WSRC-TR-99-00010
ADDENDUM 1

ADDENDUM

HAZARDS ANALYSIS

FOR THE

SPENT NUCLEAR FUEL L-EXPERIMENTAL FACILITY (U)

June 2000

[redacted]

Westinghouse Savannah River Company
Projects Engineering and Construction Division
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
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SAVANNAH RIVER SITE

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-96SR18500

DISCLAIMER

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ADDENDUM 1

Key Words: Hazards Analysis
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ADDENDUM

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June 2000

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APPROVALS

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LIST OF ACRONYMS AND ABBREVIATIONS

A	Anticipated
Al	Aluminum
ARF	Airborne Release Fraction
BEU	Beyond Extremely Unlikely
CFR	Code of Federal Regulations
DR	Damage Ratio
DU	Depleted Uranium
EOPs	Emergency Operating Procedures
EU	Extremely Unlikely
HA	Hazards Analysis
Kg	Kilogram
LEF	L – Experimental Facility
LPF	Leak Path Factor
MAR	Material-at-Risk
MOI	Maximally Exposed Offsite Individual
MTR	Material Test Reactor
MURR	University of Missouri Research Reactor
NPH	Natural Phenomena Hazard
RF	Respirable Fraction
RQ	Reportable Quantity
SFSD	Spent Fuel Storage Division
SNF	Spent Nuclear Fuel
SOPs	Standard Operating Procedures
SRS	Savannah River Site
SRTC	Savannah River Technology Center
SSCs	Structures, Systems, and Components
ST	Source Term
TPQ	Threshold Planning Quantity
TR&C	Technical Requirements & Criteria
TSF	Treatment and Storage Facility
TSFVT	Treatment and Storage Facility Validation Test
TQ	Threshold Quantity
U	Unlikely
UPS	Uninteruptable Power Supply
WSMS	Westinghouse Safety Management Solutions
WSRC	Westinghouse Savannah River Company

DEFINITIONS

Depleted Uranium –Uranium containing less than 0.71 Weight % U-235.

Loss of Normal Power – Loss of power from the site 115Kv supply system to the L-Area Facilities, including LEF.

EXECUTIVE SUMMARY

The Spent Nuclear Fuel (SNF) Treatment and Storage Facility (TSF) validation test program was developed for the purpose of validating the basic operation and concept of the full-scale TSF Melt and Dilute process (Ref. 1). The TSF is planned to receive, treat, package, and store aluminum-based spent nuclear fuel in the 105-L Building and L-Area for later disposal in a geologic repository. The TSF Validation Test (TSFVT) will take place in the 105-L Reactor Building Purification Wing Trailer Space where the requisite equipment will be installed to form the L-Experimental Facility (LEF). The tests to be conducted in the LEF will serve to validate previous SRTC tests with unirradiated fuel and surrogate materials, and will provide operational experience with melting irradiated SNF.

A comprehensive review of LEF Hazard Analysis (HA) (Ref. 1) was performed to identify additional potential accident scenarios as a result of design changes identified in the Technical Requirements & Criteria (TR&C) document (Ref. 2) since the HA was completed in January 1999. The purpose was to assess the risk associated with those accidents, and identify controls required to protect the public, the workers, and the environment. This effort is based upon available current design information and was performed in accordance with the guidelines provided in DOE Standard 3009-94 (Ref. 3).

Revisions to the hazardous materials and energy sources associated with the LEF were identified and are identified in the revised tables given in Appendix B. Following this hazard identification step, accident scenarios based on these hazardous materials and energy sources were developed. Once the accident scenarios were developed, unmitigated consequences for each of the scenarios were estimated. Additional scenario descriptions and unmitigated consequences are summarized in the revisions to the tables in Appendix D.

The review of the HA identified a total of three additional potential hazardous event scenarios. These events include a toxic chemical release of depleted uranium due to a large fire, a loss of normal power to the LEF, and failure of the Uninteruptable Power Supply (UPS) circuits and instruments and controls located in the control building outside of Building 105-L due to natural phenomena events. The amount of DU within the LEF was determined to be below the Reportable Quantity (RQ) from 40 CFR 302.4 and was not analyzed further. The unmitigated consequences of the remaining two events are given in Appendix D.

For the offsite and onsite receptors, consequences to the maximally exposed individual from the additional events do not exceed the Evaluation Guidelines if unmitigated. Therefore, further evaluation as candidates for Safety Class or Safety Significant functions may not be required.

