the same for all waste forms and all initiating events. Failure of a moderator pivotal event results in an end state that may be susceptible to nuclear criticality. The opportunity for criticality also depends on other pivotal events (e.g., loss of containment, which may allow liquid moderator into a breached canister) and physical properties of the waste form.

Each of the specific failure events included in a self-contained or system response event tree may be linked to a basic event or to the top event of a fault tree that represents equipment failure modes and human failure events that can initiate the specific event. The fault tree models are, in turn, linked to basic events that provide the failure frequencies. Some of the pivotal events represent failure of equipment whose failure probabilities are linked to a separately developed basic event and not to a fault tree.

A4 EVENT TREE DESCRIPTIONS

A4.1 EVENT TREES FOR RF-ESD-01

RF-ESD-01 covers event sequences associated with receipt of a railcar carrying a transportation cask (Ref. 2.2.34, Figure F-1). This ESD covers two types of transportation casks. Corresponding to each type of cask is an initiator event tree (Table A4.1-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.1-1. Summary of Event Trees for RF-ESD-01

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: RF-ESD01-DPC Response: RESPONSE-TCASK1	346
Transportation cask containing a TAD canister	Initiator: RF-ESD01-TAD Response: RESPONSE-TCASK1	6,976

NOTE: DPC = dual-purpose canister; ESD = event sequence diagram; RF = Receipt Facility; TAD = transportation, aging, and disposal.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.1.1 Initiating Events for RF-ESD-01

The following initiating events are associated with RF-ESD-01. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.1-2.

Railcar Derailment. This initiating event accounts for the potential impact to the transportation cask on the railcar due to a derailment. The probability of derailment per railcar received is derived from empirical data in Section 6.3 and is modeled as a single event fault tree as described in Section 6.2.2. The fault tree reflects the expectation that only rail casks will be received at the RF. The initiating event is specified as a probability of derailment per cask.

Railcar Collision. This initiating event covers the potential impact to the transportation cask on the conveyance due to a collision with another vehicle. The vehicular collision event is modeled as a fault tree and is listed in Section 6.2.2. The initiating event is specified as a probability of collision per cask.

Table A4.1-2. Initiating Event Assignments for RF-ESD-01

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Railcar derailment	RF-ESD01-DPC	ESD1-DPC-DERAIL	200-SPMRC-DERIL-PER-MILE AND 200-SPMRC-MILES-IN-RF
	RF-ESD01-TAD	ESD1-TAD-DERAIL	
Railcar collision	RF-ESD01-DPC	ESD1-DPC-COLLIDE	No further transfers
	RF-ESD01-TAD	ESD1-TAD-COLLIDE	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.1.2 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

TRANSCASK. Table A4.1-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.1-3. Basic Event Associated with the TRANSCASK Pivotal Events of RF-ESD-01

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
RF-ESD01-DPC	ESD1-DPC-DERAIL	ESD1-DPC-DERAIL-TCASK	TCASK
	ESD1-DPC-COLLIDE	ESD1-DPC-COLLIDE-TCASK	
RF-ESD01-TAD	ESD1-TAD-DERAIL	ESD1-TAD-DERAIL-TCASK	
	ESD1-TAD-COLLIDE	ESD1-TAD-COLLIDE-TCASK	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CANISTER. Table A4.1-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.1-4. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-01

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD01-DPC	ESD1-DPC-DERAIL	ESD1-DPC-DERAIL-CAN	DPC-FAIL-IN-TC
	ESD1-DPC-COLLIDE	ESD1-DPC-COLLIDE-CAN	
RF-ESD01-TAD	ESD1-TAD-DERAIL	ESD1-TAD-DERAIL-CAN	TAD-FAIL-IN-TC
	ESD1-TAD-COLLIDE	ESD1-TAD-COLLIDE-CAN	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.1-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.1-5. Basic Event Associated with the SHIELDING Pivotal Events of RF-ESD-01

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD01-DPC	ESD1-DPC-DERAIL	ESD1-DPC-DERAIL-SHIELD	TCASK-SHIELDING
	ESD1-DPC-COLLIDE	ESD1-DPC-COLLIDE-SHIELD	
RF-ESD01-TAD	ESD1-TAD-DERAIL	ESD1-TAD-DERAIL-SHIELD	
	ESD1-TAD-COLLIDE	ESD1-TAD-COLLIDE-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.1-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.1-6. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-01

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD01-DPC	ESD1-DPC-DERAIL	200-CONFINEMENT	200-CONFINEMENT
	ESD1-DPC-COLLIDE		
RF-ESD01-TAD	ESD1-TAD-DERAIL		
	ESD1-TAD-COLLIDE		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.1-7 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.1-7. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-01

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD01-DPC	ESD1-DPC-DERAIL	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD1-DPC-COLLIDE		
RF-ESD01-TAD	ESD1-TAD-DERAIL		
	ESD1-TAD-COLLIDE		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.2 EVENT TREES FOR RF-ESD-02

RF-ESD-02 covers event sequences associated with removal of impact limiters from the transportation cask, upending the transportation cask, and transferring it to the CTT (Ref. 2.2.34, Figure F-3). This ESD covers two types of transportation casks. Corresponding to each type of cask is an initiator event tree (Table A4.2-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.2-1. Summary of Event Trees for RF-ESD-02

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: RF-ESD02-DPC Response: RESPONSE-TCASK1	346
Transportation cask containing a TAD canister	Initiator: RF-ESD02-TAD Response: RESPONSE-TCASK1	6,976

NOTE: DPC = dual-purpose canister; ESD = event sequence diagram; RF = Receipt Facility; TAD = transportation, aging, and disposal canister.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.2.2 Initiating Events for RF-ESD-02

The following initiating events are associated with RF-ESD-02. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.2-2.

Cask Drop from Operational Height. This initiating event accounts for the potential impact to the transportation cask due to having been dropped from the normal operational height during transfer by the cask handling crane. The probability of drop per transfer is derived from

empirical data in Section 6.3 and is modeled as a single event fault tree as described in Attachment B. The initiating event is specified as a probability of a drop per cask.

Cask Tipover. This initiating event covers the potential impact to the transportation cask due to a tipover. The tipover event is modeled as a single event fault tree and is listed in Attachment B. The initiating event is specified as a probability of a tipover per cask.

Side Impact to Cask. This initiating event covers the potential impact to the transportation cask due to a vehicular collision or (for transportation casks that are upended off of the railcar) a failure of the tilt frame. This event is modeled as a fault tree and is listed in Attachment B. The initiating event is specified as a probability of an impact per cask.

Unplanned Conveyance Movement. This initiating event covers the potential impact to the transportation cask due to an unplanned movement of the cask handling crane or cask transfer trolley. This event is modeled as a fault tree and is listed in Attachment B. The initiating event is specified as a probability of movement per cask.

Object Dropped on Cask. This initiating event covers the potential impact to the transportation cask due to the drop of a heavy object, such as an impact limiter, on the cask. This event is modeled as a fault tree and is listed in Attachment B. The initiating event is specified as a probability of an object drop per cask.

Cask Drop from Above Operational Height. This initiating event accounts for the potential impact to the transportation cask due to having been dropped from above the normal operational height (for example, due to two-blocking) during transfer by the cask handling crane. The probability of drop per transfer is modeled as a fault tree as described in Attachment B. The initiating event is specified as a probability of a drop per cask.

Table A4.2-2. Initiating Event Assignments for RF-ESD-02

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Cask drop from operational height	RF-ESD02-DPC	ESD2-DPC-DROP	200-TILTFRAME-CSC-FOH OR 200-DPC-CRANE-DROP
	RF-ESD02-TAD	ESD2-TAD-DROP	200-CRN2-DROPTAD-CRN-DRP AND 200-TRANSNSCTTLIFTNUMBER
Transportation cask tipover	RF-ESD02-DPC	ESD2-DPC-TIP	200-OPTIPOVER001-HFI-NOD
	RF-ESD02-TAD	ESD2-TAD-TIP	200-OP-TIPOVER
Side impact	RF-ESD02-DPC	ESD2-DPC-IMPACT	No further transfers
	RF-ESD02-TAD	ESD2-TAD-IMPACT	
Unplanned conveyance movement	RF-ESD02-DPC	ESD2-DPC-MOVE	200-CRANE-SPURMOVE OR 200-CTT-SPURMOVE
	RF-ESD02-TAD	ESD2-TAD-MOVE	
Object dropped on a cask	RF-ESD02-DPC	ESD2-DPC-DROPON	200-200T-CRANE-DROPON
	RF-ESD02-TAD	ESD2-TAD-DROPON	
Cask drop from above operational height	RF-ESD02-DPC	ESD2-DPC-2BLK	200-CRN2-2-BLOCK-CRN-TBK AND 200-TRANSCTTLIFTNUMBER
	RF-ESD02-TAD	ESD2-TAD-2BLK	200-CRN2-2-BLOCK-CRN-TBK AND 200-TRANSNSCTTLIFTNUMBER

