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

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: CRCF-ESD03-DPC Response: RESPONSE-TCASK1	346
Transportation cask containing DOE Standardized SNF canisters	Initiator: CRCF-ESD03-DSTD Response: RESPONSE-TCASK1	385
Rail-based Transportation cask containing HLW canisters	Initiator: CRCF-ESD03-HLW Response: RESPONSE-TCASK1	1,960
Transportation cask containing MCOs	Initiator: CRCF-ESD03-MCO Response: RESPONSE-TCASK1	113
Transportation cask containing a TAD canister	Initiator: CRCF-ESD03-TAD Response: RESPONSE-TCASK1	6,978

Source: Ref. 2.2.31, Table 4

A4.3.1 Initiating Events for CRCF-ESD-03

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

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 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 initiating event is specified as a probability of tipover per cask.

Collision Involving Side Impact to Cask. This initiating event covers the potential impact to the transportation cask due to a collision of the cask due to various causes. The initiating event is specified as a probability of impact per cask.

Unplanned Carrier 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. 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 by the cask handling crane. The initiating event is specified as a probability of 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 initiating event is specified as a probability of a drop per cask.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Cask drop from operational height	CRCF-ESD03-DPC	ESD3-DPC-DROP	060-3-DPC-CRANE-DROP **OR** 060-TILTFRAME-CSC-FOH[b]
	CRCF-ESD03-DSTD	ESD3-DSNF-DROP	060-3-DSNF-CRANE-DROP
	CRCF-ESD03-HLW	ESD3-HLW-DROP	060-3-HLW-CRANE-DROP
	CRCF-ESD03-MCO	ESD3-MCO-DROP	060-3-DSNF-CRANE-DROP
	CRCF-ESD03-TAD	ESD3-TAD-DROP	060-3-TAD-CRANE-DROP
Transportation cask tipover	CRCF-ESD03-DPC	ESD3-DPC-TIP	060-3-OP-TIPOVER
	CRCF-ESD03-DSTD	ESD3-DSNF-TIP	
	CRCF-ESD03-HLW	ESD3-HLW-TIP	
	CRCF-ESD03-MCO	ESD3-MCO-TIP	
	CRCF-ESD03-TAD	ESD3-TAD-TIP	
Side impact	CRCF-ESD03-DPC	ESD3-DPC-IMPACT	060-3-DPC-TC-IMPACT
	CRCF-ESD03-DSTD	ESD3-DSNF-IMPACT	060-3-DSNF-TC-IMPACT
	CRCF-ESD03-HLW	ESD3-HLW-IMPACT	060-3-HLW-TC-IMPACT
	CRCF-ESD03-MCO	ESD3-MCO-IMPACT	060-3-DSNF-TC-IMPACT
	CRCF-ESD03-TAD	ESD3-TAD-IMPACT	060-3-TAD-TC-IMPACT
Unplanned conveyance movement	CRCF-ESD03-DPC	ESD3-DPC-MOVE	060-3-DPC-TC-SPURMOVE
	CRCF-ESD03-DSTD	ESD3-DSNF-MOVE	060-3-DSNF-TC-SPURMOVE
	CRCF-ESD03-HLW	ESD3-HLW-MOVE	060-3-HLW-TC-SPURMOVE
	CRCF-ESD03-MCO	ESD3-MCO-MOVE	060-3-DSNF-TC-SPURMOVE
	CRCF-ESD03-TAD	ESD3-TAD-MOVE	060-3-TAD-TC-SPURMOVE
Object dropped on a cask	CRCF-ESD03-DPC	ESD3-DPC-DROPON	060-3-200T-CRANE-DROPON
	CRCF-ESD03-DSTD	ESD3-DSNF-DROPON	
	CRCF-ESD03-HLW	ESD3-HLW-DROPON	
	CRCF-ESD03-MCO	ESD3-MCO-DROPON	
	CRCF-ESD03-TAD	ESD3-TAD-DROPON	
Cask drop from above operational height	CRCF-ESD03-DPC	ESD3-DPC-2BLK	060-CRN2-2-BLOCK-CRN-TBK **AND** 060-TRANSCTTLIFTNUMBER[c]
	CRCF-ESD03-DSTD	ESD3-DSNF-2BLK	
	CRCF-ESD03-HLW	ESD3-HLW-2BLK	
	CRCF-ESD03-MCO	ESD3-MCO-2BLK	
	CRCF-ESD03-TAD	ESD3-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.
[b] Basic event and fault tree connected by an OR gate.
[c] Basic events connected by an AND gate.