Initial screening of technical documents available during the conceptual design phase and discussions with project personnel indicated no chemical hazards are introduced to the existing facility as part of this process other than battery acid in the UPS and transport vehicle batteries, and carbon dioxide gas in portable fire suppression systems. Because of its chemical toxicity, DU was evaluated as a potential toxic hazard in this Addendum.

INTRODUCTION

A review of the HA (Ref. 1) was performed to determine if design changes since its initial issue would require additional potential event scenarios to be developed. The results of that review identified three potential events which required evaluation. Based on that review, it was determined that an Addendum to the existing HA would be developed to address these potential events. Therefore, the purpose of this Addendum is to address the following.

(1) A description of the batching process for preparing the melt to include depleted uranium and evaluation of the DU as a chemically toxic material,

(2) an external event covering a total loss of power to LEF, and

(3) event(s) associated with locating the instrument/control and UPS circuits to the Control Building.

This Addendum only addresses the changes described above. The facility segment tables requiring revisions in Appendix B and D have been reproduced from Reference 1 with the revisions identified. Appendix C in Reference 1 is the LEF inventory tables and is not reproduced in this Addendum. Therefore, this Addendum is not considered to be stand alone and should be used with Revision 0 of the LEF HA (Ref. 1).

Open Items

The LEF process proposed for the 105-L Purification Wing is in the design stage. The results and conclusions presented in this HA Addendum are preliminary and are dependent upon listed assumptions and input data. Deviations from the assumptions and design input documents in this HA may invalidate or otherwise render the results and conclusions non-conservative. The results of this HA Addendum will require validation when the input documents are finalized.

SPENT NUCLEAR FUEL L-EXPERIMENTAL FACILITY DESCRIPTION

Depleted Uranium Batching Process

The Melt/Dilute process seeks to convert and consolidate individual Material Test Reactor (MTR) SNF assemblies into a solid, treated-SNF ingot with <20% U235 enrichment. The reduction in enrichment will be achieved by adding depleted uranium. The SNF and DU will be melted in an induction furnace with aluminum to achieve a near eutectic mixture. The molten mixture will be inductively stirred to ensure a homogenous composition. The furnace is expected to operate at ~850 degrees Celsius. The furnace used for the validation test will be commercially procured and will produce a treated-SNF ingot approximately 6.75 inches in diameter by 8 inches high weighing about 20 pounds.

The batching process for delivering DU to the LEF consists of preparing individual aluminum baskets at the Savannah River Technology Center (SRTC) with approximately 1.25 kilograms (kg) of depleted uranium metal encased in aluminum (Al) per basket. A total of twenty baskets are assumed to be prepared with the DU/Al ingots. The baskets and the DU will be transported to the LEF. When scheduled for treatment, a selected stored fuel assembly from the existing L-Disassembly Basin will be placed in an aluminum basket with the DU/Al ingot in the Disassembly Basin. The basket will be transferred from the Disassembly Basin through the Transfer Canal into the Transfer Bay and placed into a SRL 8 ton cask. The SNF assembly and cask will be drained, decontaminated and loaded onto a truck to be transported from the Receiving Area Transfer Bay to the Purification Wing. The truck will not leave L-Area while enroute.

CHEMICAL INVENTORY

Depleted Uranium encased in aluminum is treated as a toxic chemical. The total amount of DU (U-238) is 25 kg. This quantity of depleted uranium is a chemical concern due to the toxicity of uranium should it become airborne and respirable in the event of a large fire within the building.

A review of 40 CFR 302 Table 302.4, 29 CFR 1910.119, 40 CFR 68, and 40 CFR 355 was performed. The review indicated that no *chemical* RQs, TQs or TPQs exists for uranium metal. However, 40 CFR 302 Appendix B to Table 302.4 (the appendix radionuclide table to the 302.4 chemical table) does indicate a value of 0.1 Ci as the final RQ for uranium isotopes 234, 235, and 238. Footnotes in Appendix B to Table 302.4 direct that any conflict in RQ values between the radionuclide table (Appendix B to Table 302.4) and the chemical table (Table 302.4) should be resolved by selecting the RQ value from either table which is the lowest value. Since there is no chemical RQ listed in Table 302.4 for uranium metal, the radionuclide RQ value from Appendix B to Table 302.4 was selected as the chemical RQ by default. Therefore, the final chemical RQ value from 40 CFR 302 for the uranium isotope 238 is 0.1 Ci.

