3. HAZARD AND ACCIDENT ANALYSES

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3. HAZARD AND ACCIDENT ANALYSES

3.1 Introduction

This chapter identifies and evaluates the potential hazards associated with closure of INTEC Tanks WM-180 through WM-190 and WM-103 through WM-106. The hazard classification assigned to the closure is also discussed.

3.2 Requirements

Title 10 Code of Federal Regulations (CFR), Part 830, Subpart B, "Safety Basis Requirements,"[1] and DOE Standards DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports,"[2] and DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports,"[3] establish the requirements and guidelines for performing hazard and accident analyses and a methodology for hazard categorization.

The Department of Energy Idaho Operations Office (DOE-ID) has also established evaluation guidelines for the consistent development of safety analyses for nonreactor nuclear facilities at the INEEL. These evaluation guidelines include Risk Evaluation Guidelines and criteria for the selection of safety-class and safety-significant structures, systems, and components (SSCs) and technical safety requirements (TSRs).[4,5] In addition, DOE-ID and the managing and operations (M&O) contractor have concurred on supplemental guidance regarding the content of upgraded SARs and TSRs.[6]

3.3 Hazard Analysis

The methodology and results of the hazard analysis for the tank closure activities described in Chapter 2 are presented in this section. The hazard classification assigned to closure of the tanks is also presented.

3.3.1 Methodology

The methodology used to identify and evaluate potential hazards to the public, co-located workers, facility workers, and the environment from closure of INTEC Tanks WM-180 through WM-190 and WM-103 through WM-106 is summarized in the following sections. A description of the hazard analysis methodology, including criteria for selecting safety-class and safety-significant SSCs (safety SSCs), TSRs, and safety requirements, is also contained in the following sections.

3.3.1.1 Hazard Identification. A hazard as defined by DOE-STD-3009-94 is a source of danger (material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to an operation or to the environment (without regard for likelihood or credibility of accident scenarios or consequence mitigation). To identify potential hazards associated with closing Tanks WM-180 through WM-190 and WM-103 through WM-106, the following items were determined:

1. The maximum amounts of radioactive and hazardous materials that are potentially releasable during the closure and the forms and locations of these materials

2. Potential energy sources and potential initiating events that could directly result in injury to workers or could affect the inventory of radioactive or hazardous materials.

Safety documents that established the original and existing safety basis for the Tank Farm were sources for identification of potential hazards associated with the Tank Farm Closure Project. Historical operational incidents associated with the Tank Farm tanks as well as operational incidents and lessons learned at other DOE facilities were also used to identify potential hazards. The source of historical incident information included the DOE Occurrence Reporting and Processing System (ORPS).[7]

The checklist analysis method is an experience-based technique, and the quality of the study performed using this technique is highly dependent on the experience of the checklist authors. The what-if analysis portion of the technique, discussed in Section 3.3.1.2, encourages the team to consider potential events and consequences that are beyond the experience of the authors of a good checklist, and thus, are not covered on the checklist. The checklist portion of this technique lends a more systematic nature to the what-if analysis. Standard hazardous analysis checklists were used to support and document the complete identification of hazards and ensure completeness.

The final product of this hazard identification process was a comprehensive list of hazards applicable to closure of the Tank Farm. Further evaluation and estimates of likelihood and consequences for each hazard pathway were determined for hazard identification and are discussed in the following section.

3.3.1.2 Hazard Evaluation. A qualitative hazard evaluation was performed for the identified hazards associated with closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 that can result in an unmitigated release of radioactive or hazardous material and affect the public, co-located workers, facility workers, or the environment. Most of the consequences of these hazards are enveloped by the consequences analyzed in SAR-107. Each hazard was evaluated to determine potential release mechanisms and potential causes, which included internal events, external events, and natural phenomena. Sabotage and terrorism were not addressed.[a]

A checklist-type analysis was performed for the closure of the Tank Farm tanks to identify hazards, consider the general types of accidents that can occur, evaluate in a qualitative fashion the effects of these accidents, and determine whether the safeguards against these potential accident situations appear adequate. This method combines the creative, brainstorming features of what-if analysis with the systematic features of the checklist methodology. The activities associated with closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 warrant a less detailed hazard identification/evaluation technique.

The likelihood (anticipated, unlikely, extremely unlikely, or beyond extremely unlikely) of each hazard without controls was estimated qualitatively using the definitions in Table 3-1. No credit was taken for controls (design or administrative features) that may prevent the event. The likelihood category was based on available data, operating experience, and/or engineering judgment. If there was uncertainty in the likelihood category, the higher-frequency category was conservatively assumed. Matrices of the receptor versus consequence category for facility workers, co-located workers, and off-site public are listed in Table 3-2. The INEEL Risk Evaluation Guidelines, based on DOE-ID Order 420.D,[5] are presented in Table 3-3.

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a. The analysis of postulated accidents caused by sabotage and terrorism is not within the scope of this safety analysis. Identifying and controlling the risk of potential sabotage and terrorist threats is the responsibility of the INEEL security.

Table 3-1. Qualitative likelihood category.

Likelihood Category	Description	Frequency of Occurrence (per year)
Anticipated	Events that have occurred or are expected to occur during the lifetime of the facility (frequency between once in 10 and once in 100 y).	10^{-2} to 10^{-1}
Unlikely	Events that may occur, but are not anticipated in the lifetime of the facility (frequency between once in 100 and once in 10,000 y).	10^{-4} to 10^{-2}
Extremely Unlikely	Events that, while possible, will probably not occur in the lifetime of the facility (frequency between once in 10,000 and once in 1,000,000 y).	10^{-6} to 10^{-4}
Beyond Extremely Unlikely	Events that are considered too improbable to warrant further consideration (frequency less than once in 1,000,000 y).	Less than 10^{-6}

Note: Normal facility operation includes routine events with frequencies greater than 10^{-1} per year. These routine events that may result in a release of radioactive material are addressed in Chapter 7 of SAR-100, "Radiation Protection"; Chapter 8 of SAR-100, "Hazardous Material Protection"; and Chapter 9 of this safety analysis, "Radioactive and Hazardous Material Waste Management."

Table 3-2. Qualitative consequence category.[a]

Consequence Category	Off-Site Public	On-Site (Co-Located) Workers	Facility Workers	Environment
High (H)	Greater than 25 rem or greater than ERPG-2	Greater than 100 rem or greater than ERPG-3 or greater than Δ10 psi	Greater than 100 rem or greater than ERPG-3 or greater than Δ10 psi	Off-site contamination or major liquid release to the groundwater
Moderate (M)	5 rem to 25 rem or ERPG-1 to ERPG-2	25 rem to 100 rem or ERPG-2 to ERPG-3	25 rem to 100 rem or ERPG-2 to ERPG-3	INEEL site contamination
Low (L)	0.5 rem to 5 rem or TLV-TWA to ERPG-1	5 rem to 25 rem or ERPG-1 to ERPG-2	5 rem to 25 rem or ERPG-1 to ERPG-2	INTEC site contamination outside the facility
Negligible (N)	Less than 0.5 rem or less than TLV-TWA	Less than 5 rem or less than ERPG-1	Less than 5 rem or less than ERPG-1	No contamination outside the facility

a. The numerical consequence category guidelines for the off-site public, on-site (co-located) workers, and facility workers are based on the Risk Evaluation Guidelines and criteria for the selection of safety SSCs and TSRs established for INEEL nonreactor nuclear facilities.[5]

Notes:
1. The off-site public is a hypothetical maximally exposed individual at the INEEL site boundary.
2. The on-site (co-located) worker is located outside the facility and is assumed to be 100 m (300 ft) from the release or, for elevated or buoyant releases, at the point where the release reaches ground level.
3. The facility worker is inside the facility (i.e., in the immediate vicinity of the release).
4. Rem are total effective dose equivalent (TEDE).
5. TLV-TWA is the time-weighted average concentration for a normal 8-hr workday and a 40-hr workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
6. ERPG values are intended to provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects as described in the definitions of ERPG-1, ERPG-2, and ERPG-3 as a consequence of exposure to the specific substance.
   - The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
   - The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective actions.
   - The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects.
7. If a TLV-TWA or ERPG value for a specific substance has not been established, a concentration causing an equivalent potential health effect is used. For guidance on a hierarchy of alternative concentration-limit parameters see WSRC-MS-92-206, "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in D.O.E. Facilities."[8] Interim, temporary, or equivalent exposure limits for which official ERPGs have not been established (i.e., TEELs) are available in PEC-CAT-97-0044A, "ERPGs and TEELs for Chemicals of Concern at SRS."[9]
8. Explosion overpressure is expressed as the differential pressure (Δ psi) of the shock wave.

ERPG	Emergency Response Planning Guideline
INEEL	Idaho National Engineering and Environmental Laboratory
SSCs	structure, system and component
TEEL	temporary emergency exposure limits [
TLV	Threshold Limit Value
TSRs	technical safety requirements
TWA	Time-Weighted Average

Table 3-3. INEEL risk evaluation guidelines.

Event/Accident Likelihood/Frequency	Co-Located and Facility Worker Consequences	Off-Site Public Consequences
Anticipated (10^{-2} to 10^{-1}/yr)		
Radiological	5.0 rem (TEDE)[a]	0.5 rem (TEDE)
Nonradiological	ERPG-1 or equivalent[b]	TLV-TWA or equivalent[c]
Unlikely (10^{-4} to 10^{-2}/yr)		
Radiological	25 rem (TEDE)	5.0 rem (TEDE)
Nonradiological	ERPG-2 or equivalent	ERPG-1 or equivalent
Extremely Unlikely (10^{-6} to 10^{-4}/yr)		
Radiological	100 rem (TEDE)[d]	25 rem (TEDE)
Nonradiological	ERPG-3 or equivalent[d]	ERPG-2 or equivalent

a. TEDE = Total Effective Dose Equivalent
b. ERPG = Emergency Response Planning Guidelines (American Industrial Hygiene Association). Equivalent means a concentration of a hazardous chemical causing potential health effects similar to ERPG-1 levels, but for which an ERPG-1 concentration has not been established. Likewise, equivalent to ERPG-2 or ERPG-3 means concentrations of hazardous chemicals causing potential health effects similar to ERPG-2/3 levels, but for which ERPG-2/3 concentrations have not been established. Interim, temporary, or equivalent exposure limits for which official ERPGs have not been established (i.e., temporary emergency exposure limits (TEELs) are available in PEC-CAT-97-0044A, "ERPGs and TEELs for Chemicals of Concern at SRS." [11] See also WSRC-MS-92-206, "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for Use in D.O.E. Facilities." [10]
c. TLV-TWA = Threshold Limit Value Time-Weighted Average. Equivalent means a concentration of a hazardous chemical causing potential health effects similar to TLV-TWA levels, but for which a TLV-TWA concentration has not been established. For guidance on a hierarchy of alternative concentration-limit parameters see WSRC-MS-92-206.
d. These guidelines apply only to co-located workers, not facility workers. For most postulated accidents with severe facility worker consequences, such as unshielded criticalities or process explosions, it is not possible to identify a consequence-mitigation barrier that will allow meeting such a guideline.

A qualitative estimate of the potential unmitigated consequences to the off-site public, co-located workers, facility workers, and the environment for each hazard was made using Table 3-2. Unmitigated means that a material's quantity, form, location, dispersibility, and interaction with available energy sources is considered without taking credit for preventative and mitigative features. This does not, however, require ignoring passive design features that confine radioactive or hazardous material if failure of such features is not postulated by design (evaluation) basis events. If there was uncertainty in the consequence category, the more severe consequence category was conservatively assumed.

Based on the likelihood and consequence categories, a risk bin number was assigned using the qualitative risk matrices in Figures 3-1, 3-2, and 3-3. There is no risk bin for environmental effects. The risk bin numbers in the risk matrices indicate whether safety SSCs, TSRs, and/or safety requirements should be identified to manage the risk associated with that particular hazard.