Source: Original

A4.3.2 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are indicated below and summarized in Section A3. 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 CRC-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
CRCF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-TCASK	03-TCASK-DROP
	ESD3-DPC-TIP	ESD3-DPC-TIP-TCASK	03-TCASK_TIPOVER
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-TCASK	03-TCASK_SIMPACT
	ESD3-DPC-MOVE	ESD3-DPC-MOVE-TCASK	03-TCASK_IMPACT
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-TCASK	03-TCASK-DROPON
	ESD3-DPC-2BLK	ESD3-DPC-2BLK-TCASK2	03-TCASK_2BLK
CRCF-ESD03-DSTD	ESD3-DSNF-DROP	ESD3-DSNF-DROP-TCASK	03-TCASK-DROP
	ESD3-DSNF-TIP	ESD3-DSNF-TIP-TCASK	03-TCASK_TIPOVER
	ESD3-DSNF-IMPACT	ESD3-DSNF-IMPACT-TCASK	03-TCASK_SIMPACT
	ESD3-DSNF-MOVE	ESD3-DSNF-MOVE-TCASK	03-TCASK_IMPACT
	ESD3-DSNF-DROPON	ESD3-DSNF-DROPON-TCASK	03-TCASK-DROPON
	ESD3-DSNF-2BLK	ESD3-DSNF-2BLK-TCASK2	03-TCASK_2BLK
CRCF-ESD03-HLW	ESD3-HLW-DROP	ESD3-HLW-DROP-TCASK	03-TCASK-DROP
	ESD3-HLW-TIP	ESD3-HLW-TIP-TCASK	03-TCASK_TIPOVER
	ESD3-HLW-IMPACT	ESD3-HLW-IMPACT-TCASK	03-TCASK_SIMPACT
	ESD3-HLW-MOVE	ESD3-HLW-MOVE-TCASK	03-TCASK_IMPACT
	ESD3-HLW-DROPON	ESD3-HLW-DROPON-TCASK	03-TCASK-DROPON
	ESD3-HLW-2BLK	ESD3-HLW-2BLK-TCASK2	03-TCASK_2BLK
CRCF-ESD03-MCO	ESD3-MCO-DROP	ESD3-MCO-DROP-TCASK	03-TCASK-DROP
	ESD3-MCO-TIP	ESD3-MCO-TIP-TCASK	03-TCASK_TIPOVER
	ESD3-MCO-IMPACT	ESD3-MCO-IMPACT-TCASK	03-TCASK_SIMPACT
	ESD3-MCO-MOVE	ESD3-MCO-MOVE-TCASK	03-TCASK_IMPACT
	ESD3-MCO-DROPON	ESD3-MCO-DROPON-TCASK	03-TCASK-DROPON
	ESD3-MCO-2BLK	ESD3-MCO-2BLK-TCASK2	03-TCASK_2BLK
CRCF-ESD03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-TCASK	03-TCASK-DROP
	ESD3-TAD-TIP	ESD3-TAD-TIP-TCASK	03-TCASK_TIPOVER
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-TCASK	03-TCASK_SIMPACT
	ESD3-TAD-MOVE	ESD3-TAD-MOVE-TCASK	03-TCASK_IMPACT
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-TCASK	03-TCASK-DROPON
	ESD3-TAD-2BLK	ESD3-TAD-2BLK-TCASK2	03-TCASK_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