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.2.3 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

TRANSCASK. Table A4.2-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.2-3. Basic Event Associated with the TRANSCASK Pivotal Events of RF-ESD-02

Initiator Event Tree	Initiating Event	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
RF-ESD02-DPC	ESD2-DPC-DROP	ESD2-DPC-DROP-TCASK	TCASK-MISC-DROP
	ESD2-DPC-TIP	ESD2-DPC-TIP-TCASK	TCASK-TIPOVER
	ESD2-DPC-IMPACT	ESD2-DPC-IMPACT-TCASK	TCASK-MISC-IMP
	ESD2-DPC-MOVE	ESD2-DPC-MOVE-TCASK	TCASK-SPURMOVE
	ESD2-DPC-DROPON	ESD2-DPC-DROPON-TCASK	TCASK-MISC-DROP
	ESD2-DPC-2BLK	ESD2-DPC-2BLK-TCASK2	TCASK-2BLOCK
RF-ESD02-TAD	ESD2-TAD-DROP	ESD2-TAD-DROP-TCASK	TCASK-MISC-DROP
	ESD2-TAD-TIP	ESD2-TAD-TIP-TCASK	TCASK-TIPOVER
	ESD2-TAD-IMPACT	ESD2-TAD-IMPACT-TCASK	TCASK-MISC-IMP
	ESD2-TAD-MOVE	ESD2-TAD-MOVE-TCASK	TCASK-SPURMOVE
	ESD2-TAD-DROPON	ESD2-TAD-DROPON-TCASK	TCASK-MISC-DROP
	ESD2-TAD-2BLK	ESD2-TAD-2BLK-TCASK2	TCASK-2BLOCK

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CANISTER. Table A4.2-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.2-4. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-02

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD02-DPC	ESD2-DPC-DROP	ESD2-DPC-DROP-CAN	DPC_FAIL_IN_TC
	ESD2-DPC-TIP	ESD2-DPC-TIP-CAN	
	ESD2-DPC-IMPACT	ESD2-DPC-IMPACT-CAN	
	ESD2-DPC-MOVE	ESD2-DPC-MOVE-CAN	
	ESD2-DPC-DROPON	ESD2-DPC-DROPON-CAN	
	ESD2-DPC-2BLK	ESD2-DPC-2BLK-CAN2	
RF-ESD02-TAD	ESD2-TAD-DROP	ESD2-TAD-DROP-CAN	TAD_FAIL_IN_TC
	ESD2-TAD-TIP	ESD2-TAD-TIP-CAN	
	ESD2-TAD-IMPACT	ESD2-TAD-IMPACT-CAN	
	ESD2-TAD-MOVE	ESD2-TAD-MOVE-CAN	
	ESD2-TAD-DROPON	ESD2-TAD-DROPON-CAN	
	ESD2-TAD-2BLK	ESD2-TAD-2BLK-CAN2	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.2-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.2-5. Basic Events Associated with the SHIELDING Pivotal Events of RF-ESD-02

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD02-DPC	ESD2-DPC-DROP	ESD2-DPC-DROP-SHIELD	TCASK-SHIELDING-DROP
	ESD2-DPC-TIP	ESD2-DPC-TIP-SHIELD	TCASK-SHIELDING-DROP
	ESD2-DPC-MOVE	ESD2-DPC-MOVE-SHIELD	TCASK-SHIELDING-IMP
	ESD2-DPC-DROPON	ESD2-DPC-DROPON-SHIELD	TCASK-SHIELDING-DROP
	ESD2-DPC-IMPACT	ESD2-DPC-IMPACT-SHIELD	TCASK-SHIELDING-IMP
	ESD2-DPC-2BLK	ESD2-DPC-2BLK-SHIELD2	TCASK-SHIELDING-2BLK
RF-ESD02-TAD	ESD2-TAD-DROP	ESD2-TAD-DROP-SHIELD	TCASK-SHIELDING-DROP
	ESD2-TAD-TIP	ESD2-TAD-TIP-SHIELD	TCASK-SHIELDING-DROP
	ESD2-TAD-MOVE	ESD2-TAD-MOVE-SHIELD	TCASK-SHIELDING-IMP
	ESD2-TAD-DROPON	ESD2-TAD-DROPON-SHIELD	TCASK-SHIELDING-DROP
	ESD2-TAD-IMPACT	ESD2-TAD-IMPACT-SHIELD	TCASK-SHIELDING-IMP
	ESD2-TAD-2BLK	ESD2-TAD-2BLK-SHIELD2	TCASK-SHIELDING-2BLK

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.2-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.2-6. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-02

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD02-DPC	ESD2-DPC-DROP	200-CONFINEMENT	200-CONFINEMENT
	ESD2-DPC-TIP		
	ESD2-DPC-IMPACT		
	ESD2-DPC-MOVE		
	ESD2-DPC-DROPON		
	ESD2-DPC-2BLK		
RF-ESD02-TAD	ESD2-TAD-DROP		
	ESD2-TAD-TIP		
	ESD2-TAD-IMPACT		
	ESD2-TAD-MOVE		
	ESD2-TAD-DROPON		
	ESD2-TAD-2BLK		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.2-7 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.2-7. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-02

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD02-DPC	ESD2-DPC-DROP	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD2-DPC-TIP		
	ESD2-DPC-IMPACT		
	ESD2-DPC-MOVE		
	ESD2-DPC-DROPON		
	ESD2-DPC-2BLK		
RF-ESD02-TAD	ESD2-TAD-DROP		
	ESD2-TAD-TIP		
	ESD2-TAD-IMPACT		
	ESD2-TAD-MOVE		
	ESD2-TAD-DROPON		
	ESD2-TAD-2BLK		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.3 EVENT TREES FOR RF-ESD-03

RF-ESD-03 covers event sequences for cask preparation activities associated with unbolting and installation of the cask lid adaptor (Ref. 2.2.34, Figure F-4). This ESD covers two types of transportation casks. Corresponding to each type of cask is an initiator event tree (Table A4.3-1). Although the initiator event trees transfer to the same system response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.3-1. Summary of Event Trees for RF-ESD-03

Waste Form Units	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: RF-ESD03-DPC Response: RESPONSE-TCASK1	346
Transportation cask containing a TAD	Initiator: RF-ESD03-TAD Response: RESPONSE-TCASK1	6,976

NOTE: DPC = dual-purpose canister; ESD = event sequence diagram; RF = Receipt Facility; TAD = transportation, aging, and disposal canister.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.3.1 Initiating Events for RF-ESD-03

The following initiating events are associated with RF-ESD-03. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.3-2.

Cask Drop. This initiating event represents a potential impact to the transportation cask due to having been dropped by the cask handling crane due to a failure to remove the lid bolts before attempting to lift off the lid. The probability of this initiating event per cask received is modeled as a fault tree and is discussed in Attachment B. The initiating event is specified as a probability of a drop per cask.

Cask Tipover. This initiating event covers a tipover of the unsealed transportation cask due to an improper interaction of the cask or cask transfer trolley with the cask handling crane or cask preparation crane. The probability of this initiating event per cask received is modeled as a fault tree and is discussed in Attachment B. The initiating event is specified as a probability of a tipover per cask.

Side Impact to Cask. This initiating event covers an impact to the side of the cask due to improper movement by the cask preparation crane. The probability of this initiating event per cask received is modeled as a fault tree and is discussed in Attachment B. The initiating event is specified as a probability of a tipover per cask handled.

Drop of Heavy Load onto Cask. This initiating event covers the drop of a heavy object onto the cask by the cask preparation crane. The probability of this initiating event per cask received is modeled as a fault tree and is discussed in Attachment B. The initiating event is specified as a probability of a drop per cask.

