BSC

Calculation/Analysis Change Notice

Complete only applicable items.

1. QA: QA
2. Page 1 of 32

3. Document Identifier:	4. Rev.:	5. CACN:
200-PSA-RF00-00100-000-00A	00A	002

6. Title:

Receipt Facility Event Sequence Development Analysis

7. Reason for Change:

Change text of fifth bullet on page 13 per Condition Report 11989 Corrective Action 003.

Provide for increased clarity and traceability by filling in blank cells in tables in response to Condition Report 12105 Corrective Action 011.

Rectify lack of traceability in MLDs for precursor events identified in the HAZOP in response to Condition Report 12121 Corrective Action 007.

Correct event trees in 200-PSA-RF00-00100-000-00A to agree with 200-PSA-RF00-00200-000-00A.

8. Supersedes Change Notice: ☐ Yes If, Yes, CACN No.: _____ ☒ No

9. Change Impact:

Inputs Changed:	☐ Yes	☒ No	Results Impacted:	☐ Yes	☒ No
Assumptions Changed:	☐ Yes	☒ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change:

To resolve CR 11989, Action 003, the fifth bullet on page 13 is replaced by the following:

- Intentional malevolent acts, such as sabotage and other security threats, were considered in a separate safeguards and security analysis performed by others.

To resolve CR 12105, Action 011, the blank cells in Table 10, with the exceptions summarized in the next paragraph, are filled with em-dashes, indicating that no data belonged in those cells. Also to resolve CR 12105, Action 011, the blank cells in Tables E-2 through E-15, with the exceptions summarized in later paragraphs, are filled with em-dashes, "NCI" (for No Cause Identified), or N/A, indicating that no data belonged in those cells. N/A in the MLD Index Number column replaced by em-dashes.

To resolve CR 12105, Action 011, HAZOP Table Number E-12 is added for Internal Event Identifier R-1001 in Table 10. A footnote is added to explain why no ESD Figure Number is needed for Internal Event Identifier R-I311 in Table 10.

To resolve CR 12105, Action 011, prevention/mitigation suggestions are entered in the "Potential Prevention/Mitigation Design of Operational Feature" column for Node Item Number 4.5 in Table E-5, Node Item Numbers 8.5 and 8.6 in Table E-9, and Node Item Number 12.2 in Table E-13.

To resolve CR 12121, Action 007, MLD Index numbers are added in the last column of the tables for Node Item Numbers 9.3, 9.4, 9.5, 9.17, and 9-20 in Table E-10, Node Item Numbers 11.12, 11.17, and 11.18 in Table E-12, and Node Item Number 13.17 in Table E-14.

Also to resolve CR 12121, Action 007, the descriptions of R-1003 and R-1209 in Figures D-10 and D-12, respectively, are generalized to accommodate additional links with the HAZOP tables.

To resolve a discrepancy identified between 200-PSA-RF00-00100-000-00A and 200-PSA-RF00-00200-000-00A, Figures G-12 and G-13 in 200-PSA-RF00-00100-000-00A are changed to agree with the Event Tree descriptions in 200-PSA-RF00-00200-000-00A. For each of these, the entries, "ESD5 SCREENED OUT" and "ZERO," in the two blocks at the top left are replaced. "Number of DPCs handled during preclosure period" and "DPC" are entered into those two blocks in Figure G-12. "Number of TADs handled during preclosure period" and "TAD" are entered into those two blocks in Figure G-13. Change bar at the bottom of page 79 indicates a page break for Table 9 to remain, in its entirety, on page 80.

11. REVIEWS AND APPROVAL

Printed Name	Signature	Date
11a. Originator: Daniel Christman	for Dan Christman	8/29/08
11b. Checker: Norman Graves		8/27/08
11c. EGS: Michael Frank		8/27/08
11d. DEM: Michael Frank		8/27/08
11e. Design Authority: Barbara Rusinko	Brusinko	8/27/08

Other boundary conditions used in the PCSA include:

- Plant operational state. Initial state of the facility is normal with each system operating within its vendor prescribed operating conditions.

- No other simultaneous initiating events. It is standard PRA practice to not consider the occurrence of other initiating events (human-induced or naturally occurring) during the time span of an event sequence because: (a) the probability of two simultaneous initiating events within the time window is small and, (b) each initiating event will cause the operations of the waste handling facility to cease, which further reduces the conditional probability of the occurrence of a second initiating event, given the first has occurred.

- Component failure modes. The failure mode of an SSC corresponds to that required to make the initiating or pivotal event occur.

- Fundamental to the basis for the use of industry-wide reliability parameters within the PCSA, such as failure rates, is the use of SSCs within the GROA that conform to NRC accepted consensus codes and standards, and other regulatory guidance.

- Intentional malevolent acts, such as sabotage and other security threats, were considered in a separate safeguards and security analysis performed by others.

The scope of the present analysis includes operations spanning the receipt of transportation casks on rail or truck conveyances into the Cask Preparation Room of the RF through the loading of a waste form into an aging overpack and bolting the overpack lid in place in the Lid Bolting Room of the RF. Transport of the aging overpack on a site transporter from the Lid Bolting Room to its eventual destination (WHF, CRCF, or aging pad) is covered in the *Intra-Site Operations and BOP Event Sequence Development Analysis*.

This analysis includes: a process flow diagram (PFD), a master logic diagram (MLD), a hazard and operability (HAZOP), event sequence diagrams (ESDs), and event trees. Initiating events considered in this analysis include internal events (i.e., events that are initiated within the RF) as well as external events (i.e., events that are initiated from outside the RF). However, event sequences for external events (including seismic events) are not developed in this analysis. External events and any associated event sequences are evaluated and documented separately.

6.1.2.14 Node 13: Lower Canister from CTM into Aging Overpack

Once the CTM is in position over the aging overpack port, the CTM skirt is lowered, the CTM slide gate and the aging overpack port slide gate are opened. Next, the canister is lowered into the aging overpack, then the CTM grapple is disengaged and raised, and the port slide gate and the CTM slide gate are closed.

This node describes block 2.1.15 on the *Receipt Facility Mechanical Handling System Block Flow Diagram-Level 3 Sheet 6* (Ref. 2.2.45).

6.1.2.15 Node 14: Move Loaded Aging Overpack on Site Transporter Out of Receipt Facility

After the CTM loads the canister into the aging overpack, it retrieves the aging overpack lid from a storage location on the Canister Transfer Room floor and places it on the aging overpack. Next the aging overpack with the unbolted lid in place is moved into the Lid Bolting Room. The aging overpack is then positioned so that workers can access the aging overpack lid from the Lid Bolting Room platform. The aging overpack lid is then bolted to the aging overpack. Once the aging overpack lid is bolted down, the aging overpack is removed from the RF for transfer to the aging pad.

This node describes blocks 1.5.1 through 1.5.3 on the *Receipt Facility Mechanical Handling System Block Flow Diagram-Level 3 Sheet 7* (Ref. 2.2.46).

6.1.3 Identification of Initiating Events

The identification of initiating events is completed by constructing the MLD and supplementing it with a HAZOP evaluation. The methodologies for the MLD and HAZOP evaluation are described in Sections 4.3.1.2 and 4.3.1.3, respectively. The MLD diagram and HAZOP evaluation deviations for the RF are provided in Attachment D and E, respectively.

To facilitate ESD development, a unique identification number has been assigned to each initiating event. The numbers consist of "R-" to identify the facility, followed by a three- or four-digit number. The last two digits of the identification numbers uniquely identify events on each page of the MLD. The first one or two digits specify the MLD page number. For example, "R-312" means "initiating event 12 on the page 3 of the MLD" and "R-1207" means "initiating event 07 on page 12 of the MLD." A slightly different convention has been used differentiate internal fire and flood and external events from internal events. A prefix "E" is used to designate external events and a prefix of "I" is used to designate internal fire and flood events. No prefix is used for internal events. Thus, "R-E202" means external initiating event 02 on page 2 of the MLD.

A comprehensive list of initiating events identified by the MLD and HAZOP evaluation is provided in Table 9 for external events and Table 10 for internal events.

Table 9. List of External Initiating Events

Initiating Event Identifier	Initiating Event Description
R-E201	Exposure due to seismic events
R-E202	Non-seismic geologic activity (including landslides, avalanches)
R-E203	Volcanic activity
R-E204	High winds/tornadoes (including wind effects from hurricanes)
R-E205	External floods
R-E206	Lightning
R-E207	Loss of power events
R-E208	Loss of cooling capability event (non-power cause, including biological events)
R-E209	Aircraft crash
R-E210	Nearby industrial/military facility accidents (including transportation accidents)
R-E211	Onsite hazardous materials release
R-E212	External fires (including forest fires, grass fires)
R-E213	Extraterrestrial activity (including meteorites, falling satellites)

Source: Original

Table 10. List of Internal Initiating Events

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
R-101	Exposure due to RC derailment leading to cask drop	D-1	E-2, E-13	F-1
R-102	Exposure due to RC collision leads to impact	D-1	E-2	F-1
R-103	Exposure due to horizontal cask transfer trailer collision with loaded RC, CTT, or suspended cask during movement into facility to receive HTC for transfer to aging pad	D-1	—	F-1
R-I301	Internal flooding caused by piping failure	D-3	—	—
R-I302	Internal flooding caused by actuation of fire protection system	D-3	—	—
R-I303	Exposure due to large fire affecting the entire facility	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I304	Localized fire threatens TAD/AO in Vestibule/Lid Bolting Room (diesel present)	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I305	Localized fire threatens TAD/AO in Loading Room (diesel present)	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I306	Localized fire threatens TC/TAD or TC/DPC in Vestibule/Preparation Area (diesel present)	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I307	Localized fire threatens TC/TAD or TC/DPC in Preparation Area	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I308	Localized Fire Threatens Waste Form in Preparation Area	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I309	Localized fire threatens waste form in Cask Unloading Room	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I310	Localized fire threatens TAD or DPC in Transfer Room	D-3	E-2, E-2A, E-3, E-4, E-4A, E-5, E-7, E-8, E-9, E-15	F-12
R-I311	Exposure due to excessive temperature (excluding internal fire events)	D-3	—	—[a]
R-401	CTM crane drops object onto canister prior to attachment of grapple	D-4	—	F-6
R-501	Cask handling crane malfunction causes TC drop	D-5	E-4, E-5	F-2