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 CRC-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-CAN	03-DPC_FAIL_IN_TC
	ESD3-DPC-TIP	ESD3-DPC-TIP-CAN	
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-CAN	
	ESD3-DPC-MOVE	ESD3-DPC-MOVE-CAN	
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-CAN	
	ESD3-DPC-2BLK	ESD3-DPC-2BLK-CAN2	03-DPC_FAIL_IN_TC_2BL
CRCF-ESD03-DSTD	ESD3-DSNF-DROP	ESD3-DSNF-DROP-CAN	03-DSTD_FAIL_IN_TC
	ESD3-DSNF-TIP	ESD3-DSNF-TIP-CAN	
	ESD3-DSNF-IMPACT	ESD3-DSNF-IMPACT-CAN	
	ESD3-DSNF-MOVE	ESD3-DSNF-MOVE-CAN	
	ESD3-DSNF-DROPON	ESD3-DSNF-DROPON-CAN	
	ESD3-DSNF-2BLK	ESD3-DSNF-2BLK-CAN2	03-DSTD_FAIL_IN_TC_2BL
CRCF-ESD03-HLW	ESD3-HLW-DROP	ESD3-HLW-DROP-CAN	03-HLW_FAIL_IN_TC
	ESD3-HLW-TIP	ESD3-HLW-TIP-CAN	
	ESD3-HLW-IMPACT	ESD3-HLW-IMPACT-CAN	
	ESD3-HLW-MOVE	ESD3-HLW-MOVE-CAN	
	ESD3-HLW-DROPON	ESD3-HLW-DROPON-CAN	
	ESD3-HLW-2BLK	ESD3-HLW-2BLK-CAN2	03-HLW_FAIL_IN_TC_2BL
CRCF-ESD03-MCO	ESD3-MCO-DROP	ESD3-MCO-DROP-CAN	03-MCO_FAIL_IN_TC
	ESD3-MCO-TIP	ESD3-MCO-TIP-CAN	
	ESD3-MCO-IMPACT	ESD3-MCO-IMPACT-CAN	
	ESD3-MCO-MOVE	ESD3-MCO-MOVE-CAN	
	ESD3-MCO-DROPON	ESD3-MCO-DROPON-CAN	
	ESD3-MCO-2BLK	ESD3-MCO-2BLK-CAN2	03-MCO_FAIL_IN_TC_2BL
CRCF-ESD03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-CAN	03-TAD_FAIL_IN_TC
	ESD3-TAD-TIP	ESD3-TAD-TIP-CAN	
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-CAN	
	ESD3-TAD-MOVE	ESD3-TAD-MOVE-CAN	
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-CAN	
	ESD3-TAD-2BLK	ESD3-TAD-2BLK-CAN2	03-TAD_FAIL_IN_TC_2BL