Using the specific activity of U-238 (3.36E-7 Ci/g) as a good approximation of the specific activity of depleted uranium, allows conversion of the 0.1 Ci RQ to kilograms. This yields an equivalent RQ for depleted uranium of approximately 298 kg. The LEF depleted uranium inventory (25 kg) is well below this value. Therefore, per the methodology outlined in Reference 4 for toxic materials, this quantity of DU is considered to be a common industrial hazard and further analysis is not required.

No other chemicals have been identified for use in the LEF operations. It is assumed that there will be no hazardous chemical inventory within the facility other than small quantities of battery acid in the UPS and transport truck batteries and carbon dioxide gas contained within any portable fire extinguishers. A 78% zinc-bromide solution is also presently being used within the two shielded viewing windows between the crane aisle control room and the trailer space in the 105-L Purification Wing. Additionally, although not a part of the LEF operations, contaminated ion exchange resin contained within the eight (8) purification deionizer vessels is presently stored in the purification cells adjacent to the trailer space.

ASSUMPTIONS

A. Loss of normal power the LEF involves losing ventilation flow resulting in the loss of differential pressure between primary and secondary containment which is a required safety function (Ref. 5). Cooling water to the furnace will be lost during a loss of normal power event resulting in a longer cool down period (5 vs. 3 hours) to reach the melt solidification temperature (Ref. 6).

B. With the UPS operating ventilation and differential pressure between primary and secondary containment would be maintained.

C. The LEF control building outside of Building 105-L is assumed to be designed to PC-2 requirements for NPH events to protect the UPS powered circuitry from detrimental II/I interactions.

D. No hazardous chemicals will be used in the LEF process except for depleted uranium which is considered to be chemically toxic.

E. The batching process for delivering DU to the LEF consists of preparing individual aluminum baskets at the Savannah River Technology Center (SRTC) with approximately 1.25 kilograms (kg) of depleted uranium metal encased in aluminum (Al) per basket. A total of twenty baskets are assumed to be prepared with the DU/Al ingots.

HAZARD EVALUATION

One of the purposes of this Addendum to the Hazard Evaluation in Reference 1 is to identify the additional potential events that could impact the offsite and the two onsite receptors. The results from the Hazard Evaluation are then used for preliminary functional classification of the Structure, Systems, and Components in the LEF.

Determination of the event frequency and the level of consequence for each of the postulated events were performed using unmitigated initiating events and unmitigated material release.

For each of the postulated events, frequencies were estimated using such information sources as the generic frequency database (Ref. 7), natural phenomena frequency data (Ref. 8), human error database development (Ref. 9), engineering judgement, or existing safety documentation.

For the unmitigated hazards analysis, it is useful to envision a hypothetical "working" facility in the open, such as in a green field or a parking lot, with no protective aspects which might normally be expected to prevent or mitigate potential radioactive releases. This hypothetical facility may be expected to have conservatively high accident frequencies, consequences and risk, which serve as bounding reference points from which to establish the necessary controls to mitigate or prevent the accidents.

In the unmitigated analysis, to determine the consequence level of each event, a semi-quantitative assessment is performed. In this assessment, estimates of the potential radiological dose were based on the amount of hazardous material released that subsequently becomes airborne. The airborne source term (ST) was estimated using the following five component linear equation involving: Material-at-Risk (MAR), Damage Ratio (DR), Airborne Release Fraction (ARF), Respirable Fraction (RF) and Leak Path Factor (LPF).

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

The MAR is the material inventory within the facility section and was taken from Reference 1, Table C-2. The material assumed to be affected is represented by the product MAR x DR for each event, where MAR is the inventory available to be acted upon, and the DR is the fraction of the MAR actually impacted. The product of ARF x RF represents the fraction of the material impacted that becomes airborne and is respirable. The LPF is assumed to be 1.0 for unfiltered releases. Using the above, a semi-quantitative analysis was performed in Reference 1.

Using these event frequencies and consequences, the postulated events were "binned" according to the matrices given in Tables A-5, A-6, and A-7. The goal was to identify those events that pose the greatest risk to the public, onsite workers, and the environment. The results of the Hazard Evaluation for the LEF are given in the tables provided in Appendix D.

Hazardous Chemical Release Consequence

The DU is a chemical concern due to the toxicity of uranium should it become airborne and respirable in the event of a large fire within the LEF. An equivalent RQ (40 CFR 302.4, Appendix B) for depleted uranium is approximately 298 kg. The LEF uranium inventory (25 kg) is well below this value. Therefore this quantity of DU is considered to be a common industrial hazard and further analysis is not required.