Potential hazardous events initiated by natural phenomena (such as NPHs) were evaluated per the requirements and guidelines in DOE Order 420.1A, "Facility Safety,"[10] DOE-GDE-420.1-2, "Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Nonnuclear Facilities,"[11] and the referenced DOE Standards.[12,13,14,15] The potential hazardous events or postulated accidents initiated by NPH events that are unique to closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 are discussed in Section 3.3.2.3. In the hazard evaluation results summary table, the risk to the public, co-located workers, and facility workers of NPH-initiated hazardous events or accidents is estimated. The likelihood category is assumed to be unlikely since the frequency of the initiating design basis NPH event is unlikely (10^{-4} to 10^{-2} per year). However, the frequency will be adjusted accordingly based on the design of the facility or structure (including temporary enclosures). The consequence category is determined using Table 3-2 based on a qualitative estimate of unmitigated consequences.

Design and administrative features or controls that prevent the release of radioactive or hazardous material or mitigate the consequences of the release were then identified for each potential hazardous event.

3.3.2 Hazard Analysis Results

The results of the hazard analysis are summarized in this section. Hazard identification, hazard categorization, and hazard evaluation results are presented.

Consequence Category	Off-Site Public
High (H)	greater than 25 rem or greater than ERPG-2
Moderate (M)	5 rem to 25 rem or ERPG-1 to ERPG-2
Low (L)	0.5 rem to 5 rem or TLV-TWA to ERPG-1
Negligible (N)	less than 0.5 rem or less than TLV-TWA

Radiological

Likelihood Category	Negligible	Low	Moderate	High
Anticipated (10^{-2} - 10^{-1})	7	11	14	16
Unlikely (10^{-4} - 10^{-2})	4	8	12	15
Extremely Unlikely (10^{-6} - 10^{-4})	2	5	9	13
Beyond Extremely Unlikely (< 10^{-6})	1	3	6	10

Consequence Category

Nonradiological

Likelihood Category	Negligible	Low	Moderate	High
Anticipated (10^{-2} - 10^{-1})	7	11	14	16
Unlikely (10^{-4} - 10^{-2})	4	8	12	15
Extremely Unlikely (10^{-6} - 10^{-4})	2	5	9	13
Beyond Extremely Unlikely (< 10^{-6})	1	3	6	10

Consequence Category

KEY

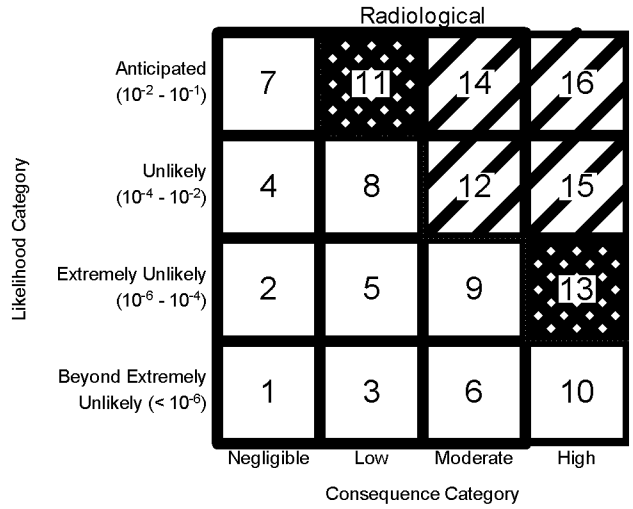
Safety-class SSCs and/or TSRs should be identified to manage off-site public risk; accident analysis may be needed.

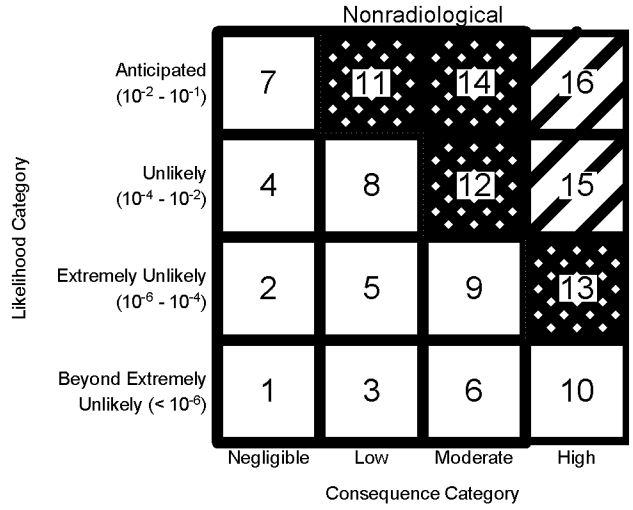
Safety-class SSCs or TSRs are generally not required to manage off-site public risk.

02-GA51330-01

Figure 3-1. Qualitative risk matrix for the off-site public.

Consequence Category	On-Site (Co-located) Workers
High (H)	greater than 100 rem or greater than ERPG-3 or greater than ▲10 psi
Moderate (M)	25 rem to 100 rem or ERPG-2 to ERPG-3
Low (L)	5 rem to 25 rem or ERPG-1 to ERPG-2
Negligible (N)	less than 5 rem or less than ERPG-1





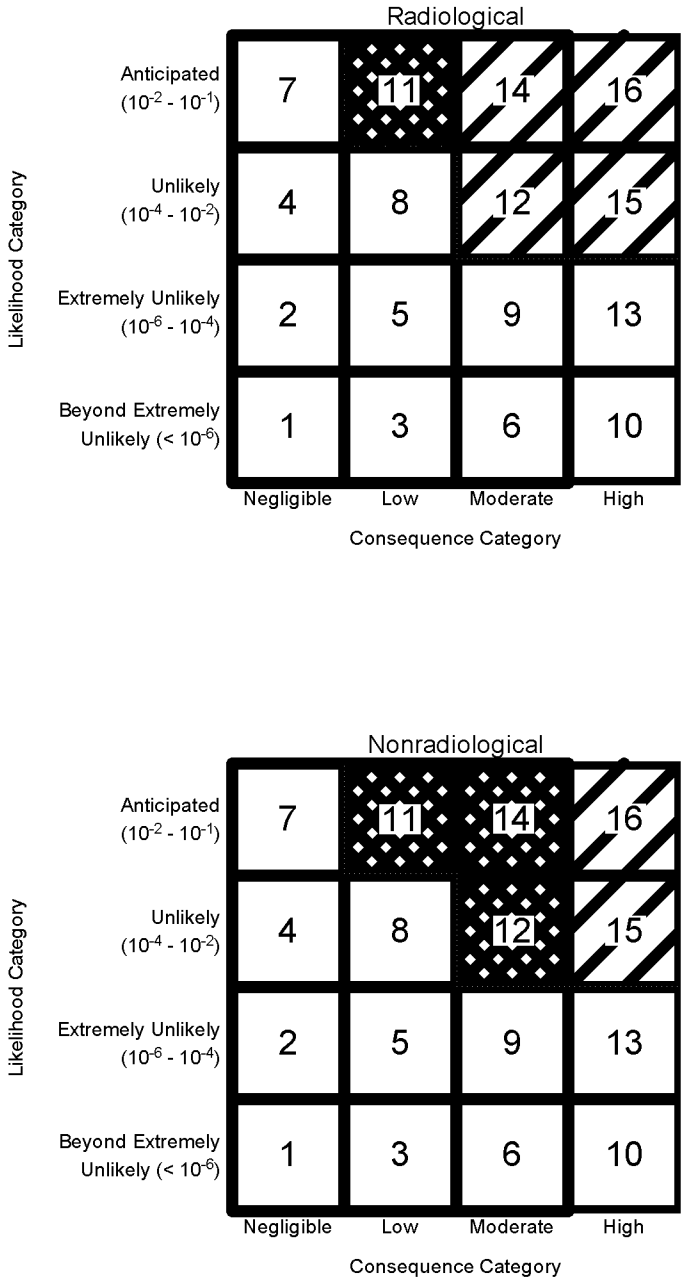
KEY

- Safety-significant SSCs and/or TSRs should be identified to manage co-located worker risk; accident analysis may be needed.
- Safety requirements should be identified to manage co-located worker risk.
- Safety SSCs, TSRs, or safety requirements are generally not required to manage co-located worker risk.

02-GA51330-02

Figure 3-2. Qualitative risk matrix for on-site (co-located) workers.

Consequence Category	Facility Workers
High (H)	greater than 100 rem or greater than ERPG-3 or greater than ▲10 psi
Moderate (M)	25 rem to 100 rem or ERPG-2 to ERPG-3
Low (L)	5 rem to 25 rem or ERPG-1 to ERPG-2
Negligible (N)	less than 5 rem or less than ERPG-1



KEY

- Safety-significant SSCs and/or TSRs should be identified to manage facility worker risk.
- Safety requirements should be identified to manage facility worker risk.
- Safety SSCs, TSRs, or safety requirements are generally not required to manage facility worker risk.

02-GA51330-03

Figure 3-3. Qualitative risk matrix for facility workers.

3.3.2.1 Hazard Identification. Identified hazards are discussed in this section.

3.3.2.1.1 Radiological Inventory—The Tank Farm 300,000-gal tanks contain radioactive liquid and solids. The maximum radioactive material inventory for a worst-case accident involving a 300,000-gal storage tank during Tank Farm closure activities is shown in Table 3-4 and is based on the inventory in Tank WM-181. The radioactive material inventory for Tank WM-181, which contains 23,000-gal of solution and 10,452 kg of solids, was used because it has the greatest potential to produce the highest internal dose. Therefore, Tank WM-181 gives the most conservative dose estimates, in comparison with the other storage tanks.

The radionuclide inventory in Table 3-4 contains both analytical and calculated data. Because the tanks contain both a liquid and sludge phase, the radioactive material inventory for each phase was calculated separately, then added together as described in Engineering Design File (EDF)-3358.[16] The radioactive material inventories for the undissolved solids[17] and for the liquid portion[18] used are from October 2002 inventories.

The contents of the 30,000-gal storage tanks (WM-103 through WM-106) were not included in the radioactive material inventory for the Tank Farm. Tanks WM-103 through WM-106 have been emptied to the extent possible using existing equipment and were confirmed to be essentially empty based on sample analysis and evaluation in 1990.[19] These tanks, therefore, are not considered a source term of any significance in the hazard evaluation and accident analysis. Any liquid that has accumulated in these tanks since 1990 is judged not to be the result of any waste transfers to the tanks but rather the effects of steam leakage by the steam jet valves and subsequent condensation of the steam and gradual buildup of water in the tanks.

The predicted radionuclide source term used in the airborne release accident scenario is discussed in Section 3.4 (see Table 3-10), and is based on the radioactive material inventory in WM-181. As stated above, the radioactive material inventory in Tank WM-181 has the potential to produce the highest internal dose in comparison with the other storage tanks.

The predicted radionuclide source term used in the direct radiation exposure accident is discussed in Section 3.4 (see Table 3-12), and is based on the radioactive material inventory in Tank WM-188. The material contained in Tank WM-188 has the potential to produce the highest external dose in comparison with the other storage tanks, as described in EDF-3359.[20]

3.3.2.1.2 Fissile Material Inventory—In the bottom of each of the 300,000-gal tanks is a heel consisting of a layer of liquid and sludge. The sludge layer contains small concentrations of uranium. The uranium-bearing solids (UBS) in the sludge have an air-dried particle density of 2.0 g/cm^3. The sludge consists of a liquid and solids portion. From the sample data, the volume fraction of liquid in the sludge is 75% and the volume fraction of the solids is 25%. The sludge in Tanks WM-182, WM-183, and WM-188 were sampled between 1999 and 2000, using the Light-Duty Utility Arm (LDUA).[17] Table 3-5 contains the concentrations of the uranium and plutonium in the solids of each of the sampled tanks. The estimated amount of sludge and uranium in Tanks WM-180, WM-181, WM-184, WM-185, and WM-186 is based on the samples taken from Tank WM-182. These tanks all received similar waste from reprocessing Zr and Al fuels. The estimated amount of sludge and uranium in Tanks WM-187 and WM-189 is based on sample results from Tank WM-188. These three tanks all received waste from the fluorinel dissolution process (FDP). The sample results for Tank WM-183 are also presented in Table 3-5.

Table 3-4. Total calculated material at risk in a 300,000-gal storage tank heel solution based on Tank WM-181 (23,000-gal of solution with 10,452 kg of solids).

Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)
H-3	2.20E+00	Sn-121m	2.87E-03	Eu-155	1.79E+01
Be-10	1.31E-07	Sn-126	5.14E-02	Gd-152	6.09E-14
C-14	1.51E-05	Sb-125	3.41E+02	Gd-153	3.22E-11
Ni-59	3.15E-01	Sb-126	2.44E-03	Ho-166m	2.00E-06
Ni-63	7.57E+00	Sb-126m	1.74E-02	Tm-171	2.18E-11
Co-60	7.15E+00	Te-123	1.65E-14	Tl-207	1.65E-06
Se-79	1.92E-02	Te-125m	1.39E-01	Tl-208	4.96E-05
Rb-87	1.22E-06	I-129	6.64E-03	Tl-209	1.74E-10
Y-90	4.38E+03	Cs-134	3.65E+01	Pb-209	8.18E-09
Sr-90	4.20E+03	Cs-135	1.11E-01	Pb-210	1.22E-07
Zr-93	9.58E-02	Cs-137	6.34E+03	Pb-211	1.65E-06
Nb-93m	7.31E-02	Ba-137m	5.99E+03	Pb-212	1.39E-04
Nb-94	1.42E-01	La-138	8.18E-12	Pb-214	3.57E-07
Tc-98	1.13E-07	Ce-142	1.31E-06	Bi-210	1.22E-07
Tc-99	1.23E+00	Ce-144	5.54E-02	Bi-210m	9.58E-21
Rh-102	3.74E-05	Nd-144	6.96E-11	Bi-211	1.65E-06
Rh-106	1.21E-01	Pr-144	8.04E-02	Bi-212	1.39E-04
Ru-106	9.54E-02	Pr-144m	3.22E-04	Bi-213	8.18E-09
Pd-107	7.14E-04	Pm-146	2.18E-03	Bi-214	3.57E-07
Ag-108	1.65E-09	Pm-147	2.13E+01	Po-210	1.13E-07
Ag-108m	1.83E-08	Sm-146	1.22E-08	Po-211	4.70E-09
Ag-109m	5.48E-12	Sm-147	3.13E-07	Po-212	8.71E-05
Ag-110	1.39E-11	Sm-148	1.65E-12	Po-213	8.01E-09
Ag-110m	1.04E-09	Sm-149	1.48E-13	Po-214	3.57E-07
Cd-109	5.48E-12	Sm-151	4.27E+01	Po-215	1.65E-06
Cd-113m	1.39E-01	Eu-150	6.18E-07	Po-216	1.39E-04
In-115	4.35E-12	Eu-152	3.11E-01	Po-218	3.57E-07
Sn-119m	2.18E-10	Eu-154	3.03E+01	At-217	8.18E-09

Table 3-4. (continued).

Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)
Rn-219	1.65E-06	Pa-231	3.83E-06	Pu-240	1.19E+00
Rn-220	1.39E-04	Pa-233	1.31E-01	Pu-241	1.74E+02
Rn-222	3.57E-07	Pa-234	1.13E-06	Pu-242	1.41E-03
Fr-221	8.18E-09	Pa-234m	8.71E-04	Pu-243	9.58E-13
Fr-223	2.26E-08	U-232	2.52E-04	Pu-244	8.56E-11
Ra-223	1.65E-06	U-233	6.41E-06	Am-241	1.27E+01
Ra-224	1.39E-04	U-234	1.03E-01	Am-242	6.53E-04
Ra-225	8.18E-09	U-235	3.60E-03	Am-242m	6.53E-04
Ra-226	3.57E-07	U-236	4.58E-03	Am-243	2.75E-03
Ra-228	2.26E-11	U-237	2.79E-04	Cm-242	5.44E-04
Ac-225	8.18E-09	U-238	1.27E-03	Cm-243	3.55E-03
Ac-227	1.65E-06	U-240	2.87E-11	Cm-244	2.21E-01
Ac-228	2.26E-11	Np-236	1.31E-07	Cm-245	3.77E-05
Th-227	1.65E-06	Np-237	8.98E-02	Cm-246	2.44E-06
Th-228	1.39E-04	Np-238	3.31E-06	Cm-247	2.75E-12
Th-229	8.18E-09	Np-239	9.58E-04	Cm-248	2.89E-12
Th-230	1.04E-04	Np-240m	2.87E-11	Cf-249	2.20E-12
Th-231	3.60E-03	Pu-236	3.47E-04	Cf-250	1.77E-12
Th-232	3.05E-11	Pu-238	2.49E+02	Cf-251	3.39E-14
Th-234	8.71E-04	Pu-239	1.67E+01	Cf-252	1.57E-15

Table 3-5. Estimated uranium and plutonium concentrations in the UBS for the Tank Farm tanks.

Tank	Estimated Mass of Sludge in Each Tank (kg)	U-235 Concentration (g/l)	U-238 Concentration (g/l)	Pu-239 Concentration (g/l)	Pu-241 Concentration (g/l)	Average U-235 Enrichment (wt%)
WM-182	10,452	2.42E-01	2.28E-01	4.74E-02	2.99E-04	51.49
WM-183	19,743	1.61E-01	3.73E-01	4.03E-02	6.16E-05	30.15
WM-188	1,161	1.82E-01	7.03E-01	1.39E-02	1.16E-4	20.56

Reference 17 provides a discussion of the sample results for the Tank Farm tanks. The 30,000-gal tanks are essentially empty and contain no significant fissile material. Tank WM-190 does not contain uranium-bearing solids (UBS), as it was the designated as the spare tank for the Tank Farm.

After a tank has been emptied to the heel, the tank will be washed to remove as much material as possible and filled with grout. The washing process will continue until the tanks meet acceptable risk limits for grouting.[21,22,23] Residual liquids and solids left in a tank may contain quantities of uranium greater than 15 g of U-235. Table 3-6 provides a summary of the Ci content and the calculated mass of U-235, Pu-239, and Pu-241. Generally, a U-235 equivalent thermal system can be obtained by multiplying the Pu-239, Pu-241, and U-233 quantities by 2. The total fissile gram equivalent in a grouted tank, based on the worst-case scenario evaluated in Chapter 6, is calculated to be 325 g.[24]

Table 3-6. Estimated fissile inventory of a 300,000-gal tank prior to grouting.

Nuclide	Total (Ci)	Total Mass (g)	U-235 Equivalent (g)
U-235	5.8E-04	269	269
Pu-239	1.70E+00	27.7	55.4[a]
Pu-241	1.84E+01	0.2	0.4[a]
Total fissile gram equivalent (g).			325

a. U-235 equivalent (g) is calculated by multiplying total mass (g) of fissile material (such as Pu-239 and Pu-241) by 2.

3.3.2.1.3 Hazardous Chemical Inventory—The predicted chemical concentrations for the 300,000-gal tanks[17,18] are enveloped by the data presented in SAR-107, Table 3-4.

The data presented in SAR-107, Table 3-5, were obtained from the material safety data sheets[25] or the National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards.[26] The chemicals listed are those to which a Tank Farm closure worker could typically be exposed. Grout mix and demineralized water are the only materials being used for closure activities that are not already described in SAR-107. A mixture of cement, fly ash, sand, water, and water reducer is used for grouting Tanks WM-180 through WM-190, and WM-103 through WM-106 and associated components. Demineralized water is used to wash the tanks and vaults and to flush the valve boxes and piping.

3.3.2.1.4 Operational Experience—This section contains a summary of filed incident reports and occurrence reports applicable to the Tank Farm Closure Project. Historical operational

incidents associated with the Tank Farm as well as operational incidents and lessons learned were used to help identify potential hazards. A summary of this operational experience follows.

Two past incidents at the Tank Farm facility were found that pertain to use of the aboveground transfer lines. In 1974, a leak was discovered in a transfer line resulting from a hole that was inadvertently drilled in the pipe during original construction in 1955 and 1956. To determine the cause of failure, a section of pipe containing the hole was cut out for inspection. This inspection indicated that the pipe in general had suffered very little corrosion damage during its 18 years of intermittent service, and the failure was strictly a result of mechanical damage.[27] Evidence of another leak was identified in 1975. In this instance, acidic solution got past a partially open valve and contacted some carbon-steel piping. A leak developed in the piping, and radioactive solution was released to the Tank Farm soil. No carbon-steel to stainless-steel piping connections now exist in the Tank Farm.[28]

A listing of filed occurrence reports associated with the Tank Farm facility operations from 1991 to 1998 is contained in SAR-107, Table 3-6. The ORPS incident information contained in SAR-107, Table 3-6 was reviewed for previously identified hazards and event initiators applicable to Tank Farm closure activities. In addition, the ORPS database was searched for new occurrences applicable to the Tank Farm Closure Project not included in SAR-107. Occurrence Report ID-BBWI-WASTEMNGT-2002-0010[29] "Loss of Configuration Control: Steam Pressurizes Containment Control Tent" was considered applicable to the hazard identification process. The report describes an event where the removal of an incorrect steam jet during construction activities caused pressurization of the temporary enclosure when steam to the new jet was turned on. The root cause was determined to be deficiencies in configuration management implementation. No additional occurrence reports have been filed to date on the Tank Farm Closure Project.

3.3.2.1.5 Hazard Summary—Table 3-7 summarizes the nonroutine material and energy source hazards from Tank Farm closure operations that potentially could affect the public, workers, or the environment. These hazards include electrical energy, explosive materials, fissile material, flammable materials, radioactive materials, thermal energy, and hazardous materials (toxic chemicals). In addition to the hazards presented in Table 3-7, there are potential external and natural phenomena hazards identified in Chapter 1. These potential Tank Farm NPHs that are unique to the closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 are further evaluated in Section 3.3.2.3.5. Other NPHs that are also applicable to the Tank Farm Closure Project, such as seismic events, are covered in SAR-107.

Table 3-8 identifies occupational hazards, including standard industrial hazards, associated with Tank Farm closure operations, and the DOE-prescribed occupational safety and health standards that prevent or protect against such hazards. The occupational hazards listed in Table 3-8 are applicable to the Tank Farm closure. Standard industrial hazards are hazards that are routinely encountered in general industry and construction; for these, national consensus codes and/or standards, such as Occupational Safety and Health Administration (OSHA) standards, exist to guide safe design and operation. In accordance with the guidelines in DOE-STD-1027-92 and DOE-STD-3009-94, no special analysis is required for these occupational hazards unless they are possible initiators for an uncontrolled release of radioactive or hazardous material. Table 3-9 describes the hazard evaluation results specific to closure and grouting of the Tank Farm tanks.

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Table 3-7. Tank Farm closure nonroutine hazard identification and initiator summary.

Hazard	Hazard Source(s)	Concern
Fissile materials	Tank Farm liquid waste (U-235, Pu-238, Pu-239, and Pu-241)	Potential for an inadvertent nuclear criticality
Radiation/Radioactive materials	Tank Farm liquid waste	Potential for direct radiation exposure and a release of radioactive material
Hazardous materials	Tank Farm liquid waste, cooling system	Potential for hazardous material release
Explosive materials	Hydrogen generation	Hydrogen deflagration/detonation that causes a release of radioactive or hazardous material
Flammable materials	Combustible material in tank vaults, valve pits, etc.	Potential for a fire that could cause a release of radioactive and hazardous material
Initiators	**Hazard Source(s)**	**Concern**
Electrical energy	Electrical Distribution Systems	Potential initiator of a fire causing a release of radioactive or hazardous material.
Kinetic energy	Moving vehicles	Potential damage to piping and equipment and a release of radioactive and hazardous material
Potential energy	Lifting of heavy equipment and loading on tank vaults caused by heavy surface equipment	Potential damage to process equipment, vaults, tanks and release of radioactive and hazardous material
Pressure	Tank cleaning, line flushing, and grout filling operations	Potential for rupturing a tank or lines and a release of radioactive and hazardous materials
Vacuum	Isolation of tank(s) from Tank Farm vessel off-gas system and removal of pressure relief valves	Potential for imploding a tank or lines and a release of radioactive or hazardous material
Natural phenomena	Earthquake, high winds, snow etc.	Potential initiators of a release of radioactive or hazardous material
External events	Vehicle fuel fire, range fire, etc.	Potential initiator of a release of radioactive or hazardous material

Table 3-8. Tank Farm closure occupational hazard analysis checklist.