Table A4.3-2. Initiating Event Assignments for RF-ESD-03

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Cask drop	RF-ESD03-DPC	ESD3-DPC-DROP	200-OPCASKDROP01-HFI-NOD
	RF-ESD03-TAD	ESD3-TAD-DROP	
Transportation cask tipover	RF-ESD03-DPC	ESD3-DPC-TIP	200-CRANE-SPURMOVE OR 200-OPTIPOVER002-HFI-NOD
	RF-ESD03-TAD	ESD3-TAD-TIP	
Side impact	RF-ESD03-DPC	ESD3-DPC-IMPACT	No further transfers
	RF-ESD03-TAD	ESD3-TAD-IMPACT	
Drop of heavy load onto cask	RF-ESD03-DPC	ESD3-DPC-DROPON	No further transfers
	RF-ESD03-TAD	ESD3-TAD-DROPON	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.3.2 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

TRANSCASK. Table A4.3-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.3-3. Basic Event Associated with the TRANSCASK Pivotal Events of RF-ESD-03

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
RF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-TCASK	TCASK-MISC-DROP
	ESD3-DPC-TIP	ESD3-DPC-TIP-TCASK	TCASK-TIPOVER
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-TCASK	TCASK-MISC-IMP
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-TCASK	TCASK-MISC-DROPON
RF-ESD-03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-TCASK	TCASK-MISC-DROP
	ESD3-TAD-TIP	ESD3-TAD-TIP-TCASK	TCASK-TIPOVER
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-TCASK	TCASK-MISC-IMP
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-TCASK	TCASK-MISC-DROPON

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CANISTER. Table A4.3-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.3-4. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-03

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-CAN	DPC_FAIL_IN_TC
	ESD3-DPC-TIP	ESD3-DPC-TIP-CAN	
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-CAN	
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-CAN	
RF-ESD-03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-CAN	TAD_FAIL_IN_TC
	ESD3-TAD-TIP	ESD3-TAD-TIP-CAN	
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-CAN	
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-CAN	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.3-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.3-5. Basic Event Associated with the SHIELDING Pivotal Events of RF-ESD-03

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-SHIELD	TCASK-SHIELDING-DROP
	ESD3-DPC-TIP	ESD3-DPC-TIP-SHIELD	TCASK-SHIELDING-DROP
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-SHIELD	TCASK-SHIELDING-DROP
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-SHIELD	TCASK-SHIELDING-IMP
RF-ESD-03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-SHIELD	TCASK-SHIELDING-DROP
	ESD3-TAD-TIP	ESD3-TAD-TIP-SHIELD	TCASK-SHIELDING-DROP
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-SHIELD	TCASK-SHIELDING-DROP
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-SHIELD	TCASK-SHIELDING-IMP

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. This pivotal event represents the success or failure of the HVAC system in continuing to provide radiological confinement after the initiating event. Success of the pivotal event requires the facility structural integrity as well as the functioning of equipment associated with the HVAC system. Table A4.3-6 specifies the fault tree that is associated with this pivotal event for each initiating event.

Table A4.3-6. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-03

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD03-DPC	ESD3-DPC-DROP	200-CONFINEMENT	200-CONFINEMENT
	ESD3-DPC-TIP		
	ESD3-DPC-IMPACT		
	ESD3-DPC-DROPON		
RF-ESD-03-TAD	ESD3-TAD-DROP		
	ESD3-TAD-TIP		
	ESD3-TAD-IMPACT		
	ESD3-TAD-DROPON		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.3-7 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.3-7. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-03

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD03-DPC	ESD3-DPC-DROP	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD3-DPC-TIP		
	ESD3-DPC-IMPACT		
	ESD3-DPC-DROPON		
RF-ESD-03-TAD	ESD3-TAD-DROP		
	ESD3-TAD-TIP		
	ESD3-TAD-IMPACT		
	ESD3-TAD-DROPON		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.4 EVENT TREES FOR RF-ESD-04

RF-ESD-04 covers event sequences for transferring either a cask or aging overpack from the Cask Preparation Room to the Cask Unloading Room (Ref. 2.2.34, Figure F-6). This ESD covers aging overpacks and four types of transportation casks. Corresponding to each type of cask or aging overpack is an initiator event tree (Table A4.4-1). Although the initiator event tree transfers to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.4-1. Summary of Event Trees for RF-ESD-04

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: RF-ESD04-DPC Response: RESPONSE-TCASK2	346
Transportation cask containing a TAD canister	Initiator: RF-ESD04-TAD Response: RESPONSE-TCASK2	6,976

NOTE: DPC = dual-purpose canister; ESD = event sequence diagram; RF = Receipt Facility; TAD = transportation, aging, and disposal canister.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.4.1 Initiating Events for RF-ESD-04

The following initiating events are associated with RF-ESD-04. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.4-2.

Impact Affecting a Transportation Cask or Aging Overpack. This initiating event represents a potential impact to the cask or aging overpack. The probability of impact per transfer is described in Section 6.2. The initiating event is specified as a probability of a drop per cask.

Collision Involving the CTT or Site Transporter. This initiating event represents a potential collision involving the CTT or site transporter. The probability of a collision is modeled as a fault tree as described in Attachment B. The initiating event is specified as a probability of a drop per cask.

Table A4.4-2. Initiating Event Assignments for RF-ESD-04

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact affecting transportation cask or aging overpack	RF-ESD04-DPC	ESD4-DPC-IMPACT	200-OPIMPACT0000-HFI-NOD
	RF-ESD04-TAD	ESD4-TAD-IMPACT	
Collision of CTT or site transporter	RF-ESD04-DPC	ESD4-DPC-COLLIDE	200-CTT-FAIL-STOP OR 200-OPCTCOLLIDE2-HFI-NOD
	RF-ESD04-TAD	ESD4-TAD-COLLIDE	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
CTT = cask transfer trolley.

Source: Original

A4.4.2 System Response Event Tree RESPONSE-TCASK2

The pivotal events that appear in RESPONSE-TCASK2 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.4-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.4-3. Fault Trees Associated with the CANISTER Pivotal Events of RF-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD04-DPC	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT-CAN	DPC-FAIL-NO-CASK-IMP
	ESD4-DPC-COLLIDE	ESD4-DPC-COLLIDE-CAN	
RF-ESD04-TAD	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT-CAN	TAD-FAIL- NO-CASK-IMP
	ESD4-TAD-COLLIDE	ESD4-TAD-COLLIDE-CAN	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.4-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.4-4. Fault Trees Associated with the SHIELDING Pivotal Events of RF-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD04-DPC	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT-SHIELD	TCASK-SHIELDING-IMP
	ESD4-DPC-COLLIDE	ESD4-DPC-COLLIDE-SHIELD	
RF-ESD04-TAD	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT-SHIELD	
	ESD4-TAD-COLLIDE	ESD4-TAD-COLLIDE-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.4-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.4-5. Fault Trees Associated with the CONFINEMENT Pivotal Events of RF-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD04-DPC	ESD4-DPC-IMPACT	200-CONFINEMENT	200-CONFINEMENT
	ESD4-DPC-COLLIDE		
RF-ESD04-TAD	ESD4-TAD-IMPACT		
	ESD4-TAD-COLLIDE		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.4-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.4-6. Fault Trees Associated with the MODERATOR Pivotal Events of RF-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD04-DPC	ESD4-DPC-IMPACT	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD4-DPC-COLLIDE		
RF-ESD04-TAD	ESD4-TAD-IMPACT		
	ESD4-TAD-COLLIDE		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.5 EVENT TREES FOR RF-ESD-05

RF-ESD-05 covers event sequences associated with collision of the shield door into the CTT or site transporter (Ref. 2.2.34, Figure F-1). For the CTT, the shield door involved is the door from the Cask Preparation Room to the Cask Unloading Room. For the site transporter, this door and the shield door between the site transporter entrance vestibule and the Cask Preparation Room apply to this event. This ESD covers aging overpacks and transportation casks.

The conveyance could collide into a stationary shield door or a moving shield door could collide into the conveyance. Since the shield doors are designed in accordance with the applicable provisions of *American National Standard Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities* (Ref. 2.2.4) to withstand the load and acceleration produced by a DBGM-2 seismic event, it is reasonable to conclude that the shield doors would remain attached to their moorings in the event of a slow speed (maximum of 2.5 mph) collision of a conveyance with the shield door. Therefore the analysis only evaluates the impact of a moving shield door with the conveyance.

A4.5.1 Initiating Events for RF-ESD-05

Collision of Shield Door into CTT or Site Transporter. This initiating event accounts for a collision of a moving shield door with the CTT or site transporter. Since normal operations would not include the movement of the conveyance through the doorway while the shield door is closing, it is postulated that the door closes due to inadvertent actuation of the door. The probability of impact per transfer is derived from empirical data in Section 6.3 and is modeled as either a hardware failure or a human failure. The assignments made within SAPHIRE for quantification of this initiating event are indicated in Table A4.5-1.

Table A4.5-1. Initiating Event Assignments for RF-ESD-05

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Collision of shield door with CTT or site transporter	RF-ESD5-DPC	ESD5-DPC-IMPACT	200-CTT-COLLIDE-SDR OR 200-ST-COLLIDE-SDR[b, c] AND 200-ST-#-OF-SHIELD-DOORS
	RF-ESD5-TAD	ESD5-TAD-IMPACT	200-CTT-COLLIDE-SDR OR 200-ST-COLLIDE-SDR[b, c] AND 200-ST-#-OF-SHIELD-DOORS

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
[b]Result of this fault tree is multiplied by factor of two to account for two shield doors.
[c]Split-fractions are used to account for percentage of operations involving the CTT and the site transporter.
CTT = cask transfer trolley.