Table 10. List of Internal Initiating Events (Continued)

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
R-502	Cask handling crane causes unplanned conveyance movement	D-5	E-5	F-2
R-503	Unplanned conveyance movement while crane is attached to TC or conveyance fixtures	D-5	E-5	F-2
R-504	Cask handling crane drops object on TC	D-5	E-4	F-2
R-505	Unplanned conveyance movement prior to cask clearing pedestals	D-5	E-6	F-2
R-506	Cask handling crane drops cask	D-5	E-6	F-2
R-507	Cask handling crane drops object on cask	D-5	—	F-2
R-508	Cask collides with object while being moved by cask handling crane	D-5	E-6	F-2
R-509	Impact from platform operations	D-5	E-4	F-2
R-510	Cask tips and drops after placed onto CTT	D-5	—	F-2
R-601	Unplanned conveyance movement prior to clearing pedestals leads to side impact of cask	D-6	—	F-2
R-602	Cask handling crane drops TC	D-6	—	F-2
R-603	Cask handling crane drops object on cask	D-6	E-7	F-2
R-604	TC collides with object during movement by cask handling crane leads to a cask drop	D-6	—	F-2
R-605	Impact due to platform operations	D-6	—	F-2
R-606	Auxiliary hook drops load on cask	D-6	E-4A	F-2
R-607	Cask handling crane malfunction causes cask stand to roll over	D-6	E-4A	F-2
R-608	Cask handling crane drops cask	D-6	E-7, E-8	F-2
R-609	Cask handling crane drops object on cask	D-6	—	F-2
R-610	Cask collides with object while being moved by cask handling crane	D-6	E-8	F-2
R-611	Auxiliary hook drops load on TC	D-6	E-3	F-2
R-612	Unplanned conveyance movement while crane is attached to TC or conveyance fixtures leading to a rollover	D-6	—	F-2
R-613	Cask handling crane malfunction causes cask conveyance to roll over	D-6	E-3	F-2
R-614	Impact from MAP operations	D-6	E-3	F-2
R-701	Unplanned conveyance movement prior to clearing pedestals leads to side impact of cask	D-7	E-7	F-2
R-702	Cask handling crane drops TC	D-7	—	F-2
R-703	Cask handling crane drops object on cask	D-7	E-7	F-2
R-704	TC collides with object during movement by cask handling crane leads to a cask drop	D-7	E-7	F-2
R-705	Impact due to platform operations	D-7	E-7	F-2
R-706	Auxiliary hook drops load on cask	D-7	—	F-2

Table 10. List of Internal Initiating Events (Continued)

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
R-707	Cask handling crane malfunction causes cask stand to roll over	D-7	—	F-2
R-801	Cask handling crane drops cask	D-8	E-8	F-2
R-802	Cask handling crane drops object on cask	D-8	E-8	F-2
R-803	Cask collides with object while being moved by cask handling crane resulting in side impact	D-8	E-8	F-2
R-804	Cask tilting frame failure leads to cask drop	D-8	E-9	F-2
R-805	Cask handling crane drops object on cask	D-8	—	F-2
R-806	Cask handling crane malfunction leads to cask drop	D-8	E-9	F-2
R-807	Cask handling crane drops cask	D-8	E-6, E-9	F-2
R-808	Cask handling crane drops object on cask	D-8	—	F-2
R-809	Cask collides with object while being moved by cask handling crane leading to side impact	D-8	E-6, E-9	F-2
R-810	Impact due to platform operations	D-8	E-9	F-2
R-901	Operation of auxiliary crane hook leads to cask tipover	D-9	—	F-3
R-902	Auxiliary crane hook drops object onto cask	D-9	E-10	F-3
R-903	Cask handling crane causes impact to side of cask	D-9	E-10	F-3
R-904	Failure to close cask preparation platform shield plates	D-9	—	F-10
R-905	Cask impact resulting from unplanned movement of CTT during installation of cask lid lift fixture	D-9	—	F-3
R-906	Inadvertent opening of cask preparation platform shield plates	D-9	—	F-10
R-1001	Heavy load dropped onto the cask or canister	D-10	E-10, E-12	F-3
R-1002	Main hook interferes with auxiliary hook resulting in cask tipover	D-10	E-10	F-3
R-1003	Lid binds during removal leads to cask tipover	D-10	E-10	F-3
R-1004	Auxiliary hook malfunction/mis-operation catches and tips over CTT leading to cask impact	D-10	E-10	F-3
R-1005	Auxiliary hook malfunction/mis-operation leads to impact to side of cask	D-10	E-10	F-3
R-1006	Collision between CTT and another moving vehicle, facility structures, or facility equipment leads to cask impact	D-10	—	F-3
R-1007	Spurious movement of CTT with crane attached to lid leads to cask damage	D-10	—	F-3
R-1008	Failure to close cask preparation platform shield plates	D-10	E-10	F-10

Table 10. List of Internal Initiating Events (Continued)

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
R-1009	Inadvertent opening of cask preparation platform shield plates	D-10	—	F-10
R-1101	Cask Unloading Room shield door closes against CTT leads to cask impact	D-11	E-11	F-5
R-1102	Collision with facility structures or equipment during movement leads to cask impact	D-11	E-11	F-4
R-1103	CTT or cask catches crane hook or rigging during movement leads to cask impact	D-11	E-11	F-4
R-1104	CTM drops object onto cask or canister	D-11	E-12	F-6
R-1105	Lid binds during removal leads to dropped cask	D-11	E-12	F-6
R-1201	Temporary loss of shielding while the canister is lifted from the cask into the CTM shield bell or lowered from the CTM shield bell into a container	D-12	E-12, E-14	F-11
R-1202	Canister drops from CTM shield bell during move	D-12	E-12	F-6
R-1203	Canister collision due to CTM malfunction leading to impact	D-12	E-12, E-13	F-6
R-1204	ST moves while loading	D-12	E-14	F-6
R-1205	CTT moves during cask unloading	D-12	E-12	F-6
R-1206	Spurious movement of CTM bridge or trolley	D-12	—	F-6
R-1207	Canister strikes port edge, CTM slide gate, or wall leading to canister drop	D-12	E-12, E-14	F-6
R-1208	Side impact to canister during lift	D-12	E-12, E-14	F-6
R-1209	CTM wire rope cut resulting in canister drop	D-12	E-12, E-14	F-6
R-1210	Canister drop into CTM shield bell (with CTM slide gate closed) due to CTM malfunction	D-12	E-12, E-14	F-6
R-1211	CTM failure or mis-operation leading to canister impact or drop	D-12	E-12, E-14	F-6
R-1301	CTM drops lid onto loaded AO in Loading Room	D-13	E-14	F-7
R-1302	CTM movement while lid is low enough to catch AO or ST	D-13	—	F-6
R-1303	Spurious movement of ST with CTM attached to lid	D-13	—	F-7
R-1304	Shield door shuts against ST carrying AO	D-13	—	F-5, F-7
R-1305	Collision between ST and facility structures or equipment	D-13	E-15	F-5, F-7
R-1306	Exposure due to collision involving the ST and another vehicle, facility structures, or equipment during movement within facility	D-13	E-15	F-5, F-7
R-1307	Exposure resulting from Lid Bolting Room crane dropping object on AO	D-13	—	F-7
R-1308	Exposure from crane interference with ST causing AO drop from ST	D-13	—	F-7

Table 10. List of Internal Initiating Events (Continued)

Identifier	General Event Description	MLD Figure #	HAZOP Table #	ESD Figure #
R-1401	Exposure due to dropped AO	D-14	—	F-8
R-1402	Exposure due to collision involving the ST and another vehicle, facility structures, or equipment	D-14	—	F-5, F-8
R-1403	Exposure resulting from ST rollover	D-14	E-15	F-8
R-1404	Exposure due to collision involving the cask transfer trailer and another vehicle, facility structures, or equipment	D-14	E-2A	F-5, F-9
R-1405	Exposure due to CT trailer rollover or load drop during loading and export	D-14	E-4A	F-9

NOTE: "Diesel present" denotes the presence of diesel fuel.
AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; DPC = dual-purpose container; HTC = a transportation cask that is never upended; MAP = mobile access platform; RC = railcar; ST = site transporter; TAD = transportation, aging, and disposal canister; TC = transportation cask; TTC = a transportation cask that is upended using a tilt frame.
[a] Shipping casks do not require external cooling.

6.2 DEVELOPMENT OF INTERNAL EVENT SEQUENCES

6.2.1 Introduction

The ESD technique, as described in Section 4.3.2.1, is used to develop event sequences associated with initiating events identified in the MLD. The resulting ESDs are presented in Attachment F (Figures F-1 through F-12). Sections 6.2.2 through 6.2.13 describe the logical flow of each ESD, from the initiating event, through the pivotal events, to the end state. In order to clearly understand the ESD logic, the text and the ESD should be considered together. The descriptions for each ESD provide the following information:

- Internal events addressed by the ESD.
- Pivotal event descriptions and the associated logic.
- A summary description of each event sequence embodied in the ESD.

6.2.2 RF-ESD-01: Event Sequences for Activities Associated with Receipt of Transportation Cask into Cask Preparation Room

6.2.2.1 Overall Description

This ESD delineates the event sequences that arise after a structural challenge to the transportation cask that occurs in the Cask Preparation Room before removal of the impact limiters from the transportation cask (Figure F-1 and Section 6.1.2.1, Node 1). This includes event sequences that arise during receipt of a transportation cask on a railcar. This ESD applies to the following waste forms:

- Transportation cask containing one DPC received on a railcar.
- Transportation cask containing one TAD canister received on a railcar.