Hazard	Applicable to Facility (Y/N)	DOE-Prescribed Program and OSH Standards
High voltage (≥600 V)	No	29 CFR 1910 Subpart S; NEC 70
Low voltage (<600 V)	Yes	29 CFR 1910 Subpart S; NEC 70
Volatile flammable or reactive gases or liquids	Yes	29 CFR 1910 Subpart H, .144, .1200; 29 CFR 1926.152
Explosive materials	No	29 CFR 1910.109; DOE Explosive Safety Manual (DOE Manual 440.1-1)
Cryogenic systems	No	None of the DOE-prescribed standards clearly address cryogenics
High temperature (≥125°F at contact or 203°F	Yes	ASME Boiler and Pressure Vessel Code, ASME Standard B31
High pressure (≥25 psig for gas or vapor or ≥200 psig for liquids)	Yes	ASME Boiler and Pressure Vessel Code, ASME Standard B31
Low pressure	Yes	ASME Boiler and Pressure Vessel Code, ASME Standard B31
Inert and low-oxygen atmospheres	Yes	29 CFR 1910.119, .120, .1200; 29 CFR 1926.651
Toxic materials	Yes	29 CFR 1910.119, .120, .1200, Subpart Z; 29 CFR 1926.353; ACGIH TLVs
Nonionizing radiation	No	29 CFR 1910.97; ACGIH TLVs
High-intensity magnetic fields	No	ACGIH TLVs
High noise levels	Yes	29 CFR 1910.95, .1200; 29 CFR 1926.52; ACGIH TLVs
Mechanical and moving equipment dangers	Yes	29 CFR 1910.147, .211 through .222; 29 CFR 1910 Subparts O, P, Q; 29 CFR 1926 Subpart W
Working at heights	Yes	29 CFR 1910.25, .28; 29 CFR 1926.951, .451
Excavation	Yes	29 CFR 1926 Subpart P
Material handling dangers	Yes	29 CFR 1910.120, .176 through .182; 29 CFR 1926.953; DOE-STD-1090-2001 Hoisting and Rigging
Material transportation	No	Hazardous Material Transportation Program, DOE Orders 460.1A and 460.2
Pesticide use	No	29 CFR 1910.1200
Temperature extremes (high and low temperatures during activities)	Yes	29 CFR 1910.120, .1200; ACGIH TLVs
Inadequate illumination	Yes	29 CFR 1910.37, .68, .120, .177 through .179, .219, .303; 29 CFR 1926.26
Construction	Yes	29 CFR 1926
Ionizing radiation	Yes	Radiation Protection Program, 10 CFR 835
Reactive materials: Alkali metal and corrosives	Yes	Chemical Safety Program DOE Order 5480.4; 29 CFR 1910.1200, .1450
Structural or natural phenomena	Yes	DOE Order 420.1A, DOE-ID Architectural Engineering Standards, DOE-GDE-420.1-2, 29 CFR 1910.119, Subpart E
Fire	Yes	Fire Protection Program, DOE Order 420.1A
Biological agents	No	None of the DOE-prescribed standards clearly address biological agents; however, the following should be adhered to: 42 CFR 72.6 and 32 CFR 627
Other	No	29 CFR 1903.1 (General Duty Clause)

ACGIH	American Conference of Government Industrial Hygienists
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
NEC	National Electric Code NEC
OSH	occupational safety and health
TLV	threshold limit value

Table 3-9. Additional hazard evaluation results for the closure of INTEC Tanks WM-180 through WM-190 and WM-103 t

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
1. Inadvertent Nuclear Criticality	Criticality in a tank	See Chapter 6	See Chapter 6	See Chapter 6	—	See Chapter 6.
2. Radiation/ Radioactive Material Release	Direct radiation exposure from radioactive material in tanks	Normal Tank Farm closure operations	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: N	7 7 7 —	Shield blocks, valve box lid, soil overburden.
	Direct radiation exposure from unshielded aboveground transfer line	Normal Tank Farm closure operations	Anticipated	Public: N Co-located worker: N Facility worker: M Environment: N	7 7 ***14*** —	—
	Releases due to storage tank failure	Static and dynamic loads on tank vaults	Anticipated	Public: N Co-located worker: N Facility worker: L Environment: H	7 7 ***11*** —	***Vault structural design.***
	Release of radioactive material during transfer of tank solution due to crane or vehicle mishap	Crane tips over while removing or installing steam jet or wash ball, or during grouting activities, causing damage to the aboveground transfer line (f)	Anticipated	Public: N Co-located worker: H Facility worker: H Environment: L	7 ***16*** ***16*** —	—

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Table 3-9. (continued).

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
	Release of radioactive material due to dropped equipment	Riser lid, shield block, or valve box lid is dropped and causes damage to aboveground transfer line (g)	Anticipated	Public: N Co-located worker: H Facility worker: H Environment: L	7 ***16*** ***16*** —	—
	Release of radioactive material from excavation	Excavation of highly contaminated soil	Anticipated	Public: N Co-located worker: N Facility worker: L Environment: L	7 7 ***11*** —	—
	Release of radioactive material from tank cleaning operations	Overpressure while cleaning insides of tank (h)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	Pressure alarms and pressure relief valves. Connections to the VOG system.
	Release of radioactive material during transfer of tank solution	Overpressure causes rupture of aboveground transfer line (h)	Unlikely	Public: N Co-located worker: H Facility worker: H Environment: L	4 ***15*** ***15*** —	***Design of aboveground transfer line secondary encasement***. Leak detection (radiation) system. Vault and valve box confinement.
	Release of radioactive material during transfer of tank solution	Leak from improper installation of aboveground transfer line or defective materials	Unlikely	Public: N Co-located worker: H Facility worker: H Environment: L	4 ***15*** ***15*** —	***Design of aboveground transfer line secondary encasement***. Leak detection (radiation) system. Vault and valve box confinement.

Table 3-9. (continued).

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
	Release of radioactive material during transfer of tank solution due to vehicle collision with the aboveground transfer line	Vehicle collision with aboveground transfer line (f)	Anticipated	Public: N Co-located worker: H Facility worker: H Environment: L	7 ***16*** ***16*** —	—
	Release of radioactive material from isolation of waste transfer lines	Expulsion of materials from a cut line due to incomplete depressurization of a transfer line (f)	Anticipated	Public: N Co-located worker: N Facility worker: L Environment: L	7 7 ***11*** —	—
	Release of radioactive material from isolation of waste transfer lines	Expulsion of materials due to sudden release of stored energy as the cut line breaks (g)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	—
	Release of radioactive material from flushing lines	Excessive pressure causes rupture of waste transfer lines or valves (h)	Unlikely	Public: N Co-located worker: N Facility worker: N Environment: L	4 4 4 —	Flushing pressures withi design limits of waste transfer lines, coolant lines, and valves. Tank level indication and alarms. Vault confinement, sumps, and sump level detection.
	Release of radioactive material from sampling activities	Releases due to tank puncture from dropped sampling equipment (g)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	Sampling equipment designed to prevent dropping. Vault confinement, sumps, and sump level detection. Vault sump pumps.
	Release of radioactive material from sampling activities	Airborne releases due to sample spill during sample handling or transportation of the sample to the Remote Analytical Laboratory	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	—

Table 3-9. (continued).

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
	Release of radioactive material from grouting activities	Overpressure of lines and valves, causing rupture and grout expulsion (h)	Unlikely	Public: N Co-located worker: N Facility worker: N Environment: N	4 4 4 —	Grouting pressure within design limits of waste transfer lines; coolant lines; and valves.
	Loss of temporary VOG system during final stages of grouting	Equipment failure, operator error (h,i)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	Temporary VOG system design.
3. Hazardous Material Release	Release of hazardous material during transfer of cooling-water	Overpressure causes rupture of aboveground cooling-water transfer line (h)	Unlikely	Public: N Co-located worker: N Facility worker: N Environment: L	4 4 4 —	Design of aboveground cooling-water transfer line and encasement.
	Release of hazardous material from aboveground cooling-water transfer line	Riser lid, shield block, or valve box lid is dropped and causes damage to aboveground cooling-water transfer line (g)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	—
	Release of hazardous material due to vehicle collision with the aboveground cooling-water transfer line	Vehicle collision with aboveground cooling-water transfer line (f)	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	—
	Release of hazardous material from grouting activities	Overpressure of lines and valves, causing rupture and grout expulsion (h)	Unlikely	Public: N Co-located worker: N Facility worker: N Environment: L	4 4 4 —	Grouting pressure within design limits of waste transfer lines; coolant lines; and valves.
4. Fire and Explosion Hazards	Electrical fire in temporary enclosure and release of radioactive and hazardous materials	Ignition of combustibles in temporary enclosure	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	7 7 7 —	—

Table 3-9. (continued).

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
	Ruptured tank and release due to hydrogen deflagration/detonation	Ignition of hydrogen gas reaching LFL	Extremely Unlikely	Public: N Co-located worker: L Facility worker: M Environment: L	2 5 9 —	Air purge system. Tanks interconnected through VOG system and instrument air flows to tanks, pressure relief valves. Temporary vesse APS.
	Ruptured tank and release due to vehicle fuel tank rupture/spill above tank	Fuel leaks into tank riser or valve box and ignition source present	Beyond Extremely Unlikely	Public: N Co-located worker: N Facility worker: L Environment: L	1 1 3 —	Tank and vault design. Riser, valve box, and reach rod design.
	Ruptured tank and release of radioactive and hazardous material due to tank heel incompatibility with grout	Grout reacts with tank heel	Unlikely	Public: N Co-located worker: N Facility worker: N Environment: L	4 4 4 —	Tank and vault structural design. Temporary vesse APS. Pressure relief valves.
5. Natural phenomena hazards	Airborne release of radioactive material due to damage/collapse of temporary enclosure, exposure to personnel and release to the environment	High wind	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	k k k —	—
	Airborne release of radioactive material due to damage/collapse of temporary enclosure, exposure to personnel and release to the environment	Snow	Anticipated	Public: N Co-located worker: N Facility worker: N Environment: L	k k k —	—
	Airborne release of radioactive material due to low temperatures causing liquid waste to freeze, expand and damage aboveground transfer line	Extreme temperature	Unlikely	Public: N Co-located worker: N Facility worker: L Environment: L	k k k —	Design of aboveground transfer line.

Table 3-9. (continued).

			Likelihood, Consequence, and Risk Without Controls			Preventive an
Hazard	Hazardous Event	Initiator/Cause	Likelihood[a] Category	Consequence Category[b]	Risk Bin Number[c]	Design[d]
	Airborne release of radioactive material due to damage/collapse of temporary enclosure, exposure to personnel and release to the environment	Range fire (k)	Unlikely	Public: N Co-located worker: N Facility worker: L Environment: L	k k k —	Fire break maintained around INTEC.

a. The likelihood categories are listed and described in Table 3-1.

b. The consequence categories are listed and described in Tables 3-2 and 3-3; N = Negligible L = Low M = Moderate H = High.

c. Risk bin numbers are highlighted in bold italics if they indicate that safety SSCs, TSRs, and/or safety requirements should be identified to manage risk (see Figure

d. SSCs designated as safety-class or safety-significant SSCs are highlighted in bold italics if they are required to prevent or mitigate a hazard, per the methodology i "Safety Structures, Systems, and Components," for additional information on these safety SSCs.

e. TSR and safety requirement-level controls are highlighted in bold italics if they are required to prevent or mitigate a hazard, per the methodology in Section 3.3.1. Technical Safety Requirements," for additional information on TSRs and safety requirements.

f. This event is initiated by kinetic energy (see Table 3-7).

g. This event is initiated by potential energy (see Table 3-7).

h. This event is initiated by pressure (see Table 3-7).

i. This event is initiated by vacuum (see Table 3-7).

j. This event is initiated by an external event (see Table 3-7).

k. The risk of the NPH is discussed in Section 3.3.2.3.5.

APS Atmospheric Protection System
CFA Central Facilities Area
INTEC Idaho Nuclear Technology and Engineering Center
LFL lower flammability limit
NPH natural phenomena hazard
SSC structure, system, and component
TSR technical safety requirement
VOG vessel off-gas

3.3.2.2 Hazard Categorization. 10 CFR 830, Subpart B, "Safety Basis Requirements,"[1] DOE-ID Order 420.C, "Safety Basis Review and Approval Process,"[4] and DOE-ID Order 420.D, "Requirements and Guidance for Safety Analysis,"[5] require that a hazard categorization be prepared for all activities over which DOE has assumed environmental, safety, and health responsibility. A hazard categorization defines the level of hazard posed by an operation or activity and assumes that no mitigating systems are available. DOE-STD-1027-92 provides a uniform methodology for hazard classification that meets the requirements of 10 CFR 830, Subpart B.

