Engineering Design Criteria*, as captured in INEL-95/0117. The HFE checklist examines temperature, humidity, ventilation, noise, illumination, and other factors impacting operations during normal operations, including routine periodic maintenance.
13.5.1 Normal Operations

These human factors studies document the tabletop task analysis, systems reviews, direct interviews with design authorities and cognizant engineers, and reviews of applicable design documentation. The INEL-95/0117 checklists are used to supplement the task analyses, interviews, and design documentation reviews.

13.5.2 Staffing and Training

13.5.2.1 Operator Capabilities

The skills, knowledge, and abilities needed to meet job standards are defined to ensure that personnel have the appropriate capabilities to perform the required activities in a safe and reliable manner. Qualification criteria define the experience, education, and training required to perform a designated job.

13.5.2.2 Staffing Levels

A staffing plan currently exists for the 105KW Facility. A review of this plan indicates that appropriate consideration was given to the following:

- Learning curves
- Loss of trainees throughout the process
- Appropriate job titles and functions for Operations personnel

Because the design of the systems minimizes HMI, staffing levels are not expected to be significant.
Chapter 14.0

Quality Assurance
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14.0 Quality Assurance

14.1 Introduction

This chapter provides the facility-specific safety-related details of the Quality Assurance Program (QAP) for the 105-K West Facility (105KW Facility). HNF-11724, *CH2M HILL Plateau Remediation Company Safety Management Program*, Chapter 14.0, provides the general company-wide safety-related details of the QAP, including program Key Attributes 14-1 through 14-9. Together, this chapter and HNF-11724, Chapter 14.0, meet the requirements of DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Chapter 14.0. Key Attributes 14-1 through 14-9 are applicable to the 105KW Facility; therefore, all Key Attributes of the Quality Assurance Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

The 105KW Facility QAPs are implemented to ensure that the design, procurement, construction, testing, inspection, operation, maintenance, packaging, handling, transportation, and interim storage activities conducted at the 105KW Facility conforms to the requirements of 10 CFR 830, “Nuclear Safety Management,” Subpart A, “Quality Assurance Requirements.”

This chapter describes the QAPs that are in place for the fuel fragment storage and sludge storage, retrieval, and transfer activities conducted at the 105KW Facility. The 105KW Facility activities are conducted under one of two QAPs. The first QAP satisfies the nuclear safety requirements specified in 10 CFR 830, Subpart A. As required by 10 CFR 830, Subpart A, the Hanford contractor has prepared and the RL has approved a QAP that is subject to enforcement under 10 CFR 820, “Procedural Rules for DOE Nuclear Activities.” These requirements are implemented in PRC-MP-QA-599, *Quality Assurance Program*.

The QAPs apply to appropriate activities that could affect the safety and reliability of the project. The extent to which quality requirements are applied to these activities is based on a graded approach reflecting the safety significance and/or safety implications of the activity. Activities related to quality by any organizations that provide equipment, services, or support to the 105KW Facility are also described in this chapter.

14.2 Requirements

The requirements that form the basis of the QAP are identified in HNF-11724, Section 14.2.

The documents and standards that form the basis for the QAP are 10 CFR 830, Subpart A; and DOE O 414.1D.

14.3 Quality Assurance Program

A summary of the QAP, including summaries of safety management policies and philosophies used as a basis for the program, is provided in HNF-11724, Section 14.3.

The QAP is governed by PRC-MP-QA-599 and addresses the requirements of 10 CFR 830, Subpart A and DOE O 414.1D. The program encompasses all applicable elements that relate to operation, maintenance, and any future modification of the 105KW Facility. PRC-MP-QA-599
has been reviewed with the appropriate management of the facility to ensure implementation of the requirements.
Chapter 15.0

Emergency Preparedness Program
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15.0 Emergency Preparedness Program

15.1 Introduction

This chapter provides the facility-specific safety-related details of the Emergency Preparedness Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 15.0, provides the general company-wide safety-related details of the Generic Program, including program Key Attributes 15-1 through 15-11. Together, this chapter and HNF-11724, Chapter 15.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 15.0. Key Attributes 15-1 through 15-11 are applicable to the 105KW Facility; therefore, all Key Attributes of the Generic Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

15.2 Requirements

The requirements that form the basis for the Emergency Preparedness Program implemented at the 105KW Facility are identified in HNF-11724, Section 15.2.

15.3 Scope of Emergency Preparedness

The spectrum of emergencies that the 105KW Facility Emergency Preparedness Program is designed to encompass is described in HNF-11724, Section 15.3, and in Chapter 3.0 of this DSA.

15.4 Emergency Preparedness Planning

HNF-11724, Section 15.4, describes the integrated emergency response approach applicable to the 105KW Facility. HNF-11724 describes the Emergency Response Organization (Section 15.4.1), Consequence Assessment Actions (Section 15.4.2), Notification (Section 15.4.3), Emergency Facilities and Equipment (Section 15.4.4), Protective Actions (Section 15.4.5), Training and Exercises (Section 15.4.6), and Recovery and Reentry (Section 15.4.7).
Chapter 16.0

Provisions for Decontamination and Decommissioning
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16.0 Provisions for Decontamination and Decommissioning

16.1 Introduction

This chapter provides the facility-specific safety-related details of the D&D Program for the 105-K West Facility (105KW Facility). HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 16.0, provides the general company-wide safety-related details of the Generic Program, including program Key Attributes 16-1 through 16-3. Together, this chapter and HNF-11724, Chapter 16.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 16.0. Key Attributes 16-1 through 16-3 are applicable to the 105KW Facility); therefore, all Key Attributes of the D&D Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

As normal 105KW Facility operations cease and the fuel fragments, sludge, and debris are removed from the 105KW Facility, D&D will be initiated based on a plan developed in accordance with the implementation guidance associated with DOE O 430.1B, Real Property and Asset Management.