No other chemicals have been identified for use in the process operation of the LEF. Other chemicals identified to be associated with the LEF exist in small quantities. They include battery acid (sulfuric acid) in the lead-acid batteries of the UPS and transport truck, a 78% zinc-bromide solution within the crane control room shielded windows, and CO_2 contained within portable fire suppression equipment. Of these chemicals, no quantities were found to exceed RQ, TQ or TPQs. These small chemical quantities do not exceed Site guidelines and may represent only a very localized hazard if released.

CONCLUSIONS

A comprehensive review of of the additional hazards associated with the Spent Nuclear Fuel LEF was performed to identify potential accident scenarios. To determine the unmitigated risk of accidents, a Hazards Analysis was performed. The hazard evaluation process identified a total of 3 potential hazardous event scenarios. For the toxic release of DU event, the amount of DU within the LEF was determined to be below the Reportable Quantity (RQ) from 40 CFR 302.4 and was not analyzed further. The unmitigated consequences of the remaining two events are given in Appendix D. Note that the Tables in Appendix D are revisions to the tables in Reference 1.

For the offsite receptor, there are no accident scenarios for which the dose to the maximally exposed individual could exceed the Evaluation Guidelines if unmitigated. For the onsite worker, there are no event scenarios for which the dose to the maximally exposed individual could exceed the Evaluation Guidelines if unmitigated.

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APPENDIX A

METHODOLOGY TABLES

Table A-1 Hazardous Material/Energy Checklist

Hazard Group	Specific Hazardous Material/Energy Source	
Electrical	Battery banks Cable runs Diesel units Electrical equipment Hot plates Heaters High voltage Locomotive, electrical Motors	Pumps Power tools Switchgear Service outlets, fittings Transformers Transmission lines Underground wiring Wiring
Thermal	Bunsen burner/ Hot plates Electrical equipment Furnaces Heaters	Steam lines Welding torch Exothermic reactions
Friction	Belts Bearings Fans	Gears Motors Power tools
Pyrophoric Material	Pu and U metal	
Spontaneous Combustion	Nitric acid and organics	
Combustibles	Combustible materials	
Chemical Reactions	Uncontrolled chemical reactions	
Open Flame	Bunsen burners Torches	Pilot lights Gas Welding
Flammables	Flammable gases Flammable liquids	Flammable mixtures
Explosives	Explosive gases Hydrogen/Tritium	Propane Explosive chemicals
Potential	Gas bottles Gas receivers	Pressure vessels Steam headers and lines
Kinetic	Fans Pumps	Motors Rotating machinery
Non-facility Events	Explosion	Fire
Radiological Material	Radiological material	
Fissile Material	Fissile material	
Non-Ionizing Radiation	Non-ionizing radiation	
Ionizing Radiation	Fissile material Radiography equipment	Radioactive material Radioactive sources
Hazardous Material	Alkali metals Asphyxiants Biologicals Carcinogens	Oxidizers Corrosives Toxics
Natural Phenomena	Earthquake Flood Lightning Rain	Snow, ice Freezing weather Straight wind Tornado
Vehicles in Motion	Airplane Helicopter Train	Truck/Car Forklift
Crane	Crane	

Table A-2 Event Categories & Relationship to Hazardous Material and Energy Sources

Event Category	Event Category Description	Hazard Energy and Material Groups
E-1	Fire	Electrical Thermal Friction Pyrophoric material Spontaneous combustion Open flame Flammables Combustibles Chemical Reactions
E-2	Explosion	Potential (pressure) Explosive materials Chemical Reactions
E-3	Loss of Containment or Confinement	Radiological Material Hazardous Material
E-4	Direct Radiological/Chemical Exposure	Ionizing radiation sources Non-ionizing radiation sources Chemicals
E-5	Nuclear Criticality	Fissile Material
E-6	External Hazards	Non-facility Events Vehicles in Motion Crane Kinetic
E-7	Natural Phenomena	Natural Phenomena

Table A-3 Initiating Event Frequency Evaluation Levels

Event Frequency Code	Description	Estimated Annual Frequency of Occurrence ($year^{-1}$)
Anticipated (A)	Accidents that may occur several times during the life cycle of the facility (accidents that commonly occur).	$f > 10^{-2}$
Unlikely (U)	Accidents that are not anticipated to occur during the life cycle of the facility. Natural phenomena of this probability class include the following: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.	$10^{-2} \geq f > 10^{-4}$
Extremely Unlikely (EU)	Accidents that will probably not occur during the life cycle of the facility. This class includes the design basis accidents.	$10^{-4} \geq f > 10^{-6}$
Beyond Extremely Unlikely (BEU)	All other accidents.	$f \leq 10^{-6}$

Table A-4 Radiological Consequence Evaluation Levels for Hazard Receptors.