Source: Original

A4.5.2 Pivotal Events

The pivotal events that appear in the event tree are listed below and summarized in Section A.3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CELL-DOOR. Table A4.5-2 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.5-2. Basic Events Associated with the CELL-DOOR Pivotal Events of RF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CELL-DOOR	Associated Fault Tree or Basic Event[a]
RF-ESD5-DPC	ESD5-DPC-IMPACT	ESD5-DPC-IMPACT-DOOR	SHIELD_DOOR_FAILURE
RF-ESD5-TAD	ESD5-TAD-IMPACT	ESD5-TAD-IMPACT-DOOR	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONTAINMENT. Table A4.5-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.5-3. Basic Events Associated with the CONTAINMENT Pivotal Events of RF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CONTAINMENT	Associated Fault Tree or Basic Event[a]
RF-ESD05-DPC	ESD5-DPC-IMPACT	ESD5-DPC-IMPACT-CONT	CAN-FAIL-SD-IMPACT
RF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-TAD-IMPACT-CONT	CAN-FAIL-SD-IMPACT

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.5-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.5-4. Basic Events Associated with the SHIELDING Pivotal Events of RF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD05-DPC	ESD5-DPC-IMPACT	ESD5-DPC-IMPACT-SHIELD	TCASK-SHIELDING-IMP
RF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-TAD-IMPACT-SHI	TCASK-SHIELDING-IMP

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.5-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.5-5. Basic Events Associated with the CONFINEMENT Pivotal Events of RF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD5-DPC	ESD5-DPC-IMPACT	200-CONFINEMENT	200-CONFINEMENT
RF-ESD5-TAD	ESD5-TAD-IMPACT		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.5-6 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.5-6. Basic Events Associated with the MODERATOR Pivotal Events of RF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD05-DPC	ESD05-DPC-IMPACT	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
RF-ESD05-TAD	ESD05-TAD-IMPACT		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.6 EVENT TREES FOR RF-ESD-06

RF-ESD-06 covers event sequences associated with CTM transfers (Ref. 2.2.34, Figure F-9). This ESD covers all canister types. Corresponding to each canister type is an initiator event tree (Table A4.6-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.6-1. Summary of Event Trees for RF-ESD-06

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
DPC	Initiator: RF-ESD06-DPC Response: RESPONSE-CANISTER1	346
TAD canister	Initiator: RF-ESD06-TAD Response: RESPONSE-CANISTER1	6,976

NOTE: Numbers of units given are the total numbers available because, from the perspective of a CTM collision involving a given type of waste form, it is not known what the waste form inside the other CTM might be.
DPC = dual-purpose canister; TAD = transportation, aging, and disposal.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4)

A4.6.1 Initiating Events for RF-ESD-06

The following initiating events are associated with RF-ESD-06. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.6-2. The initiating events are specified as frequency of occurrence per canister.

Table A4.6-2. Initiating Event Assignments for RF-ESD-06

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact with lid removal	RF-ESD06-DPC	ESD6-DPC-LIDIMP	Screened out, no lid removal for DPCs
	RF-ESD06-TAD	ESD6-TAD-LIDIMP	No further transfers
Canister drop (from operational height)	RF-ESD06-DPC	ESD6-DPC-DROP	200-LIFTS-PER-DPC-CAN AND CTM-DROP---ALL-HEIGHTS[b]
	RF-ESD06-TAD	ESD6-TAD-DROP	200-LIFTS-PER-TAD-CAN AND CTM-DROP---ALL-HEIGHTS[b]
Spurious movement	RF-ESD06-DPC	ESD6-DPC-SPUR	200-CTT-SPUR-MOVE OR 200-ST-SPURMOVE OR CTM-SHEAR
	RF-ESD06-TAD	ESD6-TAD-SPUR	
Side impact	RF-ESD06-DPC	ESD6-DPC-SIMPACT	200-LIFTS-PER-DPC-CAN AND CTM-COLLISION[b]
	RF-ESD06-TAD	ESD6-TAD-SIMPACT	200-LIFTS-PER-TAD-CAN AND CTM-COLLISION[b]
Object drop on canister	RF-ESD06-DPC	ESD6-DPC-DROPON	200-CTMOBJLIFTNUMBERD AND CTM-DROP-ONTO-CASK[b]
	RF-ESD06-TAD	ESD6-TAD-DROPON	200-CTMOBJLIFTNUMBER AND CTM-DROP-ONTO-CASK[b]
Canister drop inside bell	RF-ESD06-DPC	ESD6-DPC-CTMBELL	200-LIFTS-PER-DPC-CAN AND SHIELD-BELL-DROPS-SUBSUM
	RF-ESD06-TAD	ESD6-TAD-CTMBELL	200-LIFTS-PER-TAD-CAN AND SHIELD-BELL-DROPS-SUBSUM
Canister drop (above operational height)	RF-ESD06-DPC	ESD6-DPC-2BLK	200-LIFTS-PER-DPC-CAN AND CTM-2-BLOCK[b]
	RF-ESD06-TAD	ESD6-TAD-2BLK	200-LIFTS-PER-TAD-CAN AND CTM-2-BLOCK[b]

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
[b]Basic event and fault tree connected by an AND gate.

Source: Original

Impact Associated with Lid Removal. This initiating event covers the potential impact during cask or aging overpack lid removal due to a human failure to remove all of the lid bolts.

Canister Drop from Operational Height. This initiating event accounts for the potential impact to the canister due to having been dropped from the normal operational height during transfer by the CTM.

Impact to Canister due to Conveyance Movement. This initiating event covers the potential impact to or shear of the canister due to untimely movement of the CTM, CTT, or site transporter during loading or unloading of the canister.

Side Impact to Canister. This initiating event covers the potential impact to the canister due to a CTM collision.

Object Dropped on Canister. This initiating event covers the potential impact to the canister due to the drop of a heavy object (e.g., cask lid) by the CTM.

Canister Drop Inside Bell. This initiating event accounts for the potential impact to the canister due to having been dropped on the second floor during horizontal transfer by the CTM. This event has been subsumed within the canister drop from operational height event.

Canister Drop Above Operational Height. This initiating event accounts for the potential impact to the canister due to having been dropped from above the normal operational height due to a two-blocking event during transfer by the CTM.

A4.6.3 System Response Event Tree RESPONSE-CANISTER1

The pivotal events that appear in RESPONSE-CANISTER1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.6-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.6-3. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-06

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD06-DPC	ESD6-DPC-LIDIMP	ESD6-DPC-LIDIMP-CAN	DPC-FAIL-NO-CASK
	ESD6-DPC-DROP	ESD6-DPC-DROP-CAN	
	ESD6-DPC-SPUR	ESD6-DPC-SPUR-CAN	DPC-FAIL-SPURMOVE
	ESD6-DPC-SIMPACT	ESD6-DPC-SIMPACT-CAN	DPC-FAIL-CTM-IMPACT
	ESD6-DPC-DROPON	ESD6-DPC-DROPON-CAN	DPC-FAIL-NO-CASK
	ESD6-DPC-CTMBELL	ESD6-DPC-CTMBELL-CAN	
	ESD6-DPC-2BLK	ESD6-DPC-2BLK-CAN2	CANISTER-FAIL-CTM-2BLOCK
RF-ESD06-TAD	ESD6-TAD-LIDIMP	ESD6-TAD-LIDIMP-CAN	TAD-FAIL-NO-CASK
	ESD6-TAD-DROP	ESD6-TAD-DROP-CAN	
	ESD6-TAD-SPUR	ESD6-TAD-SPUR-CAN	TAD-FAIL-SPURMOVE
	ESD6-TAD-SIMPACT	ESD6-TAD-SIMPACT-CAN	TAD-FAIL-CTM-IMPACT
	ESD6-TAD-DROPON	ESD6-TAD-DROPON-CAN	TAD-FAIL-NO-CASK
	ESD6-TAD-CTMBELL	ESD6-TAD-CTMBELL-CAN	
	ESD6-TAD-2BLK	ESD6-TAD-2BLK-CAN2	CANISTER-FAIL-CTM-2BLOCK

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.6-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.6-4. Basic Events Associated with the SHIELDING Pivotal Events of RF-ESD-06

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD06-DPC	ESD6-DPC-LIDIMP	ESD6-DPC-LIDIMP-SHIELD	CTM-SHIELDING
	ESD6-DPC-DROP	ESD6-DPC-DROP-SHIELD	
	ESD6-DPC-SPUR	ESD6-DPC-SPUR-SHIELD	
	ESD6-DPC-SIMPACT	ESD6-DPC-SIMPACT-SHIELD	
	ESD6-DPC-DROPON	ESD6-DPC-DROPON-SHIELD	
	ESD6-DPC-CTMBELL	ESD6-DPC-CTMBELL-SHIELD	
	ESD6-DPC-2BLK	ESD6-DPC-2BLK-SHIELD	
RF-ESD06-TAD	ESD6-TAD-LIDIMP	ESD6-TAD-LIDIMP-SHIELD	
	ESD6-TAD-DROP	ESD6-TAD-DROP-SHIELD	
	ESD6-TAD-SPUR	ESD6-TAD-SPUR-SHIELD	
	ESD6-TAD-SIMPACT	ESD6-TAD-SIMPACT-SHIELD	
	ESD6-TAD-DROPON	ESD6-TAD-DROPON-SHIELD	
	ESD6-TAD-CTMBELL	ESD6-TAD-CTMBELL-SHIELD	
	ESD6-TAD-2BLK	ESD6-TAD-2BLK-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.6-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.6-5. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-06