The potential total inventories of radionuclides given in Section 3.3.2.1 for the Tank Farm exceed the 1,000-Ci threshold for mixed fission products specified in DOE Standard, DOE-STD-1027, for a Hazard Category 2 facility. Furthermore, since the tanks undergoing closure are within the boundaries of the Tank Farm, Hazard Category 2 is designated for the closure of the tanks as well (the same hazard category determined in SAR-107 for the Tank Farm).

3.3.2.3 Hazard Evaluation. Table 3-7 provides the results of the hazard evaluation for the hazards identified in Section 3.3.2.1. The following sections discuss the results presented in Table 3-9:

The discussion of the results of the hazard evaluation in this section is organized as follows.

- Criticality (Section 3.3.2.3.1)
- Radiation/Radioactive material release (Section 3.3.2.3.2)
- Hazardous material release (Section 3.3.2.3.3)
- Fire and explosion hazards (Section 3.3.2.3.4)
- Natural phenomena hazards (Section 3.3.2.3.5)

Section 3.3.2.4 is a summary of the hazard evaluation addressing planned design and operational safety improvements, defense in-depth, worker protection, environmental protection, and accident selection.

3.3.2.3.1 Criticality—Criticality hazards associated with closure of INTEC Tanks WM-180 through WM-190 and WM-103 through WM-106 were evaluated based on the fissile content of the facility inventory. Refer to Chapter 6 of this addendum for a detailed evaluation of this hazard.

3.3.2.3.2 Radiation/Radioactive Material Release—

3.3.2.3.2.1 Direct Radiation Exposure Hazards

Normal Operations: The Tank Farm tanks are located in underground vaults. Personnel are shielded from direct radiation from the tanks and underground transfer lines by the soil overburden. Removable shielding is provided for the tank risers and the access ways into the valve boxes. Under normal operating conditions, the tanks present no significant direct radiation hazard. A worker exposure to direct radiation from Tank Farm closure activities is anticipated. Tank Farm closure activities include, but are not limited, to removal and disposal of shielding and the cutting and isolation of contaminated piping (Section 3.3.2.3.2.8). The likelihood of a worker exposure to direct radiation from Tank Farm

closure activities is anticipated. The consequences of a worker exposure to direct radiation due to Tank Farm closure activities are estimated to be negligible for the off-site public, co-located workers, facility workers, and the environment. The risk associated with a release of radioactive material due to a tank failure is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Aboveground Transfer Line. Closure of Tanks WM-184 through WM-190 and WM-103 through WM-106 requires the installation and use of an aboveground transfer line. The likelihood of a worker exposure to direct radiation from an unshielded aboveground transfer line is anticipated. The consequences of this event are estimated to be "negligible" for the off-site public, co-located workers and the environment, and "moderate" for facility workers. The risk associated with a direct radiation exposure from an unshielded line is acceptable for the off-site public and co-located workers without additional controls. The facility worker risk associated with direct radiation exposure from an unshielded transfer line is unacceptable. This hazardous event was selected for further accident analysis in Section 3.4.

3.3.2.3.2.2 Releases due to Storage Tank Failure. Vault damage from static or dynamic overloading (such as construction activities or vehicle traffic over the vaults) could occur if loads exceed the design load for the vaults. The likelihood of a radioactive material release from a damaged tank due to static and dynamic loads on the tank vaults is anticipated. The weight of the crane or vehicles could overload the vault roof and cause stress cracks and the release of concrete pieces that could damage or rupture a tank. Vault confinement could also be compromised resulting in a radioactive material release. The consequences of a radioactive material release due to tank failure are estimated to be negligible for the off-site public and co-located workers, low for facility workers, and high for the environment. The risk associated with a release of radioactive material due to a tank failure is acceptable for the off-site public and co-located workers. The facility worker risk associated with a release of radioactive material is unacceptable and requires a safety-significant SSC and a safety requirement to reduce the likelihood of this event. The vaults for the 300,000-gal storage tanks are safety-significant with respect to the tanks' capability to maintain overall structural integrity under evaluation basis loads to prevent vault and subsequent tank failure and release of radioactive material. Load controls are required to preclude vehicle traffic and construction activities from overloading the tanks. Loading due to vehicles and other operations at the Tank Farm is controlled by allowing only specific types of vehicles in certain areas and by providing controls for crane operations. Application of this safety-significant SSC and safety requirement results in a reduction of the likelihood of this event to unlikely, which results in an acceptable level of risk to facility workers. A major tank failure was evaluated in the accident analysis in Section 3.4 of SAR-107.

3.3.2.3.2.3 Radioactive Material Release from Equipment Mishaps.

Crane Mishap. A radioactive material release could be initiated by a crane tipping over while removing or installing a steam jet or a wash ball, or during grouting, and damaging the aboveground transfer line. The likelihood of a radioactive material release from a damaged aboveground transfer line due to a crane mishap is anticipated. The impact of the crane boom falling on the aboveground transfer line during transfer operations could rupture the line and result in a radioactive material release. The consequences of a radioactive material release due to a crane mishap are estimated to be negligible for the off-site public, high for co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a crane mishap is acceptable for the off-site public. The risk to co-located workers and facility workers associated with a release of radioactive material is

unacceptable and requires a TSR-level administrative control to prohibit use of vehicles on the Tank Farm during aboveground transfer of tank solution to reduce the likelihood of this event. Implementation of this TSR-level administrative control results in a reduction of the likelihood of this event, which results in an acceptable level of risk to facility workers.

Equipment Drop. Dropping of heavy equipment (such as a riser lid, shield block, or valve lid) on the aboveground transfer line could rupture the line and result in a radioactive material release. The likelihood of a radioactive material release due to an equipment drop is anticipated. The consequences of a radioactive material release due to an equipment drop are estimated to be negligible for the off-site public, and high for co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to an equipment drop is acceptable for the off-site public. The risk to co-located workers and facility workers associated with a release of radioactive material is unacceptable and requires a TSR-level administrative control to prohibit use of vehicles on the Tank Farm during aboveground transfer of tank solution to reduce the likelihood of this event. Implementation of this TSR-level administrative control results in a reduction of the likelihood of this event, which results in an acceptable level of risk to facility workers.

3.3.2.3.2.4 Radioactive Material Release from Excavation. An airborne radioactive material release could result from the excavation of contaminated soil in the Tank Farm. The consequences of such a release would depend on soil and wind conditions as well as the excavation equipment used. The likelihood of an airborne radioactive material release due to excavation is anticipated. The consequences of this event are estimated to be negligible for the off-site public and co-located workers, and low for facility workers and the environment. The risk associated with a release of radioactive material due to excavation is acceptable for the off-site public and co-located workers. The facility worker risk associated with a release of radioactive material is unacceptable and requires a safety requirement to reduce the likelihood of this event. Implementation of the INTEC Excavation Control Program is required to reduce the likelihood of an airborne radioactive material release and exposures to personnel (see SAR-107). Implementation of the INTEC excavation control program reduces the likelihood of damaging underground piping and equipment to unlikely, which results in an acceptable level of risk to facility workers.

3.3.2.3.2.5 Radioactive material Release from Overpressure

Tank Overpressure. A tank failure or rupture could occur from overpressure or excessive vacuum while washing a tank. The likelihood of a radioactive material release from tank washing operations is anticipated. Vacuum or pressure damage to a tank could occur if the off-gas system is plugged or shut down. A temporary APS may be used in the final stages of grouting a tank system. If the off-gas system were plugged during emptying of a tank, a vacuum could develop that could damage the tank and result in a release to the vault. A liquid waste release to the vault could also be initiated by a rupture of a tank due to excess air or steam pressure with concurrent off-gas plugging. The consequences of a radioactive material release due to tank failure are estimated to be negligible for the off-site public, co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a tank failure is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Aboveground Transfer Line Overpressure. Closure of Tanks WM-184 through WM-190 and WM-103 through WM-106 requires the installation and use of aboveground transfer lines. An airborne radioactive material release is postulated to occur due to overpressure while transferring residual heel

material from an operating tank undergoing closure. The likelihood of an aboveground transfer line rupture due to overpressure during a transfer is unlikely. The consequences of this event are estimated to be negligible for the off-site public, high for co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a transfer-line rupture is acceptable for the off-site public. The risk to co-located workers and facility workers associated with a release of radioactive material is unacceptable. This hazardous event was selected for further accident analysis in Section 3.4.

3.3.2.3.2.6 Leak of Radioactive Waste from Aboveground Transfer Line. A leak of radioactive waste from an aboveground transfer line during a transfer is unlikely. A spill on the ground from a leaking line and a subsequent airborne radioactive material release is postulated to occur due to improper installation of the aboveground transfer line or defective materials. The consequences of this event are estimated to be negligible for the off-site public, high for co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to improper installation of the aboveground transfer line or defective materials is acceptable for the off-site public. The risk to co-located workers and facility workers associated with a release of radioactive material is unacceptable and requires a safety significant SSC to reduce the likelihood of this event. The secondary encasement for the aboveground transfer line is safety-significant with respect to its capability to provide confinement of the tank solution being transferred, should the transfer line leak during use, thus mitigating a release of radioactive and chemical constituents to the environment which results in an acceptable level of risk to facility workers.

3.3.2.3.2.7 Radioactive Material Release from Vehicle Collision. A vehicle collision with the aboveground transfer line by a vehicle within the Tank Farm and subsequent release of radioactive and hazardous material is anticipated. However, a significant vehicular impact with the aboveground cooling transfer line by a vehicle crashing through the Tank Farm fence is extremely unlikely because the elevation of the Tank Farm is higher in comparison with the surrounding road and the aboveground equipment (such as tank risers and valve boxes) obstructing the vehicle path. The hazardous materials contained in the Tank Farm waste are not analyzed separately for this event under "Hazardous Material Release," in Table 3-9 because the radioactive hazards are judged to greatly exceed the nonradioactive hazards. The consequences of this event are estimated to be negligible for the off-site public, and high for co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a transfer-line rupture is acceptable for the off-site public. The risk to co-located workers and facility workers associated with a release of radioactive material is unacceptable and requires a TSR-level administrative control to prohibit use of vehicles on the Tank Farm during aboveground transfer of tank solution to reduce the likelihood of this event. Implementation of this TSR-level administrative control results in a reduction of the likelihood of this event, which results in an acceptable level of risk to facility workers.

3.3.2.3.2.8 Radioactive Material Release from Line Isolation

<u>Radioactive Material Release Due to Pressurized Line</u>. During the closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 and subsequent isolation from the rest of the Tank Farm, certain lines must be severed. The lines to be closed, with an associated tank system, are flushed, capped, and filled with grout. All lines are cut using mechanical means. A release of radioactive material could occur if a line has not been depressurized prior to severing the line. The likelihood of a radioactive material release caused by cutting a pressurized liquid waste transfer line is anticipated. The

consequences of a radioactive material release due to a pressurized line are estimated to be negligible for the off-site public and co-located workers, and low for facility workers, and the environment. The risk associated with a release of radioactive material due to a pressurized line is acceptable for the off-site public and co-located workers without additional controls. The facility worker risk associated with a release of radioactive material is unacceptable and requires implementation of the radiation protection program. Implementation of the radiation protection program reduces the likelihood a worker exposure (both airborne and external exposure) to radioactive material by specifying workplace controls as needed.