Receptor (considered location)

Consequence Level (Abreviation) ↓	Offsite	Onsite 1 (Inside Facility)	Onsite 2 (Outside Facility)
High (H)	> 25.0 rem	(PROXIMATE WORKER) prompt worker fatality, acute injury that is immediately life threatening or permanently disabling (FACILITY WORKER) radiological consequences>100 rem or radiological material quantity exceeds Hazard Category 3 threshold (per DOE-STD-1027)	> 100.0 rem or prompt worker fatality, acute injury that is immediately life threatening or permanently disabling
Moderate (M)	$5.0 < C \leq 25.0$ rem	(PROXIMATE WORKER) serious injury, no immediate loss of life, no permanent disabilities, hospitalization required (FACILITY WORKER) radiological consequences $25 < C \leq 100$ rem	$25.0 < C \leq 100.0$ rem or serious injury, no immediate loss of life, no permanent disabilities, hospitalization required
Low (L)	$0.5 < C \leq 5.0$ rem	(PROXIMATE WORKER) minor injuries, no hospitalization (FACILITY WORKER) radiological consequences $5 < C \leq 25$ rem	$5.0 < C \leq 25.0$ rem or minor injuries, no hospitalization
Negligible (N)	≤ 0.5 rem	(PROXIMATE WORKER) <Low (FACILITY WORKER) ≤ 5.0 rem	≤ 5.0 rem or < Low

Table A-5. Risk Binning Matrix in Frequency-Consequence Space - Offsite Receptors

<table>
<tr><th>Frequency →

Consequence
↓</th><th>Beyond Extremely Unlikely

$\leq 10^{-6}$ /yr</th><th>Extremely Unlikely

$10^{-6} < f \leq 10^{-4}$ /yr</th><th>Unlikely

$10^{-4} < f \leq 10^{-2}$ /yr</th><th>Anticipated

$> 10^{-2}$ /yr</th></tr>
<tr><td>High

<u>Radiological</u>
> 25 rem
<u>Chemical</u>
> ERPG-2</td><td rowspan="3">10</td><td>7</td><td>4</td><td>1</td></tr>
<tr><td>Moderate

<u>Radiological</u>
5 < C ≤ 25 rem
<u>Chemical</u>
ERPG-1 < C ≤ ERPG-2</td><td>8</td><td>5</td><td>2</td></tr>
<tr><td>Low

<u>Radiological</u>
0.5 < C ≤ 5 rem
<u>Chemical</u>
PEL-TWA < C ≤ ERPG-1</td><td>9</td><td>6</td><td>3</td></tr>
<tr><td>Negligible

<u>Radiological</u>
≤ 0.5 rem
<u>Chemical</u>
≤ PEL-TWA</td><td>11</td><td colspan="3">12</td></tr>
</table>

Key:

(shaded) ♦ **Risk Bins 1, 2, 3, 4, 5, 7**
* Exceed Functional Classification evaluation guidelines for offsite receptors
* "Unique" events, individual examination needed

(unshaded) ♦ **Risk Bins 6, 8, 9**
* "Representative" events, examined to the extent that they are not bounded by unique events, at least one bounding event from the each event category (fires, explosions, etc.)

Table A-6. Risk Binning Matrix in Frequency-Consequence Space - Onsite 1 Receptor (Inside Facility)

Frequency → Consequence ↓	**Beyond Extremely Unlikely** ≤ 10^{-6} /yr	**Extremely Unlikely** $10^{-6} < f \leq 10^{-4}$ /yr	**Unlikely** $10^{-4} < f \leq 10^{-2}$ /yr	**Anticipated** $> 10^{-2}$ /yr
High (PROXIMATE WORKER) prompt worker fatality, acute injury that is immediately life threatening or permanently disabling (FACILITY WORKER) Radiological: radiological consequences>100 rem or radiological material quantity exceeds Hazard Category 3 threshold (per DOE-STD-1027) Chemical: uniform distribution of total release exceeds ERPG-3		**7**	**4**	**1**
Moderate (PROXIMATE WORKER) serious injury, no immediate loss of life, no permanent disabilities, hospitalization required (FACILITY WORKER) Radiological: radiological consequences 25 < C ≤100 rem Chemical: uniform distribution of total release ERPG-2 < C ≤ ERPG-3	**10**	**8**	**5**	**2**
Low (PROXIMATE WORKER) minor injuries, no hospitalization (FACILITY WORKER) Radiological: radiological consequences 5 < C≤ 25 rem Chemical: uniform distribution of total release ERPG-1 < C ≤ ERPG-2		**9**	**6**	**3**
Negligible (PROXIMATE WORKER) < Low (FACILITY WORKER) Radiological: ≤ 5 rem Chemical: ≤ ERPG-1	**11**		**12**	