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD06-DPC	ESD6-DPC-LIDIMP	200-CONFINEMENT	200-CONFINEMENT
	ESD6-DPC-DROP		
	ESD6-DPC-SPUR		
	ESD6-DPC-SIMPACT		
	ESD6-DPC-DROPON		
	ESD6-DPC-CTMBELL		
	ESD6-DPC-2BLK		
RF-ESD06-TAD	ESD6-TAD-LIDIMP		
	ESD6-TAD-DROP		
	ESD6-TAD-SPUR		
	ESD6-TAD-SIMPACT		
	ESD6-TAD-DROPON		
	ESD6-TAD-CTMBELL		
	ESD6-TAD-2BLK		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.6-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.6-6. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-06

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD06-DPC	ESD6-DPC-LIDIMP	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD6-DPC-DROP		
	ESD6-DPC-SPUR		
	ESD6-DPC-SIMPACT		
	ESD6-DPC-DROPON		
	ESD6-DPC-CTMBELL		
	ESD6-DPC-2BLK		
RF-ESD06-TAD	ESD6-TAD-LIDIMP		
	ESD6-TAD-DROP		
	ESD6-TAD-SPUR		
	ESD6-TAD-SIMPACT		
	ESD6-TAD-DROPON		
	ESD6-TAD-CTMBELL		
	ESD6-TAD-2BLK		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.7 EVENT TREES FOR RF-ESD-07

RF-ESD-07 covers event sequences associated with assembly and closure of an aging overpack (Ref. 2.2.34, Figure F-12). This ESD covers the two waste forms that are placed in aging overpacks in the RF: TAD canisters and DPCs. Corresponding to each waste form unit is an initiator event tree (Table A4.7-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.7-1. Summary of Event Trees for RF-ESD-07

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Aging overpack containing DPC	Initiator: RF-ESD07-DPC Response: RESPONSE-AO1	346
Aging overpack containing TAD canister	Initiator: RF-ESD07-TAD Response: RESPONSE-AO1	6,976

NOTE: DPC = dual-purpose canister; TAD = transportation, aging, and disposal.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.7.1 Initiating Events for RF-ESD-07

The following initiating events are associated with RF-ESD-07. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.7-2.

Impact to an Aging Overpack. This initiating event accounts for the potential impact to the aging overpack during assembly and closure of the aging overpack.

Tipover of an Aging Overpack. This initiating event accounts for the potential tipover of the aging overpack.

Object Dropped onto Aging Overpack. This initiating event accounts for the potential for the CTM to drop an object on the aging overpack.

Collision between Site Transporter and Facility Structures or Equipment. This initiating event accounts for the potential for a site transporter collision.

Table A4.7-2. Initiating Event Assignments for RF-ESD-07

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact to an aging overpack.	RF-ESD07-DPC	ESD07-DPC-IMPACT	200-ST-IMPACT
	RF-ESD07-TAD	ESD07-TAD-IMPACT	
Object dropped onto aging overpack	RF-ESD07-DPC	ESD07-DPC-DROPON	200-CTMOBJLIFTNUMBER OR CTM-DROP-ONTO-CASK[b]
	RF-ESD07-TAD	ESD07-TAD-DROPON	
Site transporter collision	RF-ESD07-DPC	ESD07-DPC-COLLIDE	200-ST-COLLISION
	RF-ESD07-TAD	ESD07-TAD-COLLIDE	
Tipover of an aging overpack	RF-ESD07-DPC	ESD07-DPC-TIP	200-OPTIPOVER003-HFI-NOD
	RF-ESD07-TAD	ESD07-TAD-TIP	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
[b]Basic event and fault tree connected by an AND gate.

Source: Original

A4.7.2 System Response Event Tree RESPONSE-AO1

The pivotal events that appear in RESPONSE-AO1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.7-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.7-3. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD07-DPC	ESD07-DPC-IMPACT	ESD07-DPC-IMPACT-CAN	CAN-IN-AO-IMPACT
	ESD07-DPC-TIP	ESD07-DPC-TIP-CAN	CAN IN AO TIP
	ESD07-DPC-COLLIDE	ESD07-DPC-COLLIDE-CAN	DPC-CAN-IN-AO-COLL
	ESD07-DPC-DROPON	ESD07-DPC-DROPON-CAN	CAN-IN-AO-DROPON
RF-ESD07-TAD	ESD07-TAD-IMPACT	ESD07-TAD-IMPACT-CAN	CAN-IN-AO-IMPACT
	ESD07-TAD-TIP	ESD07-TAD-TIP-CAN	CAN IN AO TIP
	ESD07-TAD-COLLIDE	ESD07-TAD-COLLIDE-CAN	TAD-CAN-IN-AO-COLL
	ESD07-TAD-DROPON	ESD07-TAD-DROPON-CAN	CAN-IN-AO-DROPON

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.7-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.7-4. Basic Event Associated with the SHIELDING Pivotal Events of RF-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD-7-DPC	ESD07-DPC-IMPACT	ESD07-DPC-IMPACT-SHIELD	AO-SHIELDING
	ESD07-DPC-TIP	ESD07-DPC-TIP-SHIELD	
	ESD07-DPC-COLLIDE	ESD07-DPC-COLLIDE-SHIELD	
	ESD07-DPC-DROPON	ESD07-DPC-DROPON-SHIELD	
RF-ESD07-TAD	ESD07-TAD-IMPACT	ESD07-TAD-IMPACT-SHIELD	
	ESD07-TAD-TIP	ESD07-TAD-TIP-SHIELD	
	ESD07-TAD-COLLIDE	ESD07-TAD-COLLIDE-SHIELD	
	ESD07-TAD-DROPON	ESD07-TAD-DROPON-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.7-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.7-5. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD-7-DPC	ESD07-DPC-IMPACT	200-CONFINEMENT	200-CONFINEMENT
	ESD07-DPC-TIP		
	ESD07-DPC-COLLIDE		
	ESD07-DPC-DROPON		
RF-ESD07-TAD	ESD07-TAD-IMPACT		
	ESD07-TAD-TIP		
	ESD07-TAD-COLLIDE		
	ESD07-TAD-DROPON		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.7-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.7-6. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD-7-DPC	ESD07-DPC-IMPACT	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD07-DPC-TIP		
	ESD07-DPC-COLLIDE		
	ESD07-DPC-DROPON		
RF-ESD07-TAD	ESD07-TAD-IMPACT		
	ESD07-TAD-TIP		
	ESD07-TAD-COLLIDE		
	ESD07-TAD-DROPON		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.8 EVENT TREES FOR RF-ESD-08

RF-ESD-08 covers event sequences associated with the export of an aging overpack from the RF (Ref. 2.2.34, Figure F-16). This ESD covers aging overpacks. Corresponding to each waste form unit is an initiator event tree (Table A4.8-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.8-1. Summary of Event Trees for RF-ESD-08

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Aging overpack containing DPC	RF-ESD8-DPC Response: RESPONSE-AO1	346
Aging overpack containing TAD canister	RF-ESD8-TAD Response: RESPONSE-AO1	6,976

NOTE: DPC = dual-purpose canister; TAD = transportation, aging, and disposal.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.8.1 Initiating Events for RF-ESD-08

The following initiating events are associated with RF-ESD-08. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.8-2.

Aging Overpack Dropped. This initiating event accounts for the potential impact to an aging overpack due to a malfunction of the site transporter.

Site Transporter Rollover. For a site transporter to roll over, the center of mass would have to shift laterally. This could result from traversing a significantly uneven surface or running over a very large object. There are no significantly uneven surfaces in the RF Entrance Vestibule or Cask Preparation Room. However, the site transporter rollover could occur if the site transporter loses a track and continues climbing on the failed track. This failure scenario is modeled in Section B6.4.3.

Site Transporter Collision. This initiating event accounts for the potential impact to the TAD canister due to a collision involving the site transporter. The probability of collision per TAD canister received is modeled as a fault tree as described in Attachment B. The initiating event is specified as a probability of collision per TAD canister.