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 Events Associated with the SHIELDING Pivotal Events of CRC-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD03-DPC	ESD3-DPC-DROP	ESD3-DPC-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD3-DPC-TIP	ESD3-DPC-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD3-DPC-IMPACT	ESD3-DPC-IMPACT-SHIELD	CASK-SHIELDING
	ESD3-DPC-MOVE	ESD3-DPC-MOVE-SHIELD	CASK-SHIELDING-DROP
	ESD3-DPC-DROPON	ESD3-DPC-DROPON-SHIELD	CASK-SHIELDING-DROP
	ESD3-DPC-2BLK	ESD3-DPC-2BLK-SHIELD	CASK-SHIELDING-2BLK
CRCF-ESD03-DSTD	ESD3-DSNF-DROP	ESD3-DSNF-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD3-DSNF-TIP	ESD3-DSNF-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD3-DSNF-IMPACT	ESD3-DSNF-IMPACT-SHIELD	CASK-SHIELDING
	ESD3-DSNF-MOVE	ESD3-DSNF-MOVE-SHIELD	CASK-SHIELDING-DROP
	ESD3-DSNF-DROPON	ESD3-DSNF-DROPON-SHIELD	CASK-SHIELDING-DROP
	ESD3-DSNF-2BLK	ESD3-DSNF-2BLK-SHIELD	CASK-SHIELDING-2BLK
CRCF-ESD03-HLW	ESD3-HLW-DROP	ESD3-HLW-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD3-HLW-TIP	ESD3-HLW-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD3-HLW-IMPACT	ESD3-HLW-IMPACT-SHIELD	CASK-SHIELDING
	ESD3-HLW-MOVE	ESD3-HLW-MOVE-SHIELD	CASK-SHIELDING-DROP
	ESD3-HLW-DROPON	ESD3-HLW-DROPON-SHIELD	CASK-SHIELDING-DROP
	ESD3-HLW-2BLK	ESD3-HLW-2BLK-SHIELD	CASK-SHIELDING-2BLK
CRCF-ESD03-MCO	ESD3-MCO-DROP	ESD3-MCO-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD3-MCO-TIP	ESD3-MCO-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD3-MCO-IMPACT	ESD3-MCO-IMPACT-SHIELD	CASK-SHIELDING
	ESD3-MCO-MOVE	ESD3-MCO-MOVE-SHIELD	CASK-SHIELDING-DROP
	ESD3-MCO-DROPON	ESD3-MCO-DROPON-SHIELD	CASK-SHIELDING-DROP
	ESD3-MCO-2BLK	ESD3-MCO-2BLK-SHIELD	CASK-SHIELDING-2BLK
CRCF-ESD03-TAD	ESD3-TAD-DROP	ESD3-TAD-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD3-TAD-TIP	ESD3-TAD-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD3-TAD-IMPACT	ESD3-TAD-IMPACT-SHIELD	CASK-SHIELDING
	ESD3-TAD-MOVE	ESD3-TAD-MOVE-SHIELD	CASK-SHIELDING-DROP
	ESD3-TAD-DROPON	ESD3-TAD-DROPON-SHIELD	CASK-SHIELDING-DROP
	ESD3-TAD-2BLK	ESD3-TAD-2BLK-SHIELD	CASK-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 A4.3-6 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 CRC-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD03-DPC	ESD3-DPC-DROP	ESD3-CONF[b]	060-DP-LOSS-CRCF
	ESD3-DPC-TIP		
	ESD3-DPC-IMPACT		
	ESD3-DPC-MOVE		
	ESD3-DPC-DROPON		
	ESD3-DPC-2BLK		
CRCF-ESD03-DSTD	ESD3-DSNF-DROP		
	ESD3-DSNF-TIP		
	ESD3-DSNF-IMPACT		
	ESD3-DSNF-MOVE		
	ESD3-DSNF-DROPON		
	ESD3-DSNF-2BLK		
CRCF-ESD03-HLW	ESD3-HLW-DROP		
	ESD3-HLW-TIP		
	ESD3-HLW-IMPACT		
	ESD3-HLW-MOVE		
	ESD3-HLW-DROPON		
	ESD3-HLW-2BLK		
CRCF-ESD03-MCO	ESD3-MCO-DROP		
	ESD3-MCO-TIP		
	ESD3-MCO-IMPACT		
	ESD3-MCO-MOVE		
	ESD3-MCO-DROPON		
	ESD3-MCO-2BLK		
CRCF-ESD03-TAD	ESD3-TAD-DROP		
	ESD3-TAD-TIP		
	ESD3-TAD-IMPACT		
	ESD3-TAD-MOVE		
	ESD3-TAD-DROPON		
	ESD3-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.3-7.

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

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD03-DPC	ESD3-DPC-DROP	ESD3-MOD	060-MODERATOR-SOURCE
	ESD3-DPC-TIP		
	ESD3-DPC-IMPACT		
	ESD3-DPC-MOVE		
	ESD3-DPC-DROPON		
	ESD3-DPC-2BLK		
CRCF-ESD03-DSTD	ESD3-DSNF-DROP		
	ESD3-DSNF-TIP		
	ESD3-DSNF-IMPACT		
	ESD3-DSNF-MOVE		
	ESD3-DSNF-DROPON		
	ESD3-DSNF-2BLK		
CRCF-ESD03-HLW	ESD3-HLW-DROP	HLW-MODERATOR	060-HLW-MODERATOR
	ESD3-HLW-TIP		
	ESD3-HLW-IMPACT		
	ESD3-HLW-MOVE		
	ESD3-HLW-DROPON		
	ESD3-HLW-2BLK		
CRCF-ESD03-MCO	ESD3-MCO-DROP	ESD3-MOD	060-MODERATOR-SOURCE
	ESD3-MCO-TIP		
	ESD3-MCO-IMPACT		
	ESD3-MCO-MOVE		
	ESD3-MCO-DROPON		
	ESD3-MCO-2BLK		
CRCF-ESD03-TAD	ESD3-TAD-DROP		
	ESD3-TAD-TIP		
	ESD3-TAD-IMPACT		
	ESD3-TAD-MOVE		
	ESD3-TAD-DROPON		
	ESD3-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