Radioactive Material Release Due to Release of Stored Energy. During closure of Tanks WM-180 through WM-190 and WM-103 through WM-106 from the rest of the Tank Farm, certain lines must be severed. Prior experience with cutting lines at the Tank Farm has shown that sudden, strong movement of the cut pipe ends is possible because the pipes were forced into position during construction. Such releases of stored mechanical energy could cause any contamination within the pipes to be flung about in the immediate area of the cut as well as providing some risk of injury to the workers doing the cutting from the sudden pipe movement. The likelihood of a radioactive material release from cutting a liquid waste transfer line is anticipated. The consequences of a radioactive material release due to a release of stored mechanical energy by a cut line are estimated to be negligible for the off-site public, co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a release of stored mechanical energy by a cut line is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.2.9 Radioactive Material Release from Line Flushing. Excessive pressure applied to the lines during flushing could cause the lines to rupture and release radioactive material. The overpressure could be caused by clogging of the lines as contaminated solids are removed from the pipe walls. The likelihood of a radioactive material release from a ruptured line during line flushing is unlikely. The consequences of a radioactive material release due to a ruptured line are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a ruptured line is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.2.10 Release of Radioactive Material from Sampling Activities

Tank Puncture. A tank failure or rupture could occur from dropped equipment down a tank riser during sampling, inspection, and maintenance. Tank entry equipment is designed to prevent complete passage of the equipment through the riser. The likelihood of a tank puncture resulting in a release of radioactive material is anticipated. A radioactive liquid waste release from a tank would be contained by the associated vault. There is only a very small possibility that an event like this could result in contamination reaching the soil beneath the tank and eventually finding its way to the groundwater. Designs of the samplers and procedures for use minimize the likelihood that they can be dropped in such a way that tank penetration will occur. The consequences of a radioactive material release due to a ruptured tank are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a ruptured tank is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Sample Transportation. A radioactive material release could result from a spill of a sample during handling and transport of the sample to the Remote Analytical Laboratory (RAL). A spill during the handling and transport of a sample to RAL is an anticipated event. The consequences of a radioactive

material release due to a mishap during transport of a sample to RAL are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material during sample handling and transfer of a sample to RAL is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.2.11 Release of Radioactive Material From Grouting The waste transfer lines into and out of a tank and its encasements will be isolated and grouted after cleaning as part of a tank system closure. The grouting process has the potential to overpressurize lines and cause the lines to rupture and expel some grout. The likelihood of a line rupture resulting in a release of radioactive material is unlikely. A small amount of radioactive contamination may be scoured from the pipe walls by the grout before it is expelled. The consequences of a radioactive material release due to grouting of lines are estimated to be negligible for the off-site public, co-located workers, facility workers, and the environment. The risk associated with an airborne radioactive release of radioactive material during grouting of the transfer lines is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.2.12 Loss of Temporary VOG Closure activities may require that a temporary VOG system be used in the final stages of grouting to control releases of radioactive material, to maintain negative airflow through the open risers on Tanks WM-180 through WM-190, and to isolate the tanks from the rest of the Tank Farm. An airborne radioactive release could result from failure of the temporary VOG or operator error. The likelihood of a loss of the temporary VOG system resulting in an airborne radioactive release is anticipated. The consequences of a radioactive airborne release due to a loss of the temporary VOG are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with an airborne radioactive release due to loss of the temporary VOG system is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.3 Hazardous Material Release

Aboveground Cooling Water Transfer Line Overpressure. Closure of the Tank Farm tanks with cooling capability requires the installation and use of aboveground cooling-water transfer lines. Excessive pressure applied to the cooling lines and coils during flushing could cause a line to rupture and result in a chemical release. The overpressure could be caused by clogging of the lines as solids are removed from the pipe walls. A chemical release is postulated to occur due to overpressure while using the aboveground cooling-water transfer line to transfer chromium-laden cooling water from CPP-628 to the B3 valve box. From the B3 valve box, cooling water is transferred to an operating tank using existing underground transfer lines. The likelihood of an aboveground transfer-line-failure rupture due to overpressure during a transfer is unlikely due to the design of the aboveground cooling-water transfer lines. The consequences of this event are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a chemical release due to a transfer line rupture is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Equipment Drop. Dropping of heavy equipment, such as a riser lid, shield block, or valve lid on the aboveground cooling-water transfer line could rupture the line and result in a hazardous material release. The likelihood of a hazardous material release due to an equipment drop is anticipated. The consequences of a hazardous material release due to an equipment drop are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a

release of radioactive material due to an equipment drop is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Vehicle Collision. A vehicle collision with the aboveground cooling-water transfer line by a vehicle within the Tank Farm and subsequent release of hazardous material is anticipated. A significant vehicular impact with the aboveground cooling-water transfer line by a vehicle crashing through the Tank Farm fence is unlikely because the elevation of the Tank Farm is higher in comparison with the surrounding road and the aboveground equipment (such as tank risers and valve boxes) obstructing the vehicle path. The consequences of this event are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of hazardous material due to a transfer line rupture is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Chemical Release from Grouting. The cooling lines into and out of a tank and cooling coils are isolated and grouted after cleaning as part of a tank system closure. The grouting process has the potential to overpressurize lines and cause the lines to rupture and expel some grout. A small amount of hazardous material may be scoured from the pipe walls by the grout before it is expelled. The likelihood of a line rupture resulting in a chemical release is unlikely. The consequences of a chemical release due to the grouting of lines are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a chemical release during grouting of the cooling lines and coils is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.3.4 Fire and Explosion Hazards

Temporary Enclosure Fire. Temporary enclosures are installed over the tank and vault risers to allow safe access to equipment used during closure. An electrical fire in a temporary enclosure and ignition of contaminated, combustible materials is anticipated. The consequences of a worker exposure to direct radiation due to Tank Farm closure activities are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material due to an electrical fire is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Hydrogen Explosion. The generation of hydrogen caused by radiolytic decay of water has the potential to produce explosive conditions if hydrogen concentrations reach the lower explosive limit. Opening of a tank riser to install the wash ball, or to add or remove jets or sampling equipment introduces a potential initiator of a hydrogen deflagration/detonation. Hydrogen buildup to levels of concern is prevented by maintaining the dilution flow into each tank. The few volatile organics in the solution could also be removed by the air purge of the tanks. Calculations show that the time required to build up sufficient hydrogen in the tanks after air purge failure is much greater than one week. The process off-gas (POG) system HEPA filters are located in CPP-649 downstream of the Tank Farm tanks. The POG filters will not be damaged by an explosion pressure wave or flame front propagating through the off-gas line because of the distance to the POG system due to the mist eliminators and condensers that cool the gas and provide protection for the POG filters.[30,31,32,33] In order to meet acceptable risk limits, the concentration of radionuclides will be greatly reduced. These radionuclide concentrations are significantly reduced from the original Tank Farm tank solution concentrations; therefore, the potential for hydrogen generation in the decontaminated tanks is qualitatively assessed to be reduced. With the reduction of radionuclide

concentrations, the need for air purge flow instrumentation maintenance, air purge flow instrumentation calibration checks, minimum airflow requirements, or hydrogen concentration verification was qualitatively determined to not be required. After final washing operations, the likelihood of a hydrogen deflagration/detonation is extremely unlikely. The consequences of a worker exposure to direct radiation due to Tank Farm closure activities are estimated to be negligible for the off-site public, low for co-located workers and the environment, and moderate for facility workers. The risk associated with a release of radioactive material due to a hydrogen explosion is acceptable for the off-site public, co-located workers, and facility workers without additional controls. A hydrogen explosion was evaluated in the accident analysis in Section 3.4 of SAR-107. Safety requirements have been identified in Table 3-9 for defense in-depth and are listed in Section 3.3.2.4.2.

Vehicle Related Fire. Vault and tank damage due to a fire or explosion at the Tank Farm is a potential liquid-waste-release event. An accident involving surface equipment such as trucks or cranes could result in a fuel tank puncture and flaming fuel released near the tanks undergoing closure. Another initiator is a fuel leak into a vault from a vehicle collision outside the Tank Farm fence. This is beyond extremely unlikely because of the speed limit at the INTEC and the fenced vault area. The consequences of a vehicle fire due to Tank Farm closure activities are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a fire or explosion near a tank is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Grout Incompatibility. Grout being added to a Tank Farm tank could be incompatible with the residual heel in the tank and cause an exothermic chemical reaction in a tank. The chemical aspects of adding grout to the remaining heel in the decontaminated tanks have been evaluated.[34] The temperature increase associated with the acid-base reaction at the grout/heel interface is expected to be negligible. The likelihood of incompatible grout being added to a tank resulting in a tank rupture is unlikely. The consequences of a radioactive and hazardous material release due to a tank rupture are estimated to be negligible for the off-site public, co-located workers, and facility workers, and low for the environment. The risk associated with a release of radioactive material due to a tank rupture is acceptable for the off-site public, co-located workers, and facility workers without additional controls. A waste compatibility control program is in place for the Tank Farm as derived in Chapter 5 of SAR-107 and specified in TSR-107.

3.3.2.3.5 Natural Phenomena Hazards

High Winds. The temporary enclosures could be damaged by high winds. Damage to a temporary enclosure over one of the tank or vault risers could result in a radioactive airborne release. A release of radioactive material due to high wind is anticipated. Damage and collapse of the temporary enclosure are postulated to occur. The consequences of this event are estimated to be negligible for the off-site public, co-located workers and facility workers, and low for the environment. The risk associated with a release of radioactive material due to high winds is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Snow. The weight of snow on the temporary enclosure structure could cause it to collapse. Rigid, sloped roofs are constructed over the enclosures to protect them from snow damage. The likelihood of a temporary enclosure structure collapsing because of snow loading is anticipated. The consequences of this event are estimated to be negligible for the off-site public, co-located workers, and facility workers, and

low for the environment. The risk associated with a release of radioactive material due to snow loading is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Temperature Extremes. Release of radioactive or hazardous material due to temperature extremes is estimated to be unlikely. It is postulated that extremely low temperatures cause liquid waste in an aboveground transfer line to freeze, expand, and cause damage to an aboveground transfer line. The consequences of this event are estimated to be negligible for the off-site public and co-located workers, and low for facility workers and the environment. The risk associated with a release of radioactive material due to temperature extremes is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

Range Fires. Range fires at the INEEL are addressed in Chapter 1 of SAR-100. Range fires are common on the INEEL site and have burned several tens of square miles at a time. The likelihood of a range fire occurring on the INEEL is considered anticipated. The potential exists for an ember to lodge on the exterior of a temporary enclosure. This ember could melt a hole in the enclosure material, which could result in an unfiltered airborne release. The potential also exists for the fire to degrade the temporary enclosure HEPA filters. The dust and soot from a range fire could result in the rapid loading of the HEPA filters. The consequences of a release of radioactive and hazardous materials from a fire initiated as a result of a range fire are estimated to be low for facility workers and the environment, and negligible for co-located workers and the environment. The risk associated with a release of radioactive and hazardous material due to a range fire is acceptable for the off-site public, co-located workers, and facility workers without additional controls.

3.3.2.4 Summary—This section summarizes the results of the hazard evaluation including discussions of planned design and operational safety improvements, defense in-depth, worker safety, environmental protection, and accident selection. As shown in Table 3-9, for all hazardous events where the estimated risk without controls exceeds established evaluation guidelines (risk bins in the shaded area of the risk matrices of Figures 3-1, 3-2, and 3-3), controls are designated or identified to reduce the risk below the INEEL Risk Evaluation Guidelines. Safety SSCs are also identified that provide significant defense in-depth. The SSCs, TSRs, and safety requirements listed in Section 3.3.2.4.2 of this SAR are essentially the same as those designated in SAR-107, with a few additional entries. However, since some of those given in SAR-107 do not apply to the closure of the Tank Farm, only the applicable ones are repeated.

3.3.2.4.1 Planned Design and Operational Safety Improvements—The hazard evaluation identified no needed design or operating safety improvements for closure of the Tank Farm tanks.

3.3.2.4.2 Defense In-Depth—The hazard evaluation results presented in Table 3-9 demonstrate that the Tank Farm Closure Project is designed and operations are planned with a defense-in-depth approach that protects the off-site public, co-located workers, facility workers, and the environment from the potential hazards. Physical barriers (incorporated in the design and construction of the Tank Farm), administrative controls, and mitigating features contribute to defense in-depth. Based on the hazard analysis of Sections 3.3.2.3.1 through 3.3.2.3.5 and the accident analyses of Section 3.4, safety SSCs, TSR-level controls, and safety requirements that apply to the control of all identified hazards have been derived and are listed below. Based on the radiological hazard in SAR-107, Chapter 3, and the radiological hazard in Chapter 3 of this SAR, the vaults for the 300,000-gal storage tanks are designated as safety-significant SSCs to protect the tanks from damage and to prevent a radioactive material release

to the environment. The safety function, system description, system evaluation and controls for this safety SSC are contained in Chapter 4 of SAR-107, and are not repeated in this SAR. DOE-STD-3009-94 contains the criteria and guidelines for designating SSCs as safety class or safety significant. TSRs are derived in accordance with the screening criteria in DOE-GDE-423.1-1.[35]

Safety-Significant SSCs.