Table E-2. HAZOP Worksheet

Facility/Operation: RF					Process: Receipt and Transfer into Preparation Area		
Node 1: Receive and Move TC Railcar into Preparation Area for Unloading					Process/Equipment: SPM Railcar		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
1.1	Speed	(More) SPM moves too fast	Driver drives SPM too fast	Potential loss of control or collision leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training	Creeping speed	R-102
1.2	Speed	(More) SPM moves too fast	Mechanical failure of SPM	Potential loss of control or collision leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training	Creeping speed	R-102
1.3	Speed	(Less) SPM moves too slow	Mechanical failure of SPM	No safety consequences	—	—	—
1.4	Speed	(No) SPM does not move	1 – Human failure 2 – Mechanical failure	No safety consequences	—	Always at least one-door boundary for HVAC if conveyance is stuck in doorway	—
1.5	Direction	(Reverse) SPM backs up instead of going forward	1 – Human failure 2 – Mechanical failure	Potential loss of control or collision leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training	Potential loss of HVAC boundary if collision with door	R-102
1.6	Direction	(Other Than) SPM derailment	1 – Human failure 2 – Mechanical failure	Potential derailment leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training	—	R-101
1.7	Direction	(Other Than) SPM derailment	Rail distortion due to structural failure	Potential drop leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training 3 – Rail design	—	R-101
1.8	Direction	(Other Than) SPM does not follow designated route and goes to wrong location or problem area	1 – Human failure 2 – Mechanical failure	Potential loss of control or collision leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training	Faulty track or switch indicator	R-101, R-102
1.9	Parking	(Other Than) Improper positioning and constraint of cask conveyance	1 – Human failure 2 – Mechanical failure	Potential collision leading to radioactive release	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training 3 – Brakes, chocks, and rail stops	Collision caused by unconstrained cask conveyance	R-102
1.10	Temperature	(More) Exceeds 10 CFR 71 temperature design basis	Fire	1 – Radioactive release 2 – Potential criticality	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training 3 – Combustible materials control	1–10 CFR 71 temperature design basis 2–Combustible materials control includes removing SPM prior to cask handling operations	R-I303 thru R-I310
1.11	Temperature	(Less) Below 10 CFR 71 temperature design basis	Normal condition	No safety consequences	—	—	—
1.12	Shielding	(Less) Displacement of TC shielding	Impact or fire	Direct exposure	1 – TC remains in 10 CFR 71 configuration 2 – Procedures and training 3 – Combustible materials control	Includes reduction or complete loss of shielding	R-102, R-I303 thru R-I310

NOTE: Guidewords not used in this node: As Well As and Part Of.
HVAC = heating, ventilation, and air conditioning; RF = Receipt Facility; SPM = site prime mover; TC = transportation cask
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original; Ref. 2.3.3.

Table E-2A. HAZOP Worksheet

Facility/Operation: RF					Process: Export of Horizontal Cask with DPC from Preparation and Receipt Area		
Node 1A: Move Horizontal TC on Transfer Trailer Out of Preparation Area					Process/Equipment: Cask Transfer Trailer with Tractor		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
1A.1	Speed	(More) Tractor moves too fast	Driver drives too fast	Potential loss of control or collision leading to radioactive release	1 – Tractor design 2 – Procedures and training	—	R-1404
1A.2	Speed	(More) Tractor moves too fast	Mechanical failure of SPM	Potential loss of control or collision leading to radioactive release	1 – Tractor design 2 – Procedures and training	—	R-1404
1A.3	Speed	(Less) Tractor moves too slow	Mechanical failure of SPM	No safety consequences	—	—	—
1A.4	Speed	(No) Tractor or trailer does not move	1 – Human failure 2 – Mechanical failure	No safety consequences	—	Always at least one-door boundary for HVAC if conveyance is stuck in doorway	—
1A.5	Direction	(Reverse) Backs up instead of going forward	1 – Human failure 2 – Mechanical failure	Potential loss of control or collision leading to radioactive release	1 – Tractor design 2 – Procedures and training	Potential loss of HVAC boundary if collision with door	R-1404
1A.6	Direction	(Other Than) Does not follow designated route and goes to wrong location or problem area	1 – Human failure 2 – Mechanical failure	Potential loss of control or collision leading to radioactive release	Procedures and training	—	R-1404
1A.7	Temperature	(More) Exceeds 10 CFR 71 temperature design basis	Fire	1 – Radioactive release 2 – Potential criticality	1 – Procedures and training 2 – Combustible materials control	Combustible materials control includes removing SPM prior to cask handling operations	R-I303 thru R-I310
1A.8	Temperature	(Less) Below 10 CFR 71 temperature design basis	Normal condition	No safety consequences	—	—	—
1A.9	Shielding	(Less) Displacement of horizontal TC shielding	Impact or fire	Direct exposure	1 – Procedures and training 2 – Combustible materials control	Includes reduction or complete loss of shielding	R-1404 R-I303 thru R-I310

NOTE: Guidewords not used in this node: As Well As and Part Of.
DPC = dual-purpose canister; HVAC = heating, ventilation, and air conditioning; RF = Receipt Facility; SPM = site prime mover; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original; Ref. 2.3.3.

Table E-3. HAZOP Worksheet

Facility/Operation: RF	Process: TC Unloading
Node 2: Remove Impact Limiters from TC	Process/Equipment: Railcar, Cask Handling Crane (Auxiliary Hook), Cask Access Platform
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of	Consequence Categories: Radioactive Release, Lack of Shielding, Criticality

Node Item Number	Parameter	Deviation Considered	Postulated Cause	Consequence(s)	Potential Prevention/Mitigation Design of Operational Feature	Notes	MLD Index Number
2.1	Load	(More) Load lifted too heavy for crane	Failure to remove restraining bolt on impact limiters	Drop of load leading to radioactive release	1 – TC design 2 – Procedures and training 3 – Crane design and below-the-hook devices	20-ton hoist	R-611
2.2	Load	(Less) Load lifted too light	NCI	No safety consequences	—	—	—
2.3	Speed (Crane)	(More) Hook lowers too fast	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Crane design	—	R-611
2.4	Speed (Crane)	(Less) Hook lowers too slow	NCI	No safety consequences	—	—	—
2.5	Travel (Crane)	(Other Than) Crane moves with hook lowered	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Crane design	—	R-613
2.6	Travel (Crane)	(More) Crane moves past desired position for activity	1 – Human failure 2 – Mechanical failure	No safety consequences	—	—	—
2.7	Travel (Crane)	(Less) Crane does not move into desired position for activity	1 – Human failure 2 – Mechanical failure	No safety consequences	—	—	—
2.8	Travel (Crane)	(Reverse) Travels in wrong direction	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Crane design	—	R-613
2.9	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	Potential fire scenario	R-I303 thru R-I310
2.10	Maintenance	(No) Improper maintenance of crane	Human failure	No safety consequences	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
2.11	Controls (PLC)	(Other Than)	NCI	No safety consequences	—	Considered in event sequence development (event tree/FTA/HRA)	—
2.12	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	No safety consequences	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	—
2.13	Alignment	(Other Than)	See 2.5 through 2.8 above	No safety consequences	—	—	—
2.14	Mobile Access Platform Operations	(Other Than) Impact from operational activities	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Platform and tool design	—	R-614

NOTE: Guidewords not used in this node: As Well As and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-4. HAZOP Worksheet

Facility/Operation: RF	Process: TC Unloading
Node 3: Attach Lift Yoke to TC on Railcar	Process/Equipment: Railcar, 200-Ton Crane, Lift Yoke, Trunnions (as required)
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of	Consequence Categories: Radioactive Release, Lack of Shielding, Criticality

Node Item Number	Parameter	Deviation Considered	Postulated Cause	Consequence(s)	Potential Prevention/Mitigation Design of Operational Feature	Notes	MLD Index Number
3.1	Speed (Crane)	(More) Yoke lowers too fast	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-504
3.2	Speed (Crane)	(Less) Yoke lowers too slow	NCI	No safety consequences	—	—	—
3.3	Travel (Crane)	(Other Than) Crane moves with yoke lowered	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-504
3.4	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	Potential fire scenario	R-I303 thru R-I310
3.5	Maintenance	(No) Improper maintenance of crane	Human failure	No safety consequences	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
3.6	Controls (PLC)	(Other Than)	NCI	No safety consequences	—	Considered in event sequence development (event tree/FTA/HRA)	—
3.7	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	No safety consequences	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	—
3.8	Mobile Access Platform Operations	(Other Than) Impact from operational activities	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Platform and tool design	—	R-509
3.9	Engagement (Yoke)	(More) Over-travel on yoke arm positioning	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Positioning interlocks 2 – Yoke adjustment motor design 3 – Pin alignment 4 – Procedures and training	—	R-501
3.10	Engagement (Yoke)	(Less) Under-travel on yoke arm positioning	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Positioning interlocks 2 – Yoke adjustment motor design 3 – Pin alignment 4 – Procedures and training	Potential partial yoke engagement	R-501
3.11	Engagement	(No) Yoke fails to engage	NCI	No safety consequence	—	—	—
3.12	Yoke	(Other Than) Trunnion installed incorrectly	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Procedures and training 2 – Trunnion design	As required for certain casks	R-501

NOTE: Guidewords not used in this node: Reverse, As Well As, and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
[a]Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-4A. HAZOP Worksheet