Ongoing operations and modification will consider impacts to D&D activities. Impacts will be minimized, as appropriate, based on cost and schedule requirements. The facility status based on residual contamination will be identified when turnover is accomplished, in accordance with DOE O 435.1, Radioactive Waste Management.

Until the point is reached where the 105KW Facility no longer requires a safety basis that complies with 10 CFR 830, “Nuclear Safety Management,” this DSA will be updated, as appropriate, to address D&D activities.

16.2 Requirements

The requirements that form the basis for D&D provisions are identified in HNF-11724, Section 16.2.

16.3 Description of Conceptual Plans

Conceptual plans are fully described in HNF-11724, Section 16.3, “Description of Conceptual Plans.” The 105KW Facility and process equipment that will be decontaminated or decommissioned will conform to the elements of the conceptual plans. The 105KW Facility has not identified any D&D activities that are unique, facility specific, or important to preventing or mitigating radiation exposure with respect to the D&D Program as presented in HNF-11724.

In-Basin ECRTS equipment is designed as skid-mounted modules with Ion Exchange Module (IXM) water addition lines for flushing transfer pipelines and equipment that transfers sludge. After flushing, process and service connections to these skid-mounted units can be disconnected via standard techniques routinely used at the 105KW Facility to make underwater connections or disconnections, and the equipment decommissioned. The lines internal to the Ingress/Egress
Assembly (slurry transfer and decant return lines) are routinely flushed with IXM water during normal operations, and additional flushing to further decontaminate these lines is possible. Slurry transfer and decant lines can also be flushed with foam swabs, referred to as “pigs,” to further decontaminate the lines and reduce radiation dose rates, if required. Hose and pipeline connections to the Ingress/Egress Assembly are designed to be disconnected. The Ingress/Egress Assembly is bolted to the basin wall, and can easily be unbolted for decommissioning.

ECRTS equipment, panels, and skids have been constructed as modules for ease of installation and decommissioning. The Transfer Line Service Box (TLSB), Decant Pump Box, and Sand Filter Skid all are engineered modules that can be flushed with IXM water to reduce internal contamination during processing and before decommissioning. Hose-in-hose (HIH) transfer pipelines are routinely flushed with IXM water during normal operations; additional flushing can be performed to further decontaminate these lines for decommissioning. HIH transfer lines between the TLSB, Decant Pump Box, Sand Filter Skid, and Sludge Transport and Storage Containers are constructed in segments with connectors that can be disconnected to facilitate decommissioning. The ECRTS Sand Filter has been designed such that the filter media can be discharged to an STSC or other vessel. The In-Basin Horizontal Shielded Hose Chase design includes covers that can be removed to facilitate decommissioning of the internal pipelines and the hose chase.

Decommissioning of the 105-K West Basin Annex (105KW Annex) is planned to include a combination of component removal and grouting in place. Monitoring equipment, cameras, and telecommunications equipment may be removed for reuse at another facility onsite. Components determined to require separate packaging for disposal, including HEPA filters, lead shielding, and any additional components not meeting the waste acceptance criteria for bulk waste disposal at ERDF must be removed from the facility. Some components, such as the TLSB, Decant Pump Box, and Sand Filter Skid may require grouting for disposal. The booster pump contains ports for adding grout to the pump body for disposal. Demolition of the 105KW Annex structure is planned to be accomplished using conventional means (e.g., heavy equipment).
Chapter 17.0

Management, Organization, & Industrial Safety Provisions
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17.0 Management, Organization, & Industrial Safety Provisions

17.1 Introduction
This chapter provides the facility-specific safety-related details of the Management, Organization, and Institutional Safety Program. HNF-11724, CH2M HILL Plateau Remediation Company Safety Management Program, Chapter 17.0, provides the general company-wide safety-related details of the Management, Organization, and Institutional Safety Program, including program Key Attributes 17-1 through 17-7. Together, this chapter and HNF-11724, Chapter 17.0, meet the requirements of DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses, Chapter 17.0. Key Attributes 17-1 through 17-7 are applicable for the 105KW Facility; therefore, all Key Attributes of the Management, Organization, and Institutional Safety Program are considered safety basis commitments. There are no additional Key Attributes required to address 105KW Facility specific hazards.

17.2 Requirements
The requirements that form the basis for management, organization, and institutional safety are identified in HNF-11724, Section 17.2.

17.3 Organizational Structure, Responsibilities, and Interfaces
The overall Hanford Site structure, responsibilities, and interfaces are identified in HNF-11724, Section 17.3. Policies and programs address organizational structure, organizational responsibilities, and staffing and qualifications. CHPRC is responsible to RL, for planning, integrating, and managing the 100K Area activities, including programs, projects, and operations. CHPRC’s responsibilities include operation of the 105KW Facility, which includes fuel fragment storage and sludge storage, retrieval, and transfer activities.

17.4 Safety Management Policies and Programs
The safety management policies and programs applicable to the 105KW Facility are identified in HNF-11724, Section 17.4. Policies and programs address safety review and performance assessment, configuration and document control, occurrence reporting, and the general safety culture developed and maintained through implementation of an integrated safety management system.
Chapter 18.0

References
18.0 References


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