Table A4.8-2. Initiating Event Assignments for RF-ESD-08

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Aging overpack dropped	RF-ESD8-DPC	ESD8-DPC-DROP	200-ST-DROP
	RF-ESD8-TAD	ESD8-TAD-DROP	
Site transporter rollover	RF-ESD8-DPC	ESD8-DPC-ROLL	200-ST-ROLLOVER
	RF-ESD8-TAD	ESD8-TAD-ROLL	
Site transporter collision	RF-ESD8-DPC	ESD8-DPC-COLLIDE	200-ST-COLLISION
	RF-ESD8-TAD	ESD8-TAD-COLLIDE	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.8.2 System Response Event Tree RESPONSE-AO1

The pivotal events that appear in RESPONSE-AO1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.8-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.8-3. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-08

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD8-DPC	ESD8-DPC-DROP	ESD8-DPC-DROP-CAN	CAN IN AO DROP
	ESD8-DPC-COLLIDE	ESD8-DPC-COLLIDE-CAN	DPC-CAN-IN-AO-COLL
	ESD8-DPC-ROLL	ESD8-DPC-ROLL-CAN	CAN IN AO ROLLOVER
RF-ESD8-TAD	ESD8-TAD-DROP	ESD8-TAD-DROP-CAN	CAN IN AO DROP
	ESD8-TAD-COLLIDE	ESD8-TAD-COLLIDE-CAN	TAD-CAN-IN-AO-COLL
	ESD8-TAD-ROLL	ESD8-TAD-ROLL-CAN	CAN IN AO ROLLOVER

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.8-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.8-4. Basic Event Associated with the SHIELDING Pivotal Events of RF-ESD-08

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD8-DPC	ESD8-DPC-DROP	ESD8-DPC-DROP-SHIELD	AO_SHIELDING
	ESD8-DPC-COLLIDE	ESD8-DPC-COLLIDE-SHIELD	
	ESD8-DPC-ROLL	ESD8-DPC-ROLL-SHIELD	
RF-ESD8-TAD	ESD8-TAD-DROP	ESD8-TAD-DROP-SHIELD	
	ESD8-TAD-COLLIDE	ESD8-TAD-COLLIDE-SHIELD	
	ESD8-TAD-ROLL	ESD8-TAD-ROLL-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.8-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.8-5. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-08

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD8-DPC	ESD8-DPC-DROP	200-CONFINEMENT	200-CONFINEMENT
	ESD8-DPC-COLLIDE		
	ESD8-DPC-ROLL		
RF-ESD8-TAD	ESD8-TAD-DROP		
	ESD8-TAD-COLLIDE		
	ESD8-TAD-ROLL		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.8-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.8-6. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-08

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD8-DPC	ESD8-DPC-DROP	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD8-DPC-COLLIDE		
	ESD8-DPC-ROLL		
RF-ESD8-TAD	ESD8-TAD-DROP		
	ESD8-TAD-COLLIDE		
	ESD8-TAD-ROLL		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.9 EVENT TREES FOR RF-ESD-09

RF-ESD-09 covers event sequences associated with export of the horizontal cask on a cask transfer trailer (Ref. 2.2.34). This ESD only covers DPCs since TAD canisters are not transported using this vehicle (Table A4.9-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.9-1. Summary of Event Trees for RF-ESD-09

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: RF-ESD09-DPC Response: RESPONSE-TCASK1	346

NOTE: DPC = dual-purpose canister.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.9.1 Initiating Events for RF-ESD-09

The following initiating events are associated with RF-ESD-09. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.9-2.

Cask Transfer Trailer Rollover. This initiating even accounts for the potential of the cask transfer trailer rolling over in the Receipt Facility. However, per HFE Section 6.4, this initiating event has been screened out as a non-credible event.

Cask Transfer Trailer Collision. This initiating event covers the potential impact to the transportation cask on the cask transfer trailer due to a collision with another vehicle, facility structures or equipment.

Table A4.9-2. Initiating Event Assignments for RF-ESD-09

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Cask transfer trailer collision	RF-ESD9	ESD9-COLLIDE	200-HCTT-COLLISION
Cask transfer trailer rollover	RF-ESD9	ESD9-ROLL	200-HCTT-ROLL

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.9.2 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

TRANSCASK. Table A4.9-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.9-3. Basic Event Associated with the TRANSCASK Pivotal Events of RF-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
RF-ESD9	ESD9-COLLIDE	ESD9-COLLIDE-TCASK	TCASK-FAIL-COLL
	ESD9-ROLL	ESD9-ROLL-TCASK	TCASK-FAIL ROLLOVER

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CANISTER. Table A4.9-4 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.9-4. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD9	ESD9-COLLIDE	ESD9-COLLIDE-CAN	DPC_FAIL_IN_TC
	ESD9-ROLL	ESD9-ROLL-CAN	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. Table A4.9-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.9-5. Basic Event Associated with the SHIELDING Pivotal Events of RF-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD9	ESD9-COLLIDE	ESD9-COLLIDE-SHIELD	TCASK-SHIELDING
	ESD9-ROLL	ESD9-ROLL-SHIELD	

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.9-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.9-6. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD9	ESD9-COLLIDE	200-CONFINEMENT	200-CONFINEMENT
	ESD9-ROLL		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.9-7 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.9-7. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD9	ESD9-COLLIDE	200-MODERATOR-SOURCE	200-MODERATOR-SOURCE
	ESD9-ROLL		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.10 EVENT TREES FOR RF-ESD-10

RF-ESD-10 covers event sequences associated with direct exposure during cask preparation activities (Ref. 2.2.34, Figure F-17). This ESD is only applicable to DPCs because the lid is not removed from the TAD container in this operation. Corresponding to each waste form unit is an initiator event tree (Table A4.10-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.10-1. Summary of Event Trees for RF-ESD-10

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	RF-ESD10	346

NOTE: DPC = dual-purpose canister.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.10.1 Initiating Events for RF-ESD-10

The following initiating events are associated with RF-ESD-10. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.10-2.

Temporary Shielding Loss during Cask Preparation Activities. This initiating event accounts for the loss of shielding during cask preparation activities. Loss of shielding could occur due to the failure to close the cask preparation platform shield plate or the inadvertent opening of the cask preparation platform shield plate. The probability of drop per transfer is derived from empirical data in Section 6.3 and is modeled as a single event fault tree as described in Section 6.2. The initiating event is specified as a probability of a drop per cask.

Table A4.10-2. Initiating Event Assignments for RF-ESD-10

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Temporary loss of shielding during preparation activities	RF-ESD10	PREPSHIELD	200-LIDDISPLACE1-HFI-NOD OR 200-OPDPCSHIELD1-HFI-NOW

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A4.10.2 System Response Event Tree for RF-ESD-10

There are no pivotal events associated with RF-ESD-10.

A4.11 EVENT TREES FOR RF-ESD-11

RF-ESD-11 covers event sequences associated with direct exposure during canister transfer activities (Ref. 2.2.34, Figure F-18). This ESD covers all waste forms. Corresponding to each waste form unit is an initiator event tree (Table A4.11-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.11-1. Summary of Event Trees for RF-ESD-11

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
All waste forms	RF-ESD11	7,324

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.11.1 Initiating Events for RF-ESD-11

The following initiating events are associated with RF-ESD-11. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.11-2.

Temporary Shielding Loss during CTM Activities. This initiating event accounts for the loss of shielding during cask preparation activities. Loss of shielding could occur due to the failure of the shield bell or the inadvertent opening of a slide gate or shield skirt. The probability of drop per transfer is derived from empirical data in Section 6.3 and is modeled as a single event fault tree as described in Section 6.2. The initiating event is specified as a probability of a drop per cask.

Table A4.11-2. Initiating Event Assignments for RF-ESD-11

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Temporary loss of shielding during CTM activities	RF-ESD11	CTMSHIELD	No further transfers

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
CTM = canister transfer machine.

Source: Original

A4.11.2 System Response Event Tree for RF-ESD-11

There are no pivotal events associated with RF-ESD-11.

A4.12 EVENT TREES FOR RF-ESD-12

RF-ESD-12 covers event sequences associated with fires in the RF (Ref. 2.2.34, Figure F-20). This ESD covers all waste forms (Table A4.12-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

Table A4.12-1. Summary of Event Trees for RF-ESD-12

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask or aging overpack containing a DPC	Initiator: RF-ESD12-DPC Response: RESPONSE-FIRE	346
Transportation cask or aging overpack containing a TAD canister	Initiator: RF-ESD12-TAD Response: RESPONSE-FIRE	6,976

NOTE: DPC = dual-purpose canister; TAD = transportation, aging, and disposal.

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.27, Table 4) for numbers of waste form units

A4.12.1 Initiating Events for RF-ESD-12

The following initiating events are associated with RF-ESD-12. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.12-2.

Localized Fire Threatens TAD Canister or DPC in Aging Overpack in Vestibule/Lid Bolting Room (diesel present) on Site Transporter. This initiating event accounts for the potential impact from a fire threatening a TAD canister in an aging overpack in the Vestibule/Lid Bolting Room with diesel present.

Localized Fire Threatens TAD Canister or DPC in Aging Overpack in Loading Room (diesel present) on Site Transporter. This initiating event accounts for the potential impact from a fire threatening a TAD canister in an aging overpack in the Loading Room with diesel present.

Localized Fire Threatens TAD Canister or DPC in Transportation Cask in Vestibule/Preparation Area (diesel present) on Site Prime Mover. This initiating event accounts for the potential impact from a fire threatening a cask in the Preparation Room with diesel present.