1. The vaults for the 300,000-gal storage tanks (WM-180 through WM-190) are safety-significant SSCs with respect to the capability to maintain overall structural integrity under evaluation basis loads (such as static soil) to prevent vault and subsequent tank failure, and to prevent the uncontrolled release of liquid waste.

2. The aboveground transfer line secondary encasement protects workers from radioactive material release exposure accidents during transfers of tank solution.

TSR Controls.

The TSRs listed in TSR-100 and TSR-107 are applicable to closure of tanks WM-180 through WM-190 and WM-103 through WM-106. A TSR-level administrative control is required for risk management based on the hazard evaluation in Chapter 3. Specifically, a TSR-level administrative control is required to prohibit use of vehicles on the Tank Farm during aboveground transfers of tank solution. This facility-specific TSR-level control is as follows:

- Use of vehicles on the Tank Farm shall be prohibited during transfers of tank solution using the aboveground transfer line.

Safety Requirements.

Safety requirements have been identified for risk management based on the hazard evaluation (Table 3-9) and to provide additional defense in-depth. The first four safety requirements in the list below were derived in SAR-107 and provide additional defense in-depth against a hydrogen deflagration/ detonation in a 300,000-gal tank. Once the determination has been made that the tank solution in a tank undergoing closure is below acceptable risk limits,[21,22,23] these safety requirements no longer apply. The acceptable risk limits are the contamination levels at which the tanks are deemed acceptably decontaminated to receive grout. At these levels of residual contamination the hydrogen generation rate is qualitatively assessed to be negligible based on the level of contamination. The elimination of the safety requirements related to hydrogen buildup will be based on evaluation of the sample data and comparison of the data to the acceptable risk limits for each tank. An additional safety requirement was also identified to provide additional defense in-depth. Liquid-waste transfers involving Tank Farm closure activities are required to be monitored to ensure the transfer is proceeding as planned. This safety requirement is taken from the existing Tank Farm SAR–107 covering normal operations and is applicable to Tank Farm closure activities.

The following safety requirements apply to the closure of Tanks WM-180 through WM-190 and WM-103 through WM-106.

1. The Tank Farm air purge flow instruments shall be operable during storage of waste in the nominal 300,000-gal storage tanks. If the instrument fails, corrective action shall be taken. If an

instrument cannot be restored to service within one month, an alternative means of equivalent air purge to the effected tank shall be provided.

2. Calibration checks of the Tank Farm air purge flow instruments shall be performed once a year.

3. The minimum airflow requirements based on the waste heat generation rate shall be maintained and verified once per week for each 300,000-gal storage tanks (Tanks WM-180 through WM-190). If the airflow is below the minimum value and the minimum airflow cannot be restored within eight hours, the instrument shall be considered inoperable, the airflow is assumed to be zero until the instrument is restored, and corrective action shall be taken.

4. The hydrogen concentration in a 300,000-gal storage tank (Tanks WM-180 through WM-190) shall be verified to be less than 1.0% before any tank entry is initiated on that tank.

5. Tank Farm load controls shall be established, implemented, and maintained to ensure that any loads affecting the Tank Farm vaults do not increase the load on any structural member by more than 10% above the load from at-rest soil conditions.

6. Liquid waste transfers involving Tank Farm closure activities shall be monitored to ensure the transfer is proceeding as planned, using appropriate instrumentation such as installed radiation detectors, video equipment, and sump leak detectors. (Note: Specific monitoring requirements will be provided in operating procedures).

7. The existing INTEC excavation control program shall be implemented and maintained to reduce the likelihood of a radioactive material release and exposures to personnel (see SAR-107).

3.3.2.4.3 Worker Safety—Features that protect facility workers from potential radiological hazards during the closure of INTEC Tanks WM-180 through WM-190 and WM-103 through WM-106 include: management procedures, operating procedures, reviews and audits, emergency preparedness procedures, requirements of the radiation protection program, configuration management, measuring and test equipment, quality assurance, occurrence reporting and lessons learned, qualification and training, and operating records procedures, as well as the safety management programs required in TSR-100 and DOE regulations.

Design features during tank closure that limit the exposure of workers to hazardous and radioactive material are the design of secondary containment for the aboveground heel and cooling-water transfer lines.

3.3.2.4.4 Environmental Protection—Design and management procedures associated with the closure of INTEC Tanks WM-180 through WM-190 that reduce the potential for releases to the environment are discussed in this section.

The largest potential environmental releases are postulated to occur because of natural phenomena and are discussed in Section 3.3.2.3 of SAR-107. Design features and administrative requirements at the Tank Farm that limit potential tank and line leakage and release radioactive and hazardous material to the environment are listed in Section 3.3.2.3.6.4 of SAR-107.

3.3.2.4.5 Accident Selection—Based on the results of the hazard analysis, two accident categories were selected for further analysis in Section 3.4. The postulated accident types are: (1) an exposure to airborne radioactive material due to a rupture of the aboveground transfer line and (2) a direct radiation exposure from an aboveground, unshielded, transfer line.

3.4 Accident Analysis

This section presents quantitative analyses of the postulated accidents identified above. These accidents are the design (evaluation) basis accidents for the closure of Tanks WM-180 through WM-190 and WM-103 through WM-106, and are the representative, bounding, and unique accidents identified by the hazard analysis in Section 3.3.

The methodology used for the consequence analysis of the postulated accidents is summarized in Section 3.4.1. Section 3.4.2 contains the scenario development, source term analysis, consequence analysis, comparison to guidelines, and summary of safety SSCs and TSR controls. Section 3.4.3 discusses beyond-design (evaluation) basis accidents.

3.4.1 Methodology

The purpose of this section is to summarize the general methodology used to quantify the consequences of the postulated accidents associated with closure of Tank Farm Tanks WM-180 through WM-190 and WM-103 through WM-106.

The consequences from postulated accidents involving radiological and/or chemical releases were calculated using the Radiological Safety Analysis Computer (RSAC)-6 code.[36] Radiological and chemical release impacts are calculated using RSAC-6 for hypothetical, co-located workers at 100, 200, and 500 m; the TRA at 2,414 m; CFA at 4,024 m; and at 13,700 m for a hypothetical, maximally exposed individual at the nearest INEEL site boundary. The facility worker dose is qualitatively determined to be negligible, low, moderate, or high based on Table 3-2. At all locations, three exposure pathways were considered: direct gamma exposure from the cloud of airborne radioactive material, direct exposure from radioactive material deposited on the ground, and internal exposure from inhalation of radioactive material. Ingestion of radioactive material was not considered for the individuals at the INEEL site boundary.

RSAC-6 is an INEEL-developed computer code for estimating the potential radiation doses to maximally exposed individuals from accidental releases of radioactive material. The code, which is adapted to INEEL conditions, uses well-established scientific and engineering principles as the basis for the various calculational steps. The code has been validated to accepted standards for this kind of computer software.

Meteorological conditions were assumed that represent atmospheric dispersion behavior that is not expected to be exceeded more than 5% of the time and that result in conservative (maximum) doses to the receptors.

The consequences from postulated accidents involving radiological direct radiation exposure were calculated using MicroShield 5.05 computer code.[37] MicroShield Version 5.05 is fully validated and verified in accordance with applicable standards. The assumptions used by the RSAC-6 and MicroShield models for postulated accidents are contained in the following engineering design files (EDFs):

- EDF-3358, "Accident Dose Analysis for Tank Farm Above Ground Transfer Line Rupture"[16]
- EDF-3359, "Shielding Analysis for Above Ground Tank Farm Transfer Pipe"[20]

3.4.2 Design Basis Accidents

The postulated accidents analyzed in this section bound accidents initiated by internal events, external events, and natural phenomena. The selection and analysis of these design basis accidents satisfy the requirements and guidelines of 10 CFR 830 and DOE-STD-3009-94. The response of SSCs to the range of the bounding accident scenarios is estimated to evaluate accident consequences.

3.4.2.1 Aboveground Transfer Line Airborne Release Accident

3.4.2.1.1 Scenario Development—As part of Tank Farm closure operations, the tank solution remaining in the various Tank Farm tanks will be jetted through an aboveground transfer line (see Section 2.4.6.1) to a final consolidation tank. This scenario postulates that the transfer line is damaged due to overpressure and ruptures, releasing radioactive material to the environment.

During the transfer operation the tank heel is under pressure (100 psi steam) and is capable of producing an airborne radioactive release if the transfer line is ruptured. The pump has the capacity of 100 gpm. If there were an unrestricted release for 15 min, the material released to the environment would be 1,500-gal. There are three types of release scenarios to consider: venting of pressurized liquids, free fall spill and aerodynamic entrainment. The damage ratio for the 1,500-gal spill scenario is 1.0, and it assumes that the release (pressurized venting) duration is 15 min and the 1,500-gal dumped to the environment remains as an uncovered pool for 10 h (aerodynamic entrainment release).

The total effective dose equivalent (TEDE) for an airborne radiological exposure is qualitatively determined to a facility worker who remains in the area during the 15-min release.[16] The TEDE is also calculated for workers at the site who are 100; 200; 500; 2,414 (TRA); and 4,024 m (CFA) downwind from the release point for both a 15-min release and a 10-h pool entrainment release. The TEDE to the public at the site boundary (1.37E+04 m downwind from the release point) is also assessed. This analysis does not address the nonradiological consequence (such as cadmium, lead, mercury, nitrates, and chromium) of this hypothetical release.

3.4.2.1.2 Source Term Analysis—Table 3-10 gives the source term for 1,500 gal of liquid and solids based on the contents of tank WM-181. Tank WM-181was used for the source term because it gives the highest TEDE to the dose receptor (the most conservative source term). The source term for tank WM 181 contains both analytical and calculated data. Since WM-181 contains both a liquid and sludge phase, the source term for each phase was derived separately, and the two were added to develop the source term for the tank contents.[17,18]

3.4.2.1.3 Consequence Analysis—Table 3-11 summarizes the RSAC-6 dose results to receptors at 100; 200; 500; 2,414; 4,024; and 13,700 m downwind from the Tank Farm release for the 15-min. and 10-h release of tank heel consisting of liquid and solids. The dose to facility workers is qualitatively determined to be high, based on Table 3-2.

Table 3-10. Source term for 1,500 gal of tank heel (WM-181).

Radionuclide	Source Term (Ci per 1500-gal of heel	Radionuclide	Source Term (Ci per 1500-gal of heel	Radionuclide	Source Term (Ci per 1500-gal of heel
H-3	3.49E-02	Ce-144	3.26E-01	Pu-239	4.17E+00
C-14	2.71E-06	Pr-144	3.26E-01	Pu-240	2.35E-01
Ni-59	8.55E-02	Pm-147	9.60E+00	Pu-241	4.37E+01
Ni-63	7.24E-01	Sm-151	7.78E+00	Pu-242	1.77E-04
Co-60	7.15E-01	Eu-152	6.70E-02	Pu-244	1.52E-11
Se-79	9.77E-03	Eu-154	4.63E+00	Am-241	2.40E+00
Y-90	6.50E+02	Eu-155	5.96E+00	Am-242	3.44E-04
Sr-90	6.50E+02	Th-230	1.79E-05	Am-243	4.88E-04
Nb-94	2.52E-02	Th-231	4.71E-04	Cm-242	2.84E-04
Tc-99	2.16E-01	U-232	4.34E-05	Cm-243	6.87E-04
Rh-106	2.35E-01	U-233	7.24E-07	Cm-244	4.51E-02
Ru-106	2.35E-01	U-234	1.81E-02	Cm-245	6.70E-06
Sn-126	9.23E-03	U-235	7.41E-04	Cm-246	4.34E-07
Sb-125	2.22E+02	U-236	8.66E-04	Cm-247	4.88E-13
I-129	1.19E-03	U-237	1.70E-04	Cm-248	5.25E-13
Cs-134	2.84E+01	U-238	1.09E-04	Cf-249	3.97E-13
Cs-135	1.99E-02	Np-237	4.77E-03	Cf-250	3.80E-13
Cs-137	1.22E+03	Pu-236	1.43E-04	Cf-251	6.16E-15
Ba-137m	1.16E+03	Pu-238	5.51E+01		

Table 3-11. Dose to receptor at various distances downwind from release (sum of 15-min release and 10-h release).