A4.4 EVENT TREES FOR CRC-ESD-04

CRC-ESD-04 covers event sequences for cask preparation activities associated with unbolting and installation of the cask lid adaptor (Ref. 2.2.33, Figure F-4). This ESD covers five types of transportation casks. Corresponding to each type of cask is an initiator event tree (Table A4.4-1). 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 A4.4-1. Summary of Event Trees for CRC-ESD-04

Waste Form Units	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: CRCF-ES04-DPC Response: RESPONSE-TCASK1	346
Transportation cask containing DOE Standardized SNF canisters	Initiator: CRCF-ESD04-DSTD Response: RESPONSE-TCASK1	385
Rail-Based Transportation cask containing HLW canisters	Initiator: CRCF-ESD04-HLW Response: RESPONSE-TCASK1	1,960
Transportation cask containing MCOs	Initiator: CRCF-ESD04-MCO Response: RESPONSE-TCASK1	113
Transportation cask containing a TAD canister	Initiator: CRCF-ESD04-TAD Response: RESPONSE-TCASK1	6,978

Source: Ref. 2.2.31, Table 4

A4.4.1 Initiating Events for CRC-ESD-04

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

Cask Drop. This initiating event represents a potential impact to the transportation cask due to having been dropped by the cask handling crane because of 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 human error basic event. 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 or a human error basic event. 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 various causes. 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 A4.4-2. Initiating Event Assignments for CRCF-ESD-04

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Cask drop	CRCF-ESD04-DPC	ESD4-DPC-DROP	060-OPCASKDROP01-HFI-NOD
	CRCF-ESD04-DSTD	ESD4-DSNF-DROP	
	CRCF-ESD04-HLW	ESD4-HLW-DROP	
	CRCF-ESD04-MCO	ESD4-MCO-DROP	
	CRCF-ESD04-TAD	ESD4-TAD-DROP	
Transportation cask tipover	CRCF-ESD04-DPC	ESD4-DPC-TIP	060-3-CRANE-SPURMOVE[b] **OR** 060-4-OP-CRANE-TIP-TC
	CRCF-ESD04-DSTD	ESD4-DSNF-TIP	
	CRCF-ESD04-HLW	ESD4-HLW-TIP	
	CRCF-ESD04-MCO	ESD4-MCO-TIP	
	CRCF-ESD04-TAD	ESD4-TAD-TIP	
Side impact	CRCF-ESD04-DPC	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT[b]
	CRCF-ESD04-DSTD	ESD4-DSNF-IMPACT	ESD4-DSNF-IMPACT[b]
	CRCF-ESD04-HLW	ESD4-HLW-IMPACT	ESD4-HLW-IMPACT[b]
	CRCF-ESD04-MCO	ESD4-MCO-IMPACT	ESD4-MCO-IMPACT[b]
	CRCF-ESD04-TAD	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT[b]
Drop of heavy load onto cask	CRCF-ESD04-DPC	ESD4-DPC-DROPON	060-DPCPREPLIFTNUMBER **AND** 060-4-CRANE-DROP-ON-DPC[c]
	CRCF-ESD04-DSTD	ESD4-DSNF-DROPON	060-CSKPREPLIFTNUMBER **AND** 060-4A-CRANE-DROP-ON[c]
	CRCF-ESD04-HLW	ESD4-HLW-DROPON	060-CSKPREPLIFTNUMBER **AND** 060-4B-CRANE-DROP-ON[c]
	CRCF-ESD04-MCO	ESD4-MCO-DROPON	060-CSKPREPLIFTNUMBER **AND** 060-4AMCO-CRANE-DROP-ON[c]
	CRCF-ESD04-TAD	ESD4-TAD-DROPON	060-CSKPREPLIFTNUMBER **AND** 060-4C-CRANE-DROP-ON[c]

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

[b] Fault trees described in Attachment B.

[c] Basic event and fault tree connected by an AND gate.