Key:

[shaded] ♦ **Risk Bins 1, 2, 4, 5, 7**
* Exceed Functional Classification evaluation guidelines for onsite receptors

Table A-7. Risk Binning Matrix in Frequency-Consequence Space - Onsite 2 Receptor (Outside Facility)

Frequency → Consequence ↓	**Beyond Extremely Unlikely** ≤ 10^{-6}/yr	**Extremely Unlikely** $10^{-6} < f \leq 10^{-4}$/yr	**Unlikely** $10^{-4} < f \leq 10^{-2}$/yr	**Anticipated** $> 10^{-2}$/yr
High Radiological: > 100 rem Chemical: > ERPG-3 Any Hazard: prompt worker fatality, acute injury that is immediately life threatening or permanently disabling		**7**	**4**	**1**
Moderate Radiological: 25 < C ≤ 100 rem Chemical: ERPG-2 < C ≤ ERPG-3 Any Hazard: serious injury, no immediate loss of life, no permanent disabilities, hospitalization required	**10**	**8**	**5**	**2**
Low Radiological: 5 < C ≤ 25 rem Chemical: ERPG-1 < C ≤ ERPG-2 Any Hazard: minor injuries, no hospitalization		**9**	**6**	**3**
Negligible Radiological: ≤ 5 rem Chemical: ≤ ERPG-1 Any Hazard: < low	**11**	**12**		

Key:

(shaded) ♦ **Risk Bins 1, 2, 4, 5, 7**
* exceed Functional Classification evaluation guidelines for onsite receptors

APPENDIX B

HAZARD IDENTIFICATION TABLES REVISIONS

APPENDIX B

HAZARD IDENTIFICATION TABLES REVISIONS

Table B-1 Hazard Energy Sources, Materials, and Their Locations for the SNF L-Experimental Facility - Furnace Area

(Page 3 of 3)

Location (identifier for system, sub-system, or operational feature in this facility section)	Hazard Energy Sources and Materials																															
				Ionizing Rad.					Hazardous Materials								Natural Phenomena									Vehicles in Motion						
	Radiological Material (RM)	Fissile Material (FM)	Non-Ionizing Radiation (NI)	Fissile Material (FM)	Radiography Equipment (RE)	Radioactive Materials (RM)	Radioactive Sources (RS)	Other	Alkali Metals (AM)	Asphyxiants (AS)	Biological (BI)	Carcinogens (CA)	Oxidizers (OX)	Corrosives (CO)	Toxics (TX)	Other	Earthquake (EQ)	Flood (FD)	Lightning (LT)	Rain (RN)	Snow, Ice (SN)	Freezing Weather (FW)	Straight Wind (SW)	Tornado (TO)	Other	Airplane (AP)	Helicopter (HL)	Train (TN)	Truck/Car (TR)	Forklift/Lift Truck (FK)	Other	Crane/Hoist (CR)
Area																																
Furnace Area (Trailer Space)	X	X		X		X		X[1]						X[2]	X[3]		X	X	X	X		X	X	X		X	X		X	X		X

X = Refers to the hazards considered applicable

FOOTNOTES:

1 Deionizer pressure vessels,resins, filters, and evaporator

2 Truck battery acid

3 Added Depleted Uranium

Table B-3 Hazard Energy Sources, Materials, and Their Locations for the SNF L-Experimental Facility - Furnace Control Station

(Page 1 of 3)