Exposure Pathway	Dose to worker at 100 m (rem)	Dose to worker at 200 m (rem)	Dose to worker at 500 m (rem)	Dose to worker at 2414 m (rem)	Dose to worker at 4024 m (rem)	Dose to person at 1.37E+04 m (rem)
CEDE from inhalation	1.44E+02	5.00E+01	1.24E+01	1.30E+00	6.56E-01	1.45E-01
EDE from ground surface	2.56E-01	8.84E-02	2.20E-02	2.29E-03	1.16E-03	1.08E-03
EDE from cloud gamma	6.22E-05	3.41E-05	1.58E-05	3.76E-06	2.33E-06	7.54E-07
Total effective dose equivalent	1.44E+02	5.00E+01	1.24E+01	1.30E+00	6.57E-01	1.46E-01
INEEL Risk Evaluation Guideline (Unlikely)	25 rem	25 rem	25 rem	25 rem	25 rem	5.0 rem

CEDE committed effective dose equivalent
EDE effective dose equivalent
TEDE total effective dose equivalent

The facility worker will also be exposed to direct radiation from the open pool of liquid and solids. The exposure rate at 30 cm (1 ft) from the edge of the pool is 2 R/h. Since the worker remains in the area for 15 min, his or her exposure will not exceed 0.5 rem.

3.4.2.1.4 Comparison to the Evaluation Guideline—The INEEL Risk Evaluation Guidelines are listed in Table 3-3. Comparison of Table 3-11 to the values in Table 3-3 show that the TEDE values are exceeded for the 15-min and 10-h unmitigated release scenarios for co-located workers at all distances, except up to the 4,024 m distance. The dose to off-site public is not exceeded.

3.4.2.1.5 Summary of Safety SSCs and TSR Controls—The consequence analysis and evaluation results for an accident involving an airborne release of heel material due to an aboveground transfer line rupture requires a control to reduce the risk to the facility worker. Therefore, a safety SSC is required to mitigate the dose impacts to the facility worker from this postulated accident. The aboveground transfer line secondary encasement is designated as a safety-significant SSC to prevent or mitigate an airborne radioactive material release, and is further described in Chapter 4.

3.4.2.2 Direct Radiation Exposure Accident from an Aboveground Unshielded Transfer Line

3.4.2.2.1 Scenario Development—The heel material remaining in the various 300,000-gal tanks will be consolidated into one tank. Most of the transfers can be done through existing underground piping. However, to get the final residual from the bottom of the tanks, an aboveground transfer will be required. Since the transfer pipe is above ground, an external radiation hazard will be created for facility personnel. The scenario for the direct radiation exposure accident is a direct radiation exposure to workers from the unshielded aboveground transfer line.

The transfer pipe from the B3 valve box to WM-186 was used for this analysis because it is the most conservative (longest straight section of pipe). Only one transfer pipe will be in use at a time. The scope of this analysis was limited to the Schedule 40 stainless-steel 2-in. (5.1-cm) transfer pipe with a Schedule 10 stainless-steel 6-in. (15.2-cm) pipe encasement. The shielding analysis using the Schedule 40 stainless-steel 2-in. (5.1-cm) pipe and the Schedule 10 stainless-steel 6-in. (15.2-cm) pipe is bounding for the other possible pipe-wall thickness combinations.

The maximum exposure rates to a facility worker from the unshielded transfer pipe were calculated using MicroShield, Version 5.05, at the pipe midpoint 5 m (16.4 ft) and various distances from the surface of the pipe (2.54 cm [1.0 in.], 30 cm [1 ft], 61 cm [2 ft], 91 cm [3 ft], 122 cm [4 ft], 152 cm [5 ft], 244 cm [8 ft], 305 cm [10 ft], 457 cm [15 ft], 917 cm [30 ft], 10 m [33 ft], 91.4 m [300 ft], and 100 m [328 ft]).[37] The distance from the unshielded pipe to the 5 mR/hr boundary was also determined.

3.4.2.2.2 Source Term Analysis—Table 3-12 gives the source term used for this accident analysis, based on the contents of tank WM-188. The radioactive material inventory for tank WM-188 was used because it is the most conservative yielding the highest dose from direct external radiation. EDF-3359 provides details on source term development methodology.[20]

3.4.2.2.3 Consequence Analysis—Table 3-13 contains the calculated exposure rates for the unshielded transfer pipe at various distances from the middle of the pipe. The maximum exposure rate for the unshielded pipe at 2.54 cm (1.0 in.) is 13 R/h. The maximum exposure rates for the unshielded pipe from 30 cm to 100 m (1 to 328 ft) range from 3.4 R/h to 3.6E-01 mR/h. The distance from the unshielded pipe to the 5 mR/h boundary was calculated to be 31.7 m (104 ft).

Table 3-12. Source term for aboveground tank heel transfers based on tank WM-188 (20.4-L).

Radionuclide	Inventory (Ci/L)	Radionuclide	Inventory (Ci/L)	Radionuclide	Inventory (Ci/L)
H-3	5.36E-03	Sn-126	1.96E-04	Gd-153	1.68E-14
Be-10	7.03E-11	Sb-125	4.46E-02	Ho-166m	1.07E-09
C-14	5.75E-08	Sb-126	2.74E-05	Tm-171	1.16E-14
Ni-59	1.73E-03	Sb-126m	1.96E-04	Tl-207	9.02E-10
Ni-63	1.50E-02	Te-123	8.87E-18	Tl-208	2.60E-07
Co-60	4.87E-03	Te-125m	1.10E-02	Tl-209	9.48E-14
Se-79	2.07E-04	I-129	2.53E-05	Pb-209	9.19E-12
Rb-87	6.73E-10	Cs-134	2.44E-02	Pb-210	9.34E-11
Y-90	5.21E+01	Cs-135	4.21E-04	Pb-211	9.02E-10
Sr-90	5.18E+01	Cs-137	2.49E+01	Pb-212	7.22E-07
Zr-93	5.20E-05	Ba-137m	2.26E+01	Pb-214	7.39E-10
Nb-93m	3.98E-05	La-138	4.43E-15	Bi-210	5.05E-24
Nb-94	3.75E-02	Ce-142	6.88E-10	Bi-210m	9.31E-11
Tc-98	5.96E-11	Ce-144	3.06E-04	Bi-211	9.02E-10
Tc-99	4.58E-03	Nd-144	3.67E-14	Bi-212	7.22E-07
Rh-102	1.99E-08	Pr-144	3.06E-04	Bi-213	9.12E-12
Rh-106	4.64E-04	Pr-144m	4.35E-06	Bi-214	7.39E-10
Ru-106	4.64E-04	Pm-146	1.18E-06	Po-210	8.25E-11
Pd-107	3.82E-07	Pm-147	8.07E-02	Po-211	2.45E-12
Ag-108	8.87E-13	Sm-146	6.42E-12	Po-212	4.74E-08
Ag-108m	9.94E-12	Sm-147	1.71E-10	Po-213	4.28E-12
Ag-109m	2.91E-15	Sm-148	8.72E-16	Po-214	1.83E-10
Ag-110	7.65E-15	Sm-149	7.80E-17	Po-215	9.02E-10
Ag-110m	5.66E-13	Sm-151	1.61E-01	Po-216	7.22E-07
Cd-109	2.91E-15	Eu-150	3.36E-10	Po-218	7.39E-10
Cd-113m	7.65E-05	Eu-152	1.19E-03	At-217	4.43E-12
In-115	2.29E-15	Eu-154	8.23E-03	Rn-219	9.02E-10
Sn-119m	1.16E-13	Eu-155	7.60E-02	Rn-220	7.22E-07
Sn-121m	1.53E-06	Gd-152	3.36E-17	Rn-222	7.39E-10

Table 3-12. (continued).

Radionuclide	Inventory (Ci/L)	Radionuclide	Inventory (Ci/L)	Radionuclide	Inventory (Ci/L)
Fr-221	9.12E-12	Pa-234	3.03E-09	Pu-241	5.75E-02
Fr-223	1.24E-11	Pa-234m	1.68E-06	Pu-242	3.76E-06
Ra-223	9.02E-10	U-232	9.58E-07	Pu-243	5.05E-16
Ra-224	7.22E-07	U-233	1.68E-08	Pu-244	3.22E-13
Ra-225	9.25E-12	U-234	3.84E-04	Am-241	1.98E-02
Ra-226	7.42E-10	U-235	2.50E-06	Am-242	3.52E-07
Ra-228	1.29E-14	U-236	1.58E-05	Am-242m	3.52E-07
Ac-225	9.19E-12	U-237	1.50E-07	Am-243	1.04E-05
Ac-227	9.10E-10	U-238	1.68E-06	Cm-242	3.15E-07
Ac-228	9.12E-07	U-240	3.22E-13	Cm-243	1.34E-05
Th-227	8.87E-10	Np-236	7.19E-11	Cm-244	8.39E-04
Th-228	7.24E-07	Np-237	9.63E-05	Cm-245	1.42E-07
Th-229	9.33E-12	Np-238	1.83E-09	Cm-246	9.21E-09
Th-230	3.92E-07	Np-239	1.04E-05	Cm-247	1.04E-14
Th-231	2.50E-06	Np-240m	1.53E-14	Cm-248	1.11E-14
Th-232	1.94E-14	Pu-236	1.30E-06	Cf-249	8.38E-15
Th-234	1.68E-06	Pu-238	8.34E-02	Cf-250	6.69E-15
Pa-231	2.29E-09	Pu-239	5.64E-03	Cf-251	1.31E-16
Pa-233	9.63E-05	Pu-240	4.98E-03		

Table 3-13. Exposure rate at various distances from the surface of the unshielded transfer pipe.

Distance from Surface of Transfer Pipe	Exposure Rate
2.54 cm (1.0 in.)	13 R/h
30 cm (1 ft)	3.4 R/h
61 cm (2 ft)	1.9 R/h
91 cm (3 ft)	1.3 R/h
122 cm (4 ft)	9.9E+02 mR/h
152 cm (5 ft)	7.8E+02 mR/h
244 cm (8 ft)	4.6E+02 mR/h
305 cm (10 ft)	3.4E+02 mR/h
457 cm (15 ft)	1.9E+02 mR/h
917 cm (30 ft)	5.9E+01 mR/h
10 m (33 ft)	5.0E+01 mR/h
31.7 m (104 ft)	5.0 mR/h
91.4 m (300 ft)	4.5E-01 mR/h
100 m (328 ft)	3.6E-01 mR/h

***3.4.2.2.4 Consequence Evaluation*—**The DOE-ID Risk Evaluation Guidelines are listed in Table 3-3. The calculated exposure rates for the unshielded transfer pipe at various distances from the middle of the pipe are shown in Table 3-13. Comparison of Table 3-13 to the values in Table 3-3 shows that the exposure rate from contact 2.54 cm (1.0 in.) with the pipe (unshielded) could produce doses in excess of the INEEL Risk Evaluation Guidelines. A facility worker at a distance 2.54 cm (1.0 in.) from a filled, unshielded transfer line could receive a 5-rem dose in less than 25 min. The dose to co-located workers and the off-site public is not exceeded.

***3.4.2.2.5 Summary of Safety SSCs and TSR Controls*—**Based on the accident analysis, no safety-class or safety-significant SSCs are required. The facility worker risk associated with a postulated accident involving a direct radiation exposure due to an unshielded aboveground transfer line is unacceptable and requires implementation of the radiation protection program. Implementation of the Radiation Protection Program reduces the likelihood of worker over exposure to direct radiation by posting and establishing radiological boundaries and controlling access to the Tank Farm area.

3.4.3 Beyond-Design Basis Accidents

The evaluation of accidents beyond the design (or evaluation) basis to provide a perspective of the residual risk is required by 10 CFR 830. The intent is to provide insight regarding the magnitudes of consequences of events beyond the design basis. Beyond-design basis accident results are neither compared to evaluation guidelines nor used in the assessment of safety SSCs and TSRs. Beyond-design basis accidents for the Tank Farm are analyzed in SAR-107; no additional design basis accidents have been identified for closure of tanks WM-180 through WM-190 and WM-103 through WM-106.

3.5 References

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