Source: Original

A4.4.2 System Response Event Tree RESPONSE-TCASK1

The pivotal events that appear in RESPONSE-TCASK1 are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

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

Table A4.4-3. Basic Event Associated with the TRANSCASK Pivotal Events of CRC-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DPC	ESD4-DPC-DROP	ESD4-DPC-DROP-TCASK	04-TCASK-DROP
	ESD4-DPC-TIP	ESD4-DPC-TIP-TCASK	04-TCASK_IMPACT_TIP
	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT-TCASK	04-TCASK_SIMPACT
	ESD4-DPC-DROPON	ESD4-DPC-DROPON-TCASK	04-TCASK-DROPON
CRCF-ESD04-DSTD	ESD4-DSNF-DROP	ESD4-DSNF-DROP-TCASK	04-TCASK-DROP
	ESD4-DSNF-TIP	ESD4-DSNF-TIP-TCASK	04-TCASK_IMPACT_TIP
	ESD4-DSNF-IMPACT	ESD4-DSNF-IMPACT-TCASK	04-TCASK_SIMPACT
	ESD4-DSNF-DROPON	ESD4-DSNF-DROPON-TCASK	04-TCASK-DROPON
CRCF-ESD04-HLW	ESD4-HLW-DROP	ESD4-HLW-DROP-TCASK	04-TCASK-DROP
	ESD4-HLW-TIP	ESD4-HLW-TIP-TCASK	04-TCASK_IMPACT_TIP
	ESD4-HLW-IMPACT	ESD4-HLW-IMPACT-TCASK	04-TCASK_SIMPACT
	ESD4-HLW-DROPON	ESD4-HLW-DROPON-TCASK	04-TCASK-DROPON
CRCF-ESD04-MCO	ESD4-MCO-DROP	ESD4-MCO-DROP-TCASK	04-TCASK-DROP
	ESD4-MCO-TIP	ESD4-MCO-TIP-TCASK	04-TCASK_IMPACT_TIP
	ESD4-MCO-IMPACT	ESD4-MCO-IMPACT-TCASK	05-TCASK_SIMPACT
	ESD4-MCO-DROPON	ESD4-MCO-DROPON-TCASK	04-TCASK-DROPON
CRCF-ESD04-TAD	ESD4-TAD-DROP	ESD4-TAD-DROP-TCASK	04-TCASK-DROP
	ESD4-TAD-TIP	ESD4-TAD-TIP-TCASK	04-TCASK_IMPACT_TIP
	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT-TCASK	04-TCASK_SIMPACT
	ESD4-TAD-DROPON	ESD4-TAD-DROPON-TCASK	04-TCASK-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 A4.4-4 indicates the basic events that are associated with this pivotal event for each initiating event.

Table A4.4-4. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DPC	ESD4-DPC-DROP	ESD4-DPC-DROP-CAN	04-DPC_FAIL_IN_TC
	ESD4-DPC-TIP	ESD4-DPC-TIP-CAN	
	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT-CAN	
	ESD4-DPC-DROPON	ESD4-DPC-DROPON-CAN	
CRCF-ESD04-DSTD	ESD4-DSNF-DROP	ESD4-DSNF-DROP-CAN	04-DSNF_FAIL_IN_TC
	ESD4-DSNF-TIP	ESD4-DSNF-TIP-CAN	
	ESD4-DSNF-IMPACT	ESD4-DSNF-IMPACT-CAN	
	ESD4-DSNF-DROPON	ESD4-DSNF-DROPON-CAN	
CRCF-ESD04-HLW	ESD4-HLW-DROP	ESD4-HLW-DROP-CAN	04-HLW_FAIL_IN_TC
	ESD4-HLW-TIP	ESD4-HLW-TIP-CAN	
	ESD4-HLW-IMPACT	ESD4-HLW-IMPACT-CAN	
	ESD4-HLW-DROPON	ESD4-HLW-DROPON-CAN	
CRCF-ESD04-MCO	ESD4-MCO-DROP	ESD4-MCO-DROP-CAN	04-MCO_FAIL_IN_TC
	ESD4-MCO-TIP	ESD4-MCO-TIP-CAN	
	ESD4-MCO-IMPACT	ESD4-MCO-IMPACT-CAN	
	ESD4-MCO-DROPON	ESD4-MCO-DROPON-CAN	
CRCF-ESD04-TAD	ESD4-TAD-DROP	ESD4-TAD-DROP-CAN	04-TAD_FAIL_IN_TC
	ESD4-TAD-TIP	ESD4-TAD-TIP-CAN	
	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT-CAN	
	ESD4-TAD-DROPON	ESD4-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 A4.4-5 indicates the basic event that is associated with this pivotal event for each initiating event.