Facility/Operation: RF					Process: TC Unloading		
Node 3A: Install Trunnions on Horizontal Storage TC on Cask Stand					Process/Equipment: Cask Stand, 200-Ton Crane, Trunnions		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
3A.1	Speed	(More) Trunnions lowered too fast	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-606
3A.2	Speed (Crane)	(Less) Trunnions lowered too slow	NCI	No safety consequences	—	—	—
3A.3	Travel (Crane)	(Other Than) Crane moves with yoke lowered	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-607
3A.4	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	Potential fire scenario	R-I303 thru R-I310
3A.5	Maintenance	(No) Improper maintenance of crane	Human failure	No safety consequences	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
3A.6	Controls (PLC)	(Other Than)	NCI	No safety consequences	—	Considered in event sequence development (event tree/FTA/HRA)	—
3A.7	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	No safety consequences	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	—
3A.8	Trunnions	(Other Than) Trunnion installed incorrectly	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Procedures and training 2 – Trunnion design	As required for certain casks	R-1405

NOTE: Guidewords not used in this node: Reverse, As Well As, and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-5. HAZOP Worksheet

Facility/Operation: RF	Process: TC Unloading
Node 4: Upright TC on Railcar	Process/Equipment: Railcar, 200-Ton Crane
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of	Consequence Categories: Radioactive Release, Lack of Shielding, Criticality

Node Item Number	Parameter	Deviation Considered	Postulated Cause	Consequence(s)	Potential Prevention/Mitigation Design of Operational Feature	Notes	MLD Index Number
4.1	Load	(More) Load lifted too heavy for crane	Failure to remove tie-downs	Drop of load leading to radioactive release	1 – Procedures and training 2 – Crane design	1 – 200-ton hoist 2 – TC may mitigate event, depending on passive equipment failure analysis	R-501
4.2	Load	(Less) Load lifted too light	NCI	No safety consequences	—	—	—
4.3	Speed (Crane and Hook)	(More or Less) Hook and crane speed not matched during lifting motion	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design and below-the-hook design	TC may mitigate event, depending on passive equipment failure analysis	R-501
4.4	Travel (Crane)	(Reverse) Travels in wrong direction	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design and below-the-hook design	1 – TC may mitigate event, depending on passive equipment failure analysis 2 – Crane feature to prevent rapid rundown needs to be subjected to FTA	R-502
4.5	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	1 – Procedures and training 2 – Design features	Potential fire scenario	R-I303 thru R-I310
4.6	Motor Motive Force	(Less or No) Loss of motive force allows rapid rundown	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	Crane design and below-the-hook design	1 – TC may mitigate event, depending on passive equipment failure analysis 2 – Crane feature to prevent rapid rundown needs to be subjected to FTA	R-501
4.7	Maintenance	(No) Improper maintenance of crane	Human failure	Potential radioactive release	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	R-501
4.8	Controls (PLC)	(Other Than) Control system failures	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	R-501, R-502, R-503
4.9	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	Potential radioactive release resulting from slap-down	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	R-501
4.10	Alignment	(Other Than)	See 4.3 above	—	—	—	R-501
4.11	Pivot Point	(Other Than) Pivot point constraint fails	Cover brackets fail or are removed out of sequence	Potential radioactive release resulting from slap-down	1 – Transportation skid pedestal design 2 – Procedures and training	—	R-501

NOTE: Guidewords not used in this node: As Well As and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-6. HAZOP Worksheet

Facility/Operation: RF	Process: TC Unloading
Node 5: Transfer TC to CTT (Air Pallet)	Process/Equipment: Railcar, 200-Ton Crane, CTT
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of	Consequence Categories: Radioactive Release, Lack of Shielding, Criticality

Node Item Number	Parameter	Deviation Considered	Postulated Cause	Consequence(s)	Potential Prevention/Mitigation Design of Operational Feature	Notes	MLD Index Number
5.1	Pedestal	(Other Than) Chooses wrong cask pedestal	Human failure	Cask tip-over resulting in release	1 – Procedures and training 2 – Pedestal design	1 – Human factors 2 – Scheduling by campaigns may minimize occurrence	R-508, R-809
5.2	Lift	(More) Two-blocking	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop	1 – Crane design 2 – Procedures and training	1 – TC may mitigate event, depending on passive equipment failure analysis 2 – 20 ft or greater drop considered	R-506, R-807
5.3	Lift	(Less) Not lifted high enough to clear other structures or equipment	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop or impact	Procedures and training	—	R-505, R-508, R-809
5.4	Lift	(No)	–	No safety consequences	—	—	—
5.5	Lift	(Reverse) Rapid rundown	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop or impact	1 – Crane design 2 – Procedures and training	TC may mitigate event, depending on passive equipment failure analysis	R-506, R-807
5.6	Speed (Crane)	(More) Crane moves faster than allowed by procedures	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – Crane design 2 – Procedures and training	TC design may mitigate event, depending on passive equipment failure analysis	R-508, R-809
5.7	Speed (Crane)	(Less) Crane moves too slow	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from drop	Procedures and training	Prolonged exposure time for sequence initiation	R-508, R-809
5.8	Speed (Crane)	(Other Than) Abrupt stop	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – Crane design 2 – Procedures and training	TC design may mitigate event, depending on passive equipment failure analysis	R-506, R-807
5.9	Alignment (Trolley)	(No) Improper alignment	Human failure	Potential radioactive release resulting from collision with structures or equipment	Procedures and training	Check for self-aligning features or electronic-aligning features	R-508, R-809

NOTE: Guidewords not used in this node: As Well As and Part Of.
CTT = cask transfer trolley; ft = feet; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-7. HAZOP Worksheet

Facility/Operation: RF					Process: TC Unloading		
Node 6: Attach Slings to TC on Railcar for Horizontal Lift					Process/Equipment: Railcar, 200-Ton Crane, Lift Slings		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
6.1	Speed (Crane)	(More) Slings lowered too fast	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-603, R-703
6.2	Speed (Crane)	(Less) Slings lowered too slow	NCI	No safety consequences	—	—	—
6.3	Travel (Crane)	(Other Than) Crane moves with slings lowered	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-603, R-704
6.4	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	Potential fire scenario	R-I303 thru R-I310
6.5	Maintenance	(No) Improper maintenance of crane	Human failure	No safety consequences	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
6.6	Controls (PLC)	(Other Than)	NCI	No safety consequences	—	Considered in event sequence development (event tree/FTA/HRA)	—
6.7	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	No safety consequences	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	—
6.8	Mobile Access Platform Operations	(Other Than) Impact from operational activities	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – TC design 2 – Procedures and training 3 – Platform and tool design	—	R-705
6.9	Engagement (Slings)	(More) Over-travel on sling arm positioning	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Positioning interlocks 2 – Sling adjustment motor design 3 – Pin alignment 4 – Procedures and training	—	R-608, R-701
6.10	Engagement (Slings)	(Less) Under-travel on sling arm positioning	1 – Human failure 2 – Mechanical failure	Potential drop of TC leading to radioactive release	1 – Positioning interlocks 2 – Sling adjustment motor design 3 – Pin alignment 4 – Procedures and training	Potential partial sling engagement	R-608, R-701
6.11	Engagement (Slings)	(No) Failed to engage	NCI	No safety consequences	—	—	—

NOTE: Guidewords not used in this node: Reverse, As Well As, and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-8. HAZOP Worksheet

Facility/Operation: RF					Process: TC Unloading		
Node 7: Horizontal Transfer of Cask Between Rail Car, Cask Stand and Lift Fixture or Cask Transfer Trailer					Process/Equipment: Railcar, 200-Ton Crane, Cask Stand		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
7.1	Speed (Crane)	(More) Cask lowers too fast	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-608, R-801
7.2	Speed (Crane)	(Less) Cask lowers too slow	NCI	No safety consequences	—	—	—
7.3	Travel (Crane)	(Other Than) Crane moves with cask lowered	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design	TC design may mitigate event, depending on passive equipment failure analysis	R-610, R-803
7.4	Motor	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	Potential fire scenario	R-I303 thru R-I310
7.5	Maintenance	(No) Improper maintenance of crane	Human failure	No safety consequences	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
7.6	Controls (PLC)	(Other Than)	NCI	No safety consequences	—	Considered in event sequence development (event tree/FTA/HRA)	—
7.7	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	No safety consequences	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	—
7.8	Lift	(More) Two-blocking	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop	1 – Crane design 2 – Procedures and training	1 – TC design may mitigate event, depending on passive equipment failure analysis 2 – 20 ft or greater drop considered	R-608, R-801
7.9	Lift	(Less) Not lifted high enough to clear other structures or equipment	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop or impact	Procedures and training	—	R-610, R-803
7.10	Lift	(No)	NCI	No safety consequences	—	—	—
7.11	Lift	(Reverse) Rapid rundown	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release resulting from drop or impact	1 – Crane design 2 – Procedures and training	TC design may mitigate event, depending on passive equipment failure analysis	R-608, R-801, R-802
7.12	Speed (Crane)	(More) Crane moves faster than allowed by procedures	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – Crane design 2 – Procedures and training	TC design may mitigate event, depending on passive equipment failure analysis	R-610, R-803
7.13	Speed (Crane)	(Less) Crane moves too slow	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from drop	Procedures and training	Prolonged exposure time for sequence initiation	R-801
7.14	Speed (Crane)	(Other Than) Abrupt stop	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – Crane design 2 – Procedures and training	TC design may mitigate event, depending on passive equipment failure analysis	R-801
7.15	Lift	(Other Than) 200-ton crane used instead of 20-ton entrance vestibule crane to remove impact limiters	Human failure	Drop of cask resulting in release	1 – Procedures and training 2 – Hook design	—	R-801

NOTE: Guidewords not used in this node: As Well As and Part Of.
ft = feet; FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-9. HAZOP Worksheet