Localized Fire Threatens TAD Canister or DPC in Transportation Cask in Preparation Room on Railcar. This initiating event accounts for the potential impact from a fire threatening a cask in the Preparation Room.

Localized Fire Threatens TAD Canister or DPC in Transportation Cask in Preparation Room on CTT. This initiating event accounts for the potential impact from a fire threatening a waste form in the Preparation Room.

Localized Fire Threatens TAD Canister or DPC in Transportation Cask in Cask Unloading Room on CTT. This initiating event accounts for the potential impact from a fire in the Cask Unloading Room.

Localized Fire Threatens TAD Canister or DPC in Transfer Room in CTM. This initiating event accounts for the potential impact from a fire in the Transfer Room.

Large Fire Threatens Waste Forms in RF. This initiating event accounts for the potential impact from a large fire in the RF.

Table A4.12-2. Initiating Event Assignments for RF-ESD-12

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Localized fire threatens waste form in AO in Vestibule/Lid Bolting Room (diesel present)	RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-DPC	ESD12-FIRE-IN-BOLT-DPC
	RF-ESD12-TAD	ESD12-BOLT-FIRE-CSK-TAD	ESD12-FIRE-IN-BOLT-TAD
Localized fire threatens waste form in AO in Loading Room (diesel present)	RF-ESD12-DPC	ESD12-LOAD-FIRE-CSK-DPC	ESD12-FIRE-IN-LOAD-DPC
	RF-ESD12-TAD	ESD12-LOAD-FIRE-CSK-TAD	ESD12-FIRE-IN-LOAD-TAD
Localized fire threatens waste form in Vestibule/Preparation Room (diesel present)	RF-ESD12-DPC	ESD12-PREP-FIRE-CSK-DC	ESD12-DFIRE-IN-PREP-DPC
	RF-ESD12-TAD	ESD12-PREP-FIRE-CSK-TD	ESD12-DFIRE-IN-PREP-TAD
Localized fire threatens waste form in Preparation Room	RF-ESD12-DPC	ESD12-PREP-FIRE-CSK-DPC	ESD12-FIRE-IN-PREP-DPC
	RF-ESD12-TAD	ESD12-PREP-FIRE-CSK-TAD	ESD12-FIRE-IN-PREP-TAD
Localized fire threatens waste form in Preparation Room	RF-ESD12-DPC	ESD12-PREP-FIRE-CAN-DPC	ESD12-FIRE-IN-PREPCT-DPC
	RF-ESD12-TAD	ESD12-PREP-FIRE-CAN-TAD	ESD12-FIRE-IN-PREPCT-TAD
Localized fire threatens waste form in Cask Unloading Room	RF-ESD12-DPC	ESD12-UNLD-FIRE-CAN-DPC	ESD12-FIRE-IN-UNLD-DPC
	RF-ESD12-TAD	ESD12-UNLD-FIRE-CAN-TAD	ESD12-FIRE-IN-UNLD-TAD
Localized fire threatens waste form in Transfer Room	RF-ESD12-DPC	ESD12-XFER-FIRE-CSK-DPC	ESD12-FIRE-CTM-DPC
	RF-ESD12-TAD	ESD12-XFER-FIRE-CSK-TAD	ESD12-FIRE-CTM-TAD
Large fire in RF	RF-ESD12-DPC	ESD12-LARGE-FIRE-DPC	ESD12-DPC-IN-LG-FIRE
	RF-ESD12-TAD	ESD12-LARGE-FIRE-TAD	ESD12-TAD-IN-LG-FIRE

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.
AO = aging overpack; RF = Receipt Facility.

Source: Original

A4.12.2 System Response Event Tree RESPONSE-FIRE

CANISTER. Table A4.12-3 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.12-3. Basic Events Associated with the CANISTER Pivotal Events of RF-ESD-12

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-DPC	ESD12-CAN-AO	CANISTER-FIRE-AO
	ESD12-LOAD-FIRE-CSK-DPC	ESD12-CAN-AO	CANISTER-FIRE-AO
	ESD12-PREP-FIRE-CSK-DC	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-PREP-FIRE-CSK-DPC	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-PREP-FIRE-CAN-DPC	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-UNLD-FIRE-CAN-DPC	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-XFER-FIRE-CSK-DPC	ESD12-CAN	ESD12-BARE-CAN
	ESD12-LARGE-FIRE-DPC	ESD12-CAN-SPLIT-DPC	See fault tree in Attachment B
RF-ESD12-TAD	ESD12-BOLT-FIRE-CSK-TAD	ESD12-CAN-AO	CANISTER-FIRE-AO
	ESD12-LOAD-FIRE-CSK-TAD	ESD12-CAN-AO	CANISTER-FIRE-AO
	ESD12-PREP-FIRE-CSK-TD	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-PREP-FIRE-CSK-TAD	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-PREP-FIRE-CAN-TAD	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-UNLD-FIRE-CAN-TAD	ESD12-CAN-TC	CANISTER-FIRE-TC
	ESD12-XFER-FIRE-CSK-TAD	ESD12-CAN	ESD12-BARE-CAN
	ESD12-LARGE-FIRE-TAD	ESD12-CAN-SPLIT-TAD	See fault tree in Attachment B

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

SHIELDING. This pivotal event represents the success or failure of the shielding provided by the transportation cask, aging overpack, or CTM shield bell as a result of the initiating event. Table A4.12-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.12-4. Fault Tree Associated with the SHIELDING Pivotal Events of RF-ESD-12

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-DPC	ESD12-DPC-SHIELD-AO	200-DPC-AO-SHIELD-FIRE
	ESD12-LOAD-FIRE-CSK-DPC	ESD12-DPC-SHIELD-AO	200-DPC-AO-SHIELD-FIRE
	ESD12-PREP-FIRE-CSK-DC	ESD12-DPC-SHIELD-TC	200-DPC-TC-SHIELD-FIRE
	ESD12-PREP-FIRE-CSK-DPC	ESD12-DPC-SHIELD-TC	200-DPC-TC-SHIELD-FIRE
	ESD12-PREP-FIRE-CAN-DPC	ESD12-DPC-SHIELD-TC	200-DPC-TC-SHIELD-FIRE
	ESD12-UNLD-FIRE-CAN-DPC	ESD12-DPC-SHIELD-TC	200-DPC-TC-SHIELD-FIRE
	ESD12-XFER-FIRE-CSK-DPC	ESD12-DPC-SHIELD-CAN	200-DPC-CAN-SHIELD-FIRE
	ESD12-LARGE-FIRE-DPC	ESD12-DPC-SHIELD-LF	PROB-DPC-IN-TC-IN-LF AND ESD12-DPC-SHIELD-TC
RF-ESD12-TAD	ESD12-BOLT-FIRE-CSK-TAD	ESD12-TAD-SHIELD-AO	200-TAD-AO-SHIELD-FIRE
	ESD12-LOAD-FIRE-CSK-TAD	ESD12-TAD-SHIELD-AO	200-TAD-AO-SHIELD-FIRE
	ESD12-PREP-FIRE-CSK-TD	ESD12-TAD-SHIELD-TC	200-TAD-TC-SHIELD-FIRE
	ESD12-PREP-FIRE-CSK-TAD	ESD12-TAD-SHIELD-TC	200-TAD-TC-SHIELD-FIRE
	ESD12-PREP-FIRE-CAN-TAD	ESD12-TAD-SHIELD-TC	200-TAD-TC-SHIELD-FIRE
	ESD12-UNLD-FIRE-CAN-TAD	ESD12-TAD-SHIELD-TC	200-TAD-TC-SHIELD-FIRE
	ESD12-XFER-FIRE-CSK-TAD	ESD12-TAD-SHIELD-CAN	200-TAD-CAN-SHIELD-FIRE
	ESD12-LARGE-FIRE-TAD	ESD12-TAD-SHIELD-LF	PROB-TAD-IN-TC-IN-LF AND ESD12-TAD-SHIELD-TC

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

CONFINEMENT. Table A4.12-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.12-5. Basic Event Associated with the CONFINEMENT Pivotal Events of RF-ESD-12

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-DPC	200-CONFINEMENT	No further transfers
	ESD12-LOAD-FIRE-CSK-DPC		
	ESD12-PREP-FIRE-CSK-DC		
	ESD12-PREP-FIRE-CSK-DPC		
	ESD12-PREP-FIRE-CAN-DPC		
	ESD12-UNLD-FIRE-CAN-DPC		
	ESD12-XFER-FIRE-CSK-DPC		
	ESD12-LARGE-FIRE-DPC		
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-TAD		
	ESD12-LOAD-FIRE-CSK-TAD		
	ESD12-PREP-FIRE-CSK-TD		
	ESD12-PREP-FIRE-CSK-TAD		
	ESD12-PREP-FIRE-CAN-TAD		
	ESD12-UNLD-FIRE-CAN-TAD		
	ESD12-XFER-FIRE-CSK-TAD		
	ESD12-LARGE-FIRE-TAD		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