Table A4.4-5. Basic Event Associated with the SHIELDING Pivotal Events of CRC-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DPC	ESD4-DPC-DROP	ESD4-DPC-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD4-DPC-TIP	ESD4-DPC-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD4-DPC-IMPACT	ESD4-DPC-IMPACT-SHIELD	CASK-SHIELDING
	ESD4-DPC-DROPON	ESD4-DPC-DROPON-SHIELD	CASK-SHIELDING-DROP

Table A4.4-5. Basic Event Associated with the SHIELDING Pivotal Events of CRC-ESD-04 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DSTD	ESD4-DSNF-DROP	ESD4-DSNF-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD4-DSNF-TIP	ESD4-DSNF-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD4-DSNF-IMPACT	ESD4-DSNF-IMPACT-SHIELD	CASK-SHIELDING
	ESD4-DSNF-DROPON	ESD4-DSNF-DROPON-SHIELD	CASK-SHIELDING-DROP
CRCF-ESD04-HLW	ESD4-HLW-DROP	ESD4-HLW-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD4-HLW-TIP	ESD4-HLW-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD4-HLW-IMPACT	ESD4-HLW-IMPACT-SHIELD	CASK-SHIELDING
	ESD4-HLW-DROPON	ESD4-HLW-DROPON-SHIELD	CASK-SHIELDING-DROP
CRCF-ESD04-MCO	ESD4-MCO-DROP	ESD4-MCO-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD4-MCO-TIP	ESD4-MCO-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD4-MCO-IMPACT	ESD4-MCO-IMPACT-SHIELD	CASK-SHIELDING
	ESD4-MCO-DROPON	ESD4-MCO-DROPON-SHIELD	CASK-SHIELDING-DROP
CRCF-ESD04-TAD	ESD4-TAD-DROP	ESD4-TAD-DROP-SHIELD	CASK-SHIELDING-DROP
	ESD4-TAD-TIP	ESD4-TAD-TIP-SHIELD	CASK-SHIELDING-DROP
	ESD4-TAD-IMPACT	ESD4-TAD-IMPACT-SHIELD	CASK-SHIELDING
	ESD4-TAD-DROPON	ESD4-TAD-DROPON-SHIELD	CASK-SHIELDING-DROP

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 A4.4-6 specifies the fault tree that is associated with this pivotal event for each initiating event.

Table A4.4-6. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DPC	ESD4-DPC-DROP	ESD4-CONF[b]	060-DP-LOSS-CRCF
	ESD4-DPC-TIP		
	ESD4-DPC-IMPACT		
	ESD4-DPC-DROPON		
CRCF-ESD04-DSTD	ESD4-DSNF-DROP		
	ESD4-DSNF-TIP		
	ESD4-DSNF-IMPACT		
	ESD4-DSNF-DROPON		

Table A4.4-6. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-04 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-HLW	ESD4-HLW-DROP	ESD4-CONF[b]	060-DP-LOSS-CRCF
	ESD4-HLW-TIP		
	ESD4-HLW-IMPACT		
	ESD4-HLW-DROPON		
CRCF-ESD04-MCO	ESD4-MCO-DROP		
	ESD4-MCO-TIP		
	ESD4-MCO-IMPACT		
	ESD4-MCO-DROPON		
CRCF-ESD04-TAD	ESD4-TAD-DROP		
	ESD4-TAD-TIP		
	ESD4-TAD-IMPACT		
	ESD4-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.4-7.

Table A4.4-7. Basic Event Associated with the MODERATOR Pivotal Events of CRC-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-DPC	ESD4-DPC-DROP	ESD4-MOD	060-MODERATOR-SOURCE
	ESD4-DPC-TIP		
	ESD4-DPC-IMPACT		
	ESD4-DPC-DROPON		
CRCF-ESD04-DSTD	ESD4-DSNF-DROP		
	ESD4-DSNF-TIP		
	