	Hazard Energy Sources and Materials																																
	Electrical																		Thermal								Friction						
Location (identifier for system, sub-system, or operational feature in this facility section)	Battery Banks (BB)	Cable Runs (CB)	Diesel Units (DU)	Electrical Equipment (EE)	Hot Plates (HP)	Heaters (HT)	High Voltage (HV) [> 600 V]	Locomotive, electrical (LE)	Motors (MT)	Pumps (PM)	Power Tools (PT)	Switchgear (SG)	Service Outlets, fittings (SO)	Transformers (TF)	Transmission Lines (TL)	Underground Wiring (UW)	Wiring (WR)	Other	Bunsen Burner, Hot Plate (BR)	Electrical Equipment (EE)	Furnaces (FR)	Heaters (HT)	Steam Lines (SL)	Welding Torch (WT)	Exothermic Reactions (ER)	Other	Belts (BL)	Bearings (BE)	Fans (FN)	Gears (GE)	Motors (MT)	Power Tools (PT)	Other
Area																																	
Furnace Control Station		X		X		X	X[2]		X	X	X	X	X	X[1]			X			X		X						X	X		X	X	

X = Refers to the hazards considered applicable

FOOTNOTES:

1 Rectifiers

2. Added High Voltage

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Table B-6 Hazard Energy Sources, Materials, and Their Locations for the SNF L-Experimental Facility - Transportation

(Page 3 of 3)

	Hazard Energy Sources and Materials																															
				Ionizing Rad.					Hazardous Materials								Natural Phenomena									Vehicles in Motion						
Location (identifier for system, sub-system, or operational feature in this facility section)	Radiological Material (RM)	Fissile Material (FM)	Non-Ionizing Radiation (NI)	Fissile Material (FM)	Radiography Equipment (RE)	Radioactive Materials (RM)	Radioactive Sources (RS)	Other	Alkali Metals (AM)	Asphyxiants (AS)	Biological (BI)	Carcinogens (CA)	Oxidizers (OX)	Corrosives (CO)	Toxics (TX)	Other	Earthquake (EQ)	Flood (FD)	Lightning (LT)	Rain (RN)	Snow, Ice (SN)	Freezing Weather (FW)	Straight Wind (SW)	Tornado (TO)	Other	Airplane (AP)	Helicopter (HL)	Train (TN)	Truck/Car (TR)	Forklift/Lift Truck (FK)	Other	Crane/Hoist (CR)
Area																																
Truck Transport	X	X		X		X								X[1]	X[2]		X	X	X	X	X	X	X	X		X	X	X	X	X		X

X = Refers to the hazards considered applicable

FOOTNOTES:

1 Battery acid

2 Added Depleted Uranium

APPENDIX D

UNMITIGATED HAZARD EVALUATION TABLES REVISION

Table D-1, Hazard Evaluation Table for L-Experimental Facility Furnace Area, Unmitigated Consequences (continued)

				Prevention Features		Initiating Event Freq. Level		Mitigation Features		Consequence Level		Risk Rank	
Event No.	Event Cate-gory	Postulated Event Description	Causes	Design	Administration	Unmitigated	Mitigated	Design	Administration	Unmitigated Consequence	Mitigated Consequence	Unmitigated	Mitigated
FA-37	E-7	Release of radiological material due to damage from lightning strike. Location: Furnace Area Hazard Source: Ingots; contamination in off-gas system	Direct lightning strike.	Building design; Lightning protection, Furnace secondary confinement (enclosure)	None	EU 10	TBD	Building design, Ingot canister design, Furnace secondary confinement (enclosure)	Trained personnel	Onsite 1: High Onsite 2: High Offsite: Low Assume 4 MURR ingots involved.	Onsite 1: TBD Onsite 2: TBD Offsite: TBD	7 7 9	TBD TBD TBD
FA-38	E-7	Radiological surface contamination release due to flooding. Location: Furnace Area Hazard Source: ingots, contamination in off-gas system filters	Flooding of trailer space due to: Heavy rain, Clogging of process floor drain combined with continuing discharge of furnace secondary cooling water into the drain.	Building design; Site grading Building location / elevation, Process drain design	Process Drain, Storm Drain periodic inspection/ maintenance	U 11	TBD	Building design, Ingot canister design, Furnace elevation above floor	Trained personnel, Environmental/ground water remediation	Onsite 1: Low Onsite 2: Negligible Offsite: Negligible Assumes 4 MURR involved.	Onsite 1: TBD Onsite 2: TBD Offsite: TBD	6 12 12	TBD TBD TBD
FA39	E-6	Radiological release due to off-gas/exhaust system failure. Location: Furnace Area Hazard Source: Molten SNF off-gas	Complete loss of offsite power to LEF due to 115 kv system failure, vehicle crash, and NPH events	115 KV system design	SOPs; Trained personnel	A 14	TBD	Building design; Building HVAC design; UPS, Radiation monitors / alarms	Trained personnel; EOPs; Radiation Protection Program	Onsite 1: Low Onsite 2: Negligible Offsite: Negligible Assume 1.5 MURR [6,7,9] involved.	Onsite 1: TBD Onsite 2: TBD Offsite: TBD	3 12 12	TBD TBD TBD