Facility/Operation: RF					Process: TC Unloading		
Node 8: Move Horizontal TC from Cask Stand onto Cask Tilting Frame and Upend					Process/Equipment: 200-Ton Crane, Tilting Frame		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
8.1	Load	(More) Load lifted too heavy for crane	Human failure	Drop of load leading to radioactive release	1 – Procedures and training 2 – Crane design	1 – 200-ton hoist 2 – TC design may mitigate event, depending on passive equipment failure analysis	R-806, R-807
8.2	Load	(Less) Load lifted too light	NCI	No safety consequences	—	—	—
8.3	Speed (Crane and Hook)	(More/Less) Hook and crane speed not matched during lifting motion	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design and below-the-hook design	TC design may mitigate event, depending on passive equipment failure analysis	R-806, R-807
8.4	Travel (Crane)	(Reverse) Travels in wrong direction	1 – Human failure 2 – Mechanical failure	Potential radioactive release	1 – Procedures and training 2 – Crane design and below-the-hook design	1 – TC design may mitigate event, depending on passive equipment failure analysis 2 – Crane feature to prevent rapid rundown needs to be subjected to FTA	R-806, R-807
8.5	Temperature	(More) Motor temperature too high	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	1 – Procedures and training 2 – Design features	Potential fire scenario	R-I303 thru R-I310
8.6	Motor Motive Force	(Less/No) Loss of motive force allows rapid rundown	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	1 – Procedures and training 2 – Design features	1 – TC design may mitigate event, depending on passive equipment failure analysis 2 – Crane feature to prevent rapid rundown needs to be subjected to FTA	R-806, R-807
8.7	Maintenance	(No) Improper maintenance of crane	Human failure	Potential radioactive release	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
8.8	Controls (PLC)	(Other Than) Control system failures	1 – Human failure 2 – Mechanical malfunction	Potential radioactive release	Maintenance program	Considered in event sequence development (event tree/FTA/HRA)	—
8.9	Vision/ Communication	(Other Than) Unclear communication	Poor operating environment	Potential radioactive release resulting from slap-down	1 – Crane operator training program 2 – Human factor evaluation 3 – Industrial hygiene standards	Considered in HRA	R-804, R-806, R-810
8.10	Alignment	(Other Than)	See 8.3 above	—	—	—	—
8.11	Pivot Point	(Other Than) Pivot point constraint fails	Cover brackets fail or are removed out of sequence	Potential radioactive release resulting from slap-down	1 – Transportation skid pedestal design 2 – Procedures and training	—	R-804, R-809
8.12	L-Frame	(Other Than) Cask not secured to L-frame prior to bringing upright	1 – Human failure 2 – Mechanical failure	Potential radioactive release from drop or impact	1 – Procedures and training 2 – L-frame design	—	R-804, R-807
8.13	L-Frame	(Other Than) Failure to release cask from L-frame after bringing upright	Human failure	Potential radioactive release from drop or impact	Procedures and training	—	R-804, R-807

NOTE: Guidewords not used in this node: As Well As and Part Of.
FTA = fault-tree analysis; HRA = human-reliability analysis; NCI = no cause identified; PLC = programmable logic controller; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-10. HAZOP Worksheet

Facility/Operation: RF					Process: TC Preparation		
Node 9: Prepare Cask for Unloading					Process/Equipment: Preparation Station, Common Tools, Cask Shield Ring, Standard Rigging, Cask Handling Crane		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
9.1	Load	(More) Too much load for crane	1 – Human failure 2 – Equipment failure	Potential release of materials in cask canister annulus to environment	1 – Procedures and training 2 – TC design	TC design may mitigate event, depending on passive equipment failure analysis	R-902, R-903
9.2	Load	(Less) Too light	NCI	No safety consequences	—	—	—
9.3	Loosen/Remove Lid Bolts	(Other Than) Failure to remove	Human failure	No safety consequences	—	1 – Sequence of bolt removal and installation of lift fixture may impact human failure probability associated with failure to remove bolts 2 – Precursor to cask drop if remaining bolts overloaded	R-1003
9.4	Loosen/Remove Lid Bolts	(Reverse) Tighten bolts instead of loosen	1 – Human failure 2 – Equipment failure	No safety consequences	—	Potential precursor to cask drop if remaining bolts overloaded	R-1003
9.5	Attach TC Lid Lift Fixture	(Other Than) Improper attachment	1 – Human failure 2 – Equipment failure	No safety consequences	1 – Procedures and training 2 – Potentially precluded by design	Potential precursor to cask lid drop	R-1001
9.6	Remove TC Lid	(More) Attempting to lift more than lid alone (see 9.3 and 9.4 above)	Human failure	Potential drop of cask when attempting to remove lid leading to radioactive release	1 – Procedures and training 2 – Crane design features	Model crane overload protection features and failure modes	R-903, R-1003
9.7	Remove TC Lid	(More) Attempting to lift lid too high (i.e., two-blocking)	Human failure	Potential drop of lid onto canister leading to radioactive release	1 – Procedures and training 2 – Crane design features	—	R-902, R-1001
9.8	Remove TC Lid	(Less) Not lifting lid high enough to clear cask	Human failure	Catch of lid on cask causing cask to tip over and leading to radioactive release	Procedures and training	—	R-1004
9.9	Remove TC Lid	(Other Than) Lift with fixture improperly attached (see 9.5 above)	Human failure	Potential drop of lid onto canister leading to radioactive release	Procedures and training	—	R-1001
9.10	Install Shield Ring	(More) Lift too high	1 – Human failure 2 – Equipment failure	Drop of ring onto canister leading to radioactive release	Procedures and training	Shield ring installation includes attaching ring to auxiliary hook of cask crane and moving it to shield stand	R-1001
9.11	Install Shield Ring	(Less) Lift does not lift high enough to clear cask	Human failure	Impact to side of cask leading to cask and canister drop and radioactive release	Procedures and training	—	R-1005
9.12	Install Shield Ring	(No) No installation	Human failure	Direct exposure	Procedures and training	—	R-1008
9.13	Install Shield Ring	(Other Than) Improperly installed	Human failure	Direct exposure	Procedures and training	Improper installation includes lopsided installation or misalignment	R-1008
9.14	Install Canister Lift Fixture	(More) Lift too high	1 – Human failure 2 – Equipment failure	Drop of fixture onto canister leading to radioactive release	Procedures and training	Lifted by auxiliary hook of cask crane	R-902
9.15	Install Canister Lift Fixture	(Less) Lift not high enough to clear cask	Human failure	Impact to side of cask leading to potential cask and canister drop and radioactive release	Procedures and training	—	R-902

Table E-10. HAZOP Worksheet (Continued)

Facility/Operation: RF					Process: TC Preparation		
Node 9: Prepare Cask for Unloading					Process/Equipment: Preparation Station, Common Tools, Cask Shield Ring, Standard Rigging, Cask Handling Crane		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
9.16	Install Canister Lift Fixture	(Other Than) Improperly installed for movement to installation position	Human failure	Drop of fixture onto canister leading to radioactive release	Procedures and training	—	R-902
9.17	Install Canister Lift Fixture	(Other Than) Improperly installed	Human failure	No safety consequences	Procedures and training	Precursor to canister drop during lift	R-1209
9.18	Remove and Store Shield Ring	(More) Lift too high	1–Human failure 2–Equipment failure	Drop of ring onto canister leading to radioactive release	Procedures and training	—	R-1001
9.19	Remove and Store Shield Ring	(Less) Lift not high enough to clear cask	Human failure	Impact on side of cask leading to potential cask and canister drop and radioactive release	Procedures and training	—	R-1002
9.20	Remove and Store Shield Ring	(No) No removal	Human failure	No safety consequences	Procedures and training	Precursor to drop of or impact to canister during CTM lift	R-1209

NOTE: Guidewords not used in this node: As Well As and Part Of.
CTM = canister transfer machine; NCI = no cause identified; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-11. HAZOP Worksheet

Facility/Operation: RF					Process: TC/DPC Preparation		
Node 10: Move CTT into Cask Unloading Room					Process/Equipment: CTT		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
10.1	CTT Lift	(More) Too much lift	No cause identified	—	—	Unable to lift more than 5/16-inch over longest dimension	—
10.2	CTT Lift	(Less) Not enough lift	1 – Lack of air pressure 2 – Cone malfunction	No safety consequences	—	—	—
10.3	CTT Lift	(Other Than) Uneven lift	Cone malfunction	No safety consequences	—	Unable to lift more than 5/16-inch over longest dimension	—
10.4	CTT Lift	(Other Than) Drop	Loss of air	No safety consequences	—	—	—
10.5	CTT Movement	(More) Moves too far	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – CTT design 3 – TC design	Shield door open, collision with facility structure	R-1102
10.6	CTT Movement	(More) Moves too far	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – CTT design 3 – TC design	Shield door closed, collision with shield door	R-1102
10.7	CTT Movement	(Less) Does not move enough	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	—	—
10.8	CTT Movement	(Reverse) Moves in opposite direction	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – CTT design 3 – TC design	—	R-1102, R-1103
10.9	CTT Movement	(Other Than) Sideways movement	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – CTT design 3 – TC design	—	R-1102, R-1103
10.10	Shield Door Movement	(Other Than) Spurious closure of shield door	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – Design of shield-door controls 3 – TC design	—	R-1101
10.11	Preparation Platform Position	(Other Than) Out of position leading to platform collision with CTT frame	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – CTT design 3 – TC design	—	R-1102

NOTE: Guidewords not used in this node: No, As Well As, and Part Of.
CTT = cask transfer trolley; DPC = dual-purpose canister; RF = Receipt Facility; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-12. HAZOP Worksheet

Facility/Operation: RF					Process: CTM Operation		
Node 11: Remove Canister from Cask using CTM (Vertical CTM Movement)					Process/Equipment: CTM, CTM Bay/Cell		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
11.1	Shield Door Movement	(Other Than) Failure to close shield door	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with removal of canister	R-1201
11.2	Shield Door Movement	(Other Than) Spurious opening of shield door	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with removal of canister	R-1201
11.3	Shield Door Movement	(Other Than) Failure to evacuate personnel prior to door closure	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with removal of canister	R-1201
11.4	Port Slide Gate	(Other Than) Failure to open slide gate	1 – Human failure 2 – Mechanical malfunction	No safety consequences	1 – Procedures and training 2 – Design of slide-gate controls	—	—
11.5	Port Slide Gate	(Other Than) Failure to close slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when CTM moves	1 – Procedures and training 2 – Design of slide-gate controls	—	R-1201
11.6	Port Slide Gate	(Other Than) Opening of port slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when CTM moves	1 – Procedures and training 2 – Design of slide-gate controls	—	R-1201
11.7	Port Slide Gate	(Other Than) Closure while lifting canister	1 – Human failure 2 – Mechanical malfunction	Potential release	1 – Procedures and training 2 – Design of slide-gate controls	Examine closures on rope as well as canister	R-1207, R-1208
11.8	CTM Slide Gate	(Other Than) Failure to open slide gate	1 – Human failure 2 – Mechanical malfunction	No safety consequences	1 – Procedures and training 2 – Design of slide-gate controls	—	—
11.9	CTM Slide Gate	(Other Than) Failure to close slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when skirt lifts	1 – Procedures and training 2 – Design of slide-gate controls	—	R-1201
11.10	CTM Slide Gate	(Other Than) Opening of CTM slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when skirt lifts	1 – Procedures and training 2 – Design of slide-gate controls	—	R-1201
11.11	CTM Slide Gate	(Other Than) Closure while lifting canister	1 – Human failure 2 – Mechanical malfunction	Potential release	1 – Procedures and training 2 – Design of slide-gate controls	Examine closures on rope as well as canister	R-1208, R-1209
11.12	Lid Grapple Engagement	(Other Than) Improper attachment	1 – Human failure 2 – Equipment failure	No safety consequences	1 – Procedures and training 2 – Potentially precluded by design	Potential precursor to cask lid drop	R-1001
11.13	Remove TC Lid	(More) Attempting to lift more than lid alone	Human failure	Potential radioactive release from drop of cask when attempting to remove lid	1 – Procedures and training 2 – Crane design features	Model crane overload protection features and failure modes	R-1105
11.14	Remove TC Lid	(More) Attempting to lift lid too high (i.e., two-blocking)	Human failure	Potential radioactive release from drop of lid onto canister	1 – Procedures and training 2 – Crane design features	Does not apply to DPC canisters	R-1104
11.15	Remove TC Lid	(Less) Not lifting lid high enough to clear cask	Human failure	Potential radioactive release from drop of lid onto canister	Procedures and training	Does not apply to DPC canisters	R-1105
11.16	Remove TC Lid	(Other Than) Lift with grapple improperly attached (see 11.12 above)	Human failure	Potential radioactive release from drop of cask lid onto canister	Procedures and training	Does not apply to DPC canisters	R-1104
11.17	Canister Grapple Engagement	(Other Than) Improper attachment	1 – Human failure 2 – Equipment failure	No safety consequences	1 – Procedures and training 2 – Potentially precluded by design	Potential precursor to canister drop	R-1209

Table E-12. HAZOP Worksheet (Continued)

Facility/Operation: RF						Process: CTM Operation	
Node 11: Remove Canister from Cask using CTM (Vertical CTM Movement)						Process/Equipment: CTM, CTM Bay/Cell	
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of						Consequence Categories: Radioactive Release, Lack of Shielding, Criticality	
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
11.18	Lift Canister	(More) Attempting to lift more than canister	Human failure	Potential drop of canister leading to radioactive release	1 – Procedures and training 2 – CTM design features	Model CTM overload protection features and failure modes	R-1211
11.19	Lift Canister	(More) Attempting to lift canister too high (i.e., two-blocking)	Human failure	1 – Potential drop of canister leading to radioactive release 2 – Direct exposure if lifted above top of shield bell	1 – Procedures and training 2 – CTM design features	—	R-1202
11.20	Lift Canister	(Less) Not lifting canister high enough to clear floor	Human failure	Potential shear of canister or cable when CTM moved leading to radioactive release	Procedures and training	—	R-1203, R-1207
11.21	Lift Canister	(Other Than) Movement of carrier (CTT) during lift of canister	Human failure	Potential shear of canister or cable if carrier moves during lift leading to radioactive release	1 – Procedures and training 2 – CTT and ST design features	—	R-1205
11.22	Lift Canister	(Other Than) Miscellaneous mechanical failures	Mechanical malfunction	Potential drop leading to radioactive release	CTM design features	Maintenance program	R-1210, R-1211
11.23	Lift Canister	(Other Than) Lift with grapple improperly attached (see 11.17 above)	1 – Human failure 2 – Mechanical malfunction	Potential drop of canister leading to radioactive release	Procedures and training	—	R-1212

NOTE: Guidewords not used in this node: No, Reverse, As Well As, and Part Of.
CTM = canister transfer machine; CTT = cask transfer trolley; DPC = dual-purpose canister; RF = Receipt Facility; ST = site transporter; TC = transportation cask.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-13. HAZOP Worksheet

Facility/Operation: RF					Process: CTM Operation		
Node 12: Move CTM Laterally					Process/Equipment: CTM		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
12.1	Speed (CTM)	(More) CTM moves faster than allowed by procedures	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – CTM design 2 – Procedures and training	—	R-1203
12.2	Speed (CTM)	(No) CTM stuck in middle of room during move	1 – Human failure 2 – Mechanical failure	Potential radioactive release due to heat-up, etc.	1 – Procedures and training 2 – Design features	Verify cooling requirements	R-101
12.3	Speed (CTM)	(Less) CTM moves too slow	1 – Human failure 2 – Mechanical failure	No safety consequences	N/A	—	—
12.4	Speed (CTM)	(Other Than) Abrupt stop	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision between canister and CTM	1 – CTM design 2 – Procedures and training	—	R-1203
12.5	Direction (CTM)	(More) CTM moves too far	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with structures or equipment	1 – CTM design 2 – Procedures and training	—	R-1203
12.6	Direction (CTM)	(Less) CTM does not move enough	1 – Human failure 2 – Mechanical failure	No safety consequences	—	—	—
12.7	Direction (CTM)	(Other Than) Moves in wrong direction	1 – Human failure 2 – Mechanical failure	Potential radioactive release resulting from collision with facility structures	1 – CTM design 2 – Procedures and training	—	R-1203
12.8	Miscellaneous (CTM)	(Other Than) Moves over lid not properly stored	Human failure	Potential radioactive release resulting from collision	1 – Facility design 2 – Procedures and training	—	R-1203

NOTE: Guidewords not used in this node: Reverse, As Well As, and Part Of.
CTM = canister transfer machine; RF = Receipt Facility.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

Source: Original

Table E-14. HAZOP Worksheet

Facility/Operation: RF							Process: CTM Operation
Node 13: Lower Canister from CTM into AO							Process/Equipment: CTM, AO
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of							Consequence Categories: Radioactive Release, Lack of Shielding, Criticality
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
13.1	Shield Door Movement	(Other Than) Failure to close shield door	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with lowering of canister	R-1201
13.2	Shield Door Movement	(Other Than) Spurious opening of shield door	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with lowering of canister	R-1201
13.3	Shield Door Movement	(Other Than) Failure to evacuate personnel prior to door closure	1 – Human failure 2 – Mechanical malfunction	Direct exposure	1 – Procedures and training 2 – Design of shield-door controls	Must be concurrent with lowering of canister	R-1201
13.4	Port Slide Gate	(Other Than) Failure to open slide gate	1 – Human failure 2 – Mechanical malfunction	No safety consequences	1 – Procedures and training 2 – Design of slide-gate controls	Verify with passive equipment failure analysis	—
13.5	Port Slide Gate	(Other Than) Failure to close slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when CTM moves	1 – Procedures and training 2 – Design of slide-gate controls	After canister is lowered into receptacle	R-1201
13.6	Port Slide Gate	(Other Than) Inadvertent opening of port slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when CTM moves	1 – Procedures and training 2 – Design of slide-gate controls	After canister is lowered into receptacle	R-1201
13.7	Port Slide Gate	(Other Than) Closure while lowering canister	1 – Human failure 2 – Mechanical malfunction	Potential release	1 – Procedures and training 2 – Design of slide-gate controls	Examine closures on rope as well as canister	R-1207, R-1208, R-1209
13.8	CTM Slide Gate	(Other Than) Failure to open slide gate	1 – Human failure 2 – Mechanical malfunction	No safety consequences	1 – Procedures and training 2 – Design of slide-gate controls	—	—
13.9	CTM Slide Gate	(Other Than) Failure to close slide gate	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	—	—
13.10	CTM Slide Gate	(Other Than) Opening of CTM slide gate	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure to personnel on second floor when skirt lifts	1 – Procedures and training 2 – Design of slide-gate controls	—	R-1201
13.11	CTM Slide Gate	(Other Than) Closure while lowering canister	1 – Human failure 2 – Mechanical malfunction	Potential release	1 – Procedures and training 2 – Design of slide-gate controls	Examine closures on rope as well as canister	R-1208, R-1209
13.12	Lowering of Canister	(Less) Not lowering canister enough to clear bottom of second floor	Human failure	Potential shear of canister or cable when CTM or receiver moved leading to radioactive release	Procedures and training	—	R-1207
13.13	Lowering of Canister	(Other Than) Movement of carrier (CTT, ST) during lowering of canister	Human failure	Potential shear of canister or cable if carrier moves during lift leading to radioactive release	1 – Procedures and training 2 – CTT design features	—	R-1204
13.14	Lowering of Canister	(Other Than) Miscellaneous mechanical failures	Mechanical malfunction	Potential drop leading to radioactive release	CTM design features	Maintenance program	R-1210, R-1211
13.15	Lowering of Canister	(Other Than) Lower canister without receptacle below	1 – Human failure 2 – Mechanical malfunction	Potential direct exposure	Procedures and training	—	R-1201
13.16	Lowering of Canister	(Other Than) Misalignment of CTM and port	1 – Human failure 2 – Mechanical malfunction	Potential canister impact or drop leading to radioactive release	Procedures and training	Potential of catching ledge and dropping into hole	R-1207

Table E-14. HAZOP Worksheet (Continued)

Facility/Operation: RF							Process: CTM Operation
Node 13: Lower Canister from CTM into AO							Process/Equipment: CTM, AO
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of						Consequence Categories: Radioactive Release, Lack of Shielding, Criticality	
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
13.17	Lid Grapple Engagement	(Other Than) Improper attachment	1 – Human failure 2 – Equipment failure	No safety consequences	1 – Procedures and training 2 – Potentially precluded by design	Potential precursor to cask lid drop	R-1209
13.18	Install AO Lid	(More) Lowering too rapidly impacts cask/canister	Human failure	Potential drop of cask when attempting to remove lid leading to radioactive release	1 – Procedures and training 2 – CTM design features	—	R-1301
13.19	Install AO Lid	(More) Attempting to lift lid too high (i.e., two-blocking)	Human failure	Potential drop of lid onto canister leading to radioactive release	1 – Procedures and training 2 – CTM design features	—	R-1301
13.20	Install AO Lid	(Less) Not lowering lid enough to engage cask	Human failure	Potential drop of lid onto canister if slide gate closes while lid suspended leading to radioactive release	1 – Procedures and training 2 – Grapple and CTM design features	—	R-1301
13.21	Install AO Lid	(Other Than) Lift with grapple improperly attached (see 13.17 above)	Human failure	Potential drop of cask lid onto canister leading to radioactive release	1 – Procedures and training 2 – Grapple and CTM design features	—	R-1301

NOTE: Guidewords not used in this node: No, Reverse, As Well As, and Part Of.
AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; RF = Receipt Facility; ST = site transporter.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

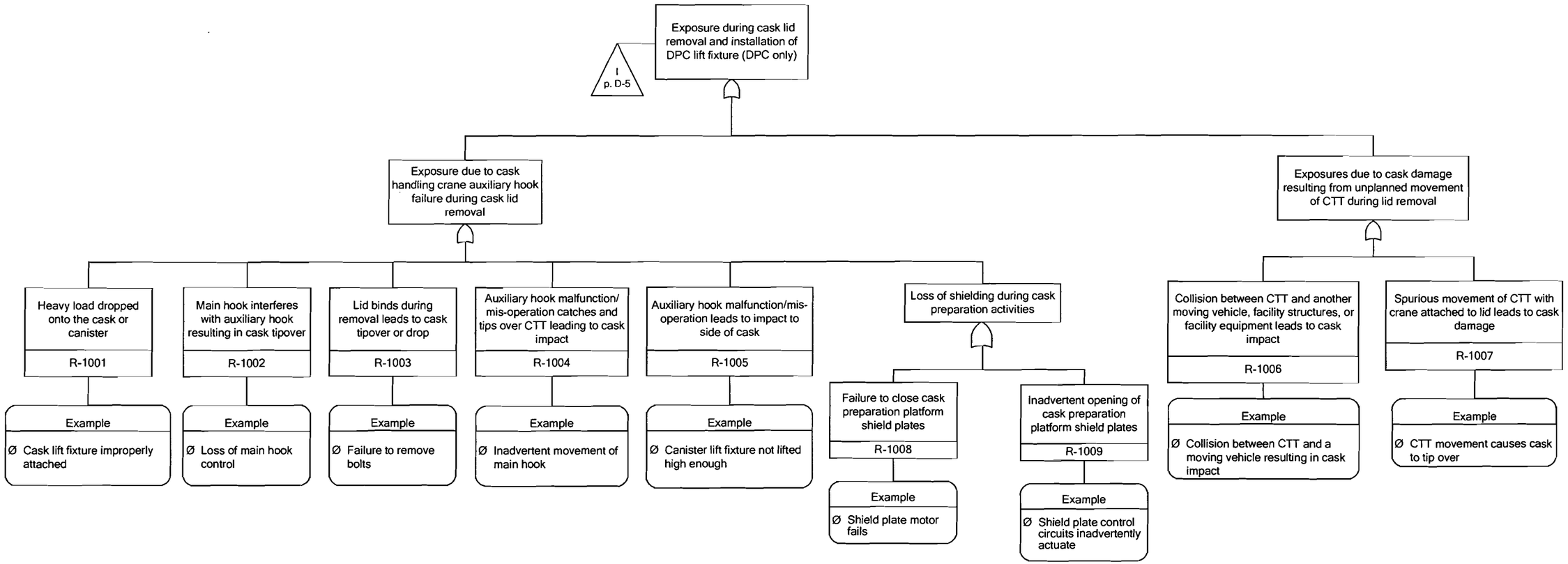
Source: Original

Table E-15. HAZOP Worksheet

Facility/Operation: RF					Process: ST Operations		
Node 14: Move Loaded AO on ST out of RF					Process Equipment: ST, AO		
Guide Words: No, More, Less, Reverse, Other Than, As Well As, Part Of					Consequence Categories: Radioactive Release, Lack of Shielding, Criticality		
Node Item Number	**Parameter**	**Deviation Considered**	**Postulated Cause**	**Consequence(s)**	**Potential Prevention/Mitigation Design of Operational Feature**	**Notes**	**MLD Index Number**
14.1	ST Movement	(More) Moves too far	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – ST design 3 – Receptacle/carrier design	Receptacle/carrier may mitigate event, depending on passive equipment failure analysis	R-1306, R-1305
14.2	ST Movement	(Less) Doesn't move enough	1 – Human failure 2 – Mechanical malfunction	No safety consequences	—	—	—
14.3	ST Movement	(Less) ST loses track or has other breakdown	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – ST design 3 – Receptacle/carrier design	—	R-1306, R-1305
14.4	ST Movement	(Reverse) Moves in opposite direction	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – ST design 3 – Receptacle/carrier design	—	R-1306, R-1305, R-1403
14.5	ST Movement	(Other Than) Steers off designated path	1 – Human failure 2 – Mechanical malfunction	Potential collision leading to radioactive release	1 – Procedures and training 2 – ST design 3 – Receptacle/carrier design	—	R-1306, R-1305
14.6	ST	(Other Than) Fire	1 – Human failure 2 – Mechanical malfunction	Potential release of radioactivity	1 – Procedures and training 2 – ST design	For PCSA fire analysis	R-I303 thru R-I310
14.7	Lift	(More) ST lifts load higher than 1 ft	1 – Human failure 2 – Mechanical failure	Potential drop leading to radioactive release	1 – ST design limits lift height to 1 ft 2 – Procedures and training	Procurement requirement	R-1306, R-1305
14.8	Lift	(Less) ST not lifted to required transport height	1 – Human failure 2 – Mechanical failure	Potential collision leading to radioactive release	1 – ST design 2 – Procedures and training	—	R-1306, R-1305
14.9	Lift	(No) ST does not lift load	1 – Human failure 2 – Mechanical failure	No safety consequences	—	1 – No loss of shielding or radioactive release 2 – Expected damage to bottom plate only	—

NOTE: Guidewords not used in this node: As Well As and Part Of.
AO = aging overpack; ft = foot; PCSA = preclosure safety analysis; RF = Receipt Facility; ST = site transporter.
Events that have no direct safety consequences but may be precursors to events that occur in other nodes are noted as "No safety consequences."

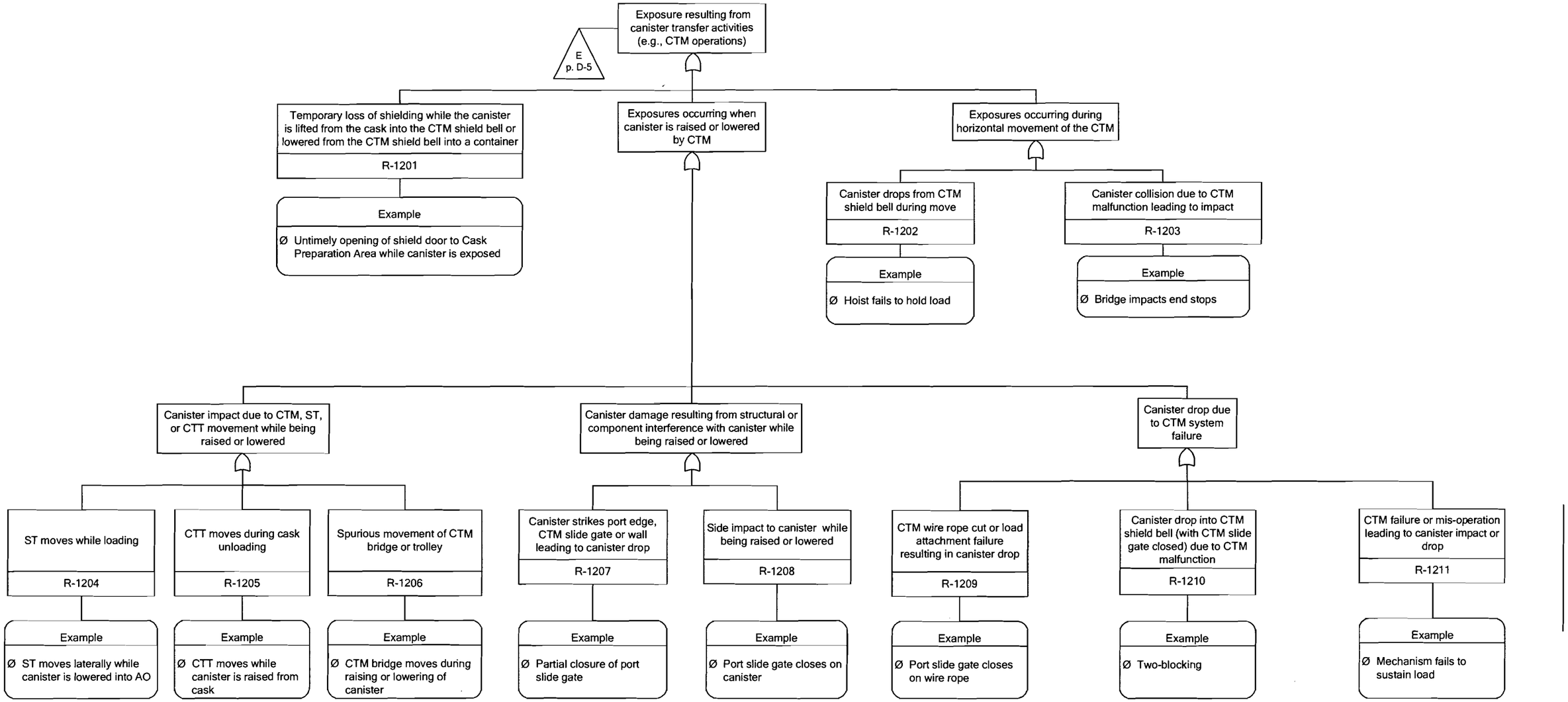
Source: Original



NOTES: Unplanned exposure of individuals to radiation or radioactive materials is referred to as "exposure."
CTT = cask transfer trolley; DPC = dual-purpose canister.

Source: Original

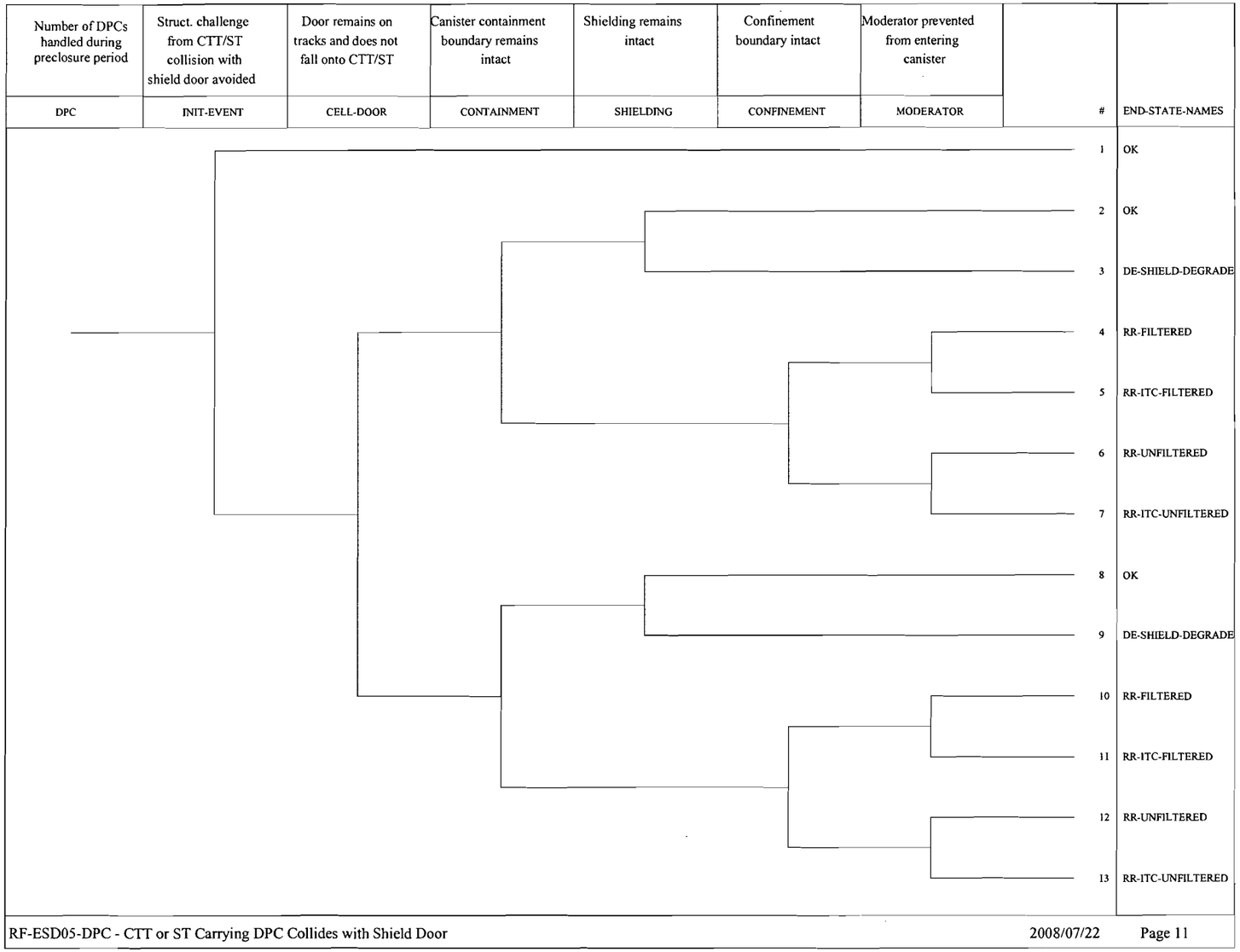
Figure D-10. Exposure During Cask Lid Removal and Installation of DPC Lift Fixture (DPC Only)



NOTES: Unplanned exposure of individuals to radiation or radioactive materials is referred to as "exposure."
AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; ST = site transporter; WP = waste package.

Source: Original

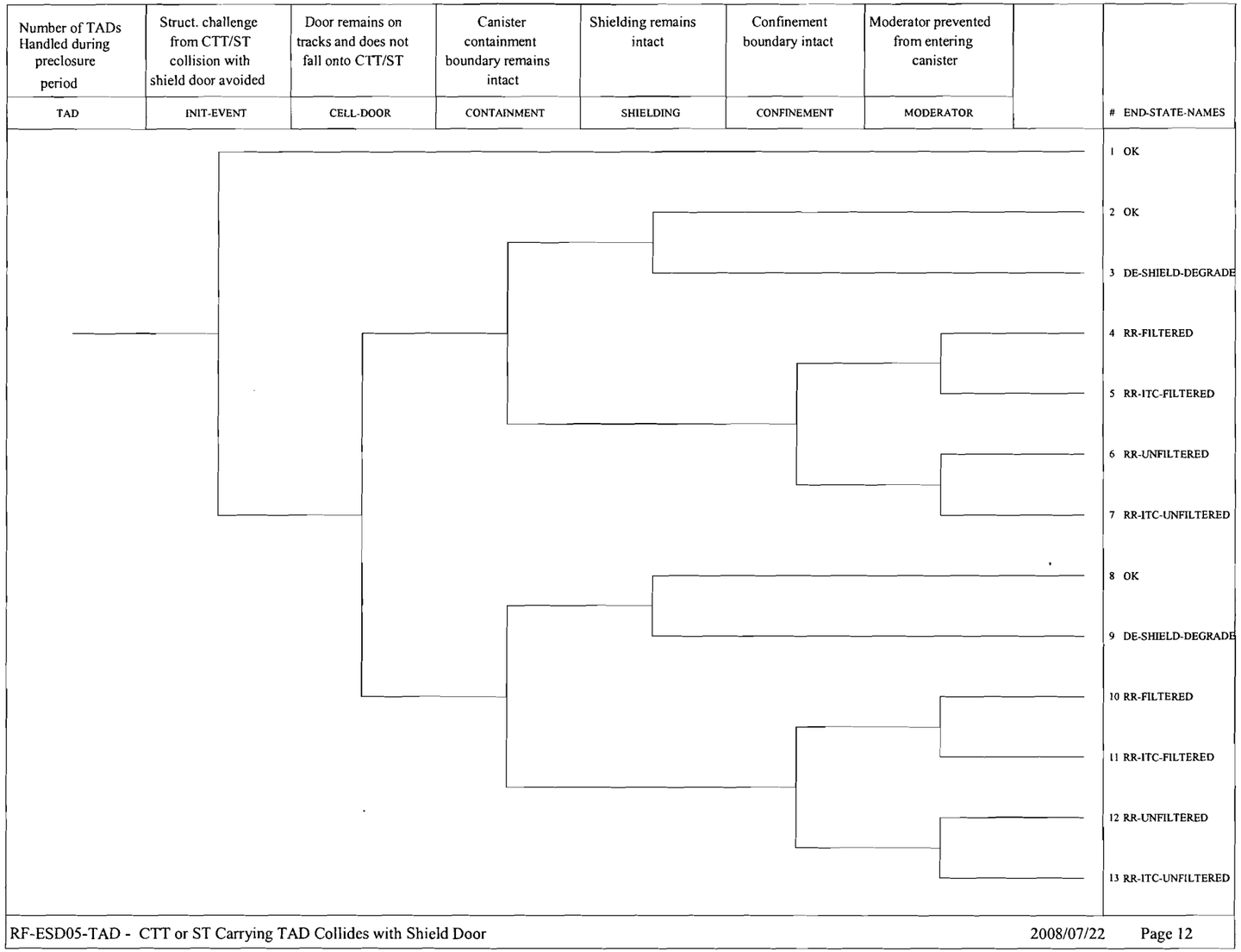
Figure D-12. Exposure Resulting from Canister Transfer Activities (e.g., CTM Operations)



NOTE: CTT = cask transfer trolley; DE = direct exposure; DPC = dual-purpose canister; HVAC = heating, ventilation, and air conditioning; INIT = initiating; ITC = important to criticality; RESP = response; RF = Receipt Facility; RR = radionuclide release; ST = site transporter; TC = transportation cask.

Source: Original

Figure G-12. Event Tree RF-ESD05-DPC – CTT or Site Transporter Carrying DPC Collides with Shield Door



NOTE: CTT = cask transfer trolley; DE = direct exposure; HVAC = heating, ventilation, and air conditioning; ITC = important to criticality; INIT = initiating; RESP = response; RF = Receipt Facility; RR = radionuclide release; ST = site transporter; T = transfer; TAD = transportation, aging, and disposal canister; TC = transportation cask.

Source: Original

Figure G-13. Event Tree RF-ESD05-TAD – CTT or Site Transporter Carrying TAD Canister Collides with Shield Door