MODERATOR. Table A4.12-6 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.12-6. Basic Event Associated with the MODERATOR Pivotal Events of RF-ESD-12

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-DPC	200-MODERATOR-SOURCE	No further transfers
	ESD12-LOAD-FIRE-CSK-DPC		
	ESD12-PREP-FIRE-CSK-DC		
	ESD12-PREP-FIRE-CSK-DPC		
	ESD12-PREP-FIRE-CAN-DPC		
	ESD12-UNLD-FIRE-CAN-DPC		
	ESD12-XFER-FIRE-CSK-DPC		
	ESD12-LARGE-FIRE-DPC		
RF-ESD12-DPC	ESD12-BOLT-FIRE-CSK-TAD		
	ESD12-LOAD-FIRE-CSK-TAD		
	ESD12-PREP-FIRE-CSK-TD		
	ESD12-PREP-FIRE-CSK-TAD		
	ESD12-PREP-FIRE-CAN-TAD		
	ESD12-UNLD-FIRE-CAN-TAD		
	ESD12-XFER-FIRE-CSK-TAD		
	ESD12-LARGE-FIRE-TAD		

NOTE: [a]This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

A5 EVENT TREES

Navigation from an initiator event tree to the corresponding response event tree is assisted by the rightmost two columns on the initiator event trees as shown in Figure A5-1. The numbers under the "#" symbol may be used by the reader to refer to a particular branch of an event tree, but it is not used elsewhere in this analysis.

Source: Original

Figure A5-1. Example Initiator Event Tree Showing Navigation Aids

Table A5-1. ESDs to Event Trees

ESD#	ESD Title	IE Event Tree Name	IE Event Tree Figure	Response Tree Name	Response Tree Figure
RF-ESD-01	Event Sequences for Activities Associated with Receipt of Transportation Cask into Cask Preparation Room	RF-ESD01-DPC RF-ESD01-TAD	Figure A5-2 Figure A5-4	RESPONSE-TCASK1	Figure A5-3
RF-ESD-02	Event Sequences for Activities Associated with Removal of Impact Limiters, Cask Upending, and transfer to CTT or Cask Transfer Trailer	RF-ESD02-DPC RF-ESD02-TAD	Figure A5-5 Figure A5-6	RESPONSE-TCASK1	Figure A5-3
RF-ESD-03	Event Sequences for Activities Associated with Unbolting and Lid Adapter Installation	RF-ESD03-DPC RF-ESD03-TAD	Figure A5-7 Figure A5-8	RESPONSE-TCASK1	Figure A5-3
RF-ESD-04	Event Sequences for Activities Associated with Transfer of a Cask on CTT from Cask Preparation Room to Cask Unloading Room	RF-ESD04-DPC RF-ESD04-TAD	Figure A5-9 Figure A5-11	RESPONSE-TCASK2	Figure A5-10
RF-ESD-05	Event Sequences for Activities Associated with a Transportation Cask on a CTT or Site Transporter Colliding with Lid Bolting Room or Cask Unloading Room Shield Doors	RF-ESD05-DPC RF-ESD05-TAD	Figure A5-12 Figure A5-13	N/A	N/A
RF-ESD-06	Event Sequences for Activities Associated with the Transfer of a Canister from Transportation Cask to Aging Overpack with CTM	RF-ESD06-DPC RF-ESD06-TAD	Figure A5-14 Figure A5-16	RESPONSE-CANISTER1	Figure A5-15
RF-ESD-07	Event Sequences for Activities Associated with Assembly and Closure of an Aging Overpack	RF-ESD07-DPC RF-ESD07-TAD	Figure A5-17 Figure A5-19	RESPONSE-AO1	Figure A5-18

Table A5-1. ESDs to Event Trees (Continued)

ESD#	ESD Title	IE Event Tree Name	IE Event Tree Figure	Response Tree Name	Response Tree Figure
RF-ESD-08	Event Sequences for Activities Associated with the Exporting of an Aging Overpack from the Receipt Facility	RF-ESD08-DPC RF-ESD08-TAD	Figure A5-20 Figure A5-21	RESPONSE-AO1	Figure A5-18
RF-ESD-09	Event Sequences for Activities Associated with Export of Horizontal Cask on Cask Transfer Trailer	RF-ESD09	Figure A5-22	RESPONSE-TCASK1	Figure A5-3
RF-ESD-10	Event Sequences for Activities Associated with Direct Exposure During DPC handling Activities	RF-ESD10	Figure A5-23	N/A	N/A
RF-ESD-11	Event Sequences for Activities Associated with Direct Exposure During CTM Activities	RF-ESD11	Figure A5-24	N/A	N/A
RF-ESD-12	Event Sequences for a Fire Occurring in Receipt Facility	RF-ESD12-DPC RF-ESD12-TAD	Figure A5-25 Figure A5-27	RESPONSE-FIRE	Figure A5-26

NOTE: CTM = canister transfer machine; CTT = cask transfer trolley; DPC = dual-purpose canister.

Source: Original

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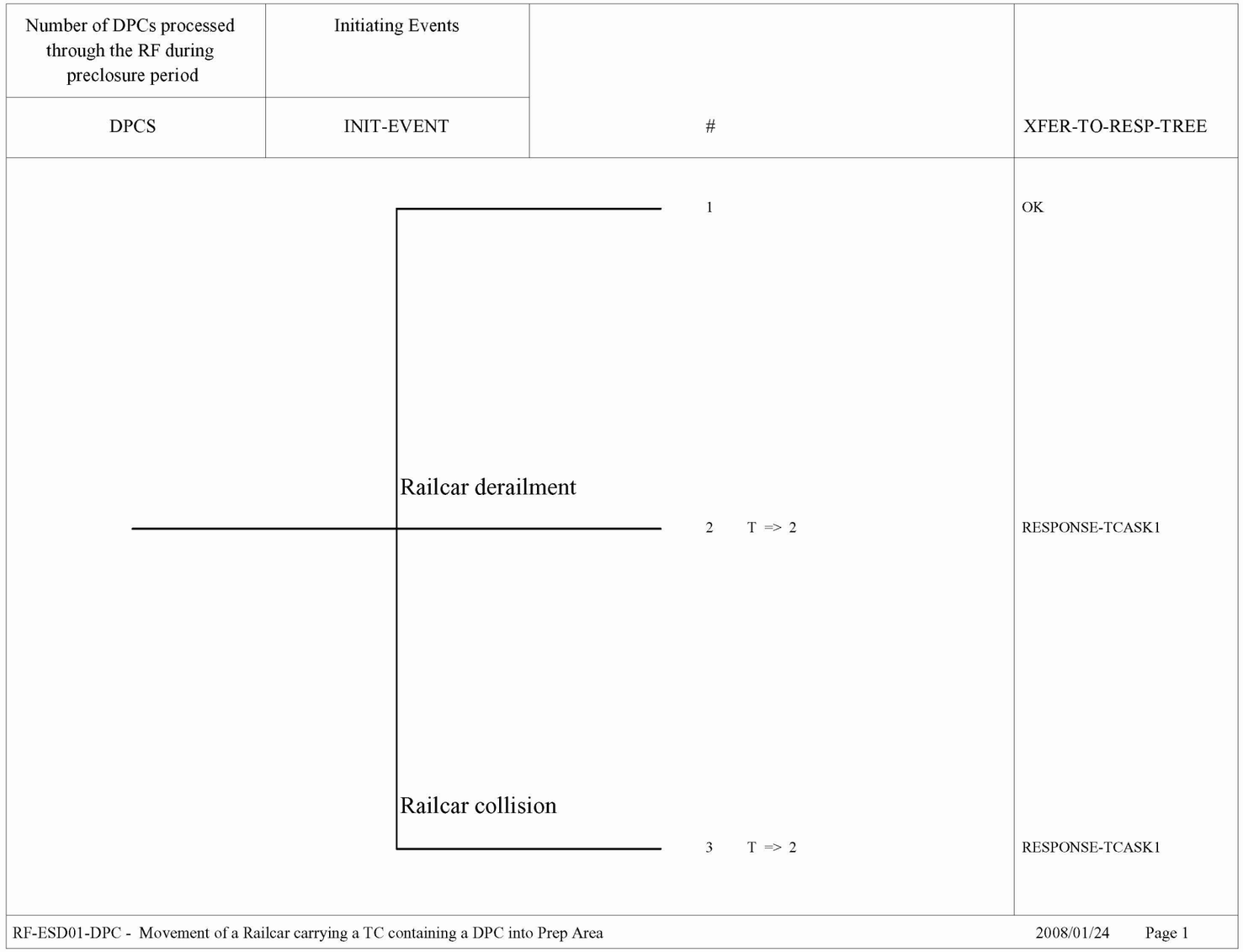

Source: Original

Figure A5-2. Event Tree RF-ESD01-DPC – Movement of a Railcar Carrying a Transportation Cask Containing a DPC into the Preparation Room

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