Table D-1, Hazard Evaluation Table for L-Experimental Facility Furnace Area, Unmitigated Consequences (continued)

Superscript Notes:

[0]-Assumes 1 MURR per melt batch.
[1]–Offgas system "filters" includes used zeolite and HEPA filters.
[2]–Note Deleted.
[3]–Assumes maximum SNF (including melted or unmelted SNF, ingots, contamination in off-gas system and filters) in FA at any one time = 5 MURR.
[4]-Assumes simultaneous furnace heating and cooling system failure or shutdown.
[5]-Worst case: Load drops on/breaches off-gas system.
[6]–Assumes off-gas filters replaced after 5th batch.
[7]-Radioactive material in off-gas system is assumed to be 10% of each MURR batch. Maximum expected inventory in offgas system = 10% x 5 MURR batches = 0.5 MURR.
[8]-Assume sample size = 1.5 % of a MURR.
[9]– Assumes 1 MURR in crucible and 0.5 MURR worth of contamination in the off-gas system.

Notes / References for Frequency Levels:

1. Initiator frequency for truck fire/explosion based on S-CLC-K-00147 and engineering judgement.
2. Initiator frequency for significant fire derived from WSRC-TR-94-0188, calculated applicable area and engineering judgement.
3. Explosion from rupture of compressed gas systems derived from WSRC-TR-93-262.
4. Mishandling accident (human error) frequency derived from WSRC-93-581 p. 78 for failure probability and SFS-RSE-98-0150 for material movement/operations frequency.
5. Electrical, mechanical or control system failure frequency derived from WSRC-TR-93-262 selected electrical and I&C component failure rates averaged and engineering judgement.
6. Frequency derived as anticipated based on actual concrete ceiling degradation from C-Reactor operational history.
7. Derived from WSRC-TR-93-581 and engineering judgement.
8. Engineering judgement/discussions with facility and material experts.
9. Derived from WSRC-TR-94-0188 and engineering judgement.
10. Derived from WSRC-RP-95-915, Rev 0 and engineering judgement.
11. Frequency derived from WSRC-TM-95-1.
12. Frequency derived from WSRC-TR-93-581 Table 4 Item 22, restricted manuevering area (i.e. congested road).
13. WSRC-RP-95-915 and the area square footage yield a helicopter impact frequency of "EU."
14. Loss of power from the 115 kv and vehicle crash is estimated to be "A" from WSRC-RP-92-1110 and engineering judgement.

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Table D-3, Hazard Evaluation Table for L-Experimental Facility - Furnace Control Station, Unmitigated Consequences (continued)

				Prevention Features		Initiating Event Freq. Level		Mitigation Features		Consequence Level		Risk Rank	
Event No.	Event Cate-gory	Postulated Event Description	Causes	Design	Administration	Unmitigated	Mitigated	Design	Administration	Unmitigated Consequence	Mitigated Consequence	Unmitigated	Mitigated
FC-14	E-7	Building collapse. Control Circuit and UPS Circuit damage. Location: Furnace Control Station Hazard Source: Structural Failure	NPH Event	None	None	U 4,6	TBD	Building Design (PC-2)	Trained Personnel; EOPs	Onsite 1: Low Onsite 2: Negligible Offsite: Negligible Assume 1.5 MURR [6, 7, 9] involved.	Onsite 1: TBD Onsite 2: TBD Offsite: TBD	3 12 12	TBD TBD TBD

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Table D-3, Hazard Evaluation Table for L-Experimental Facility - Furnace Control Station, Unmitigated Consequences (continued)

Superscript Notes:

[1] – Assume simultaneous furnace heating and cooling system failure/shutdown.

Notes / References for Frequency Levels:

1. Initiator frequency for significant fire derived from WSRC-TR-94-0188, calculated applicable area and engineering judgement.
2. Explosion from rupture of compressed gas systems derived from WSRC-TR-93-262.
3. Frequency derived from WSRC-TR-93-581, Table 4 Item 22, Congested road.
4. Derived from WSRC-RP-95-915, Rev 0 and engineering judgement.
5. WSRC-RP-95-915 and the area square footage yield a helicopter impact frequency of "EU."
6. Frequency derived from WSRC-TM-95-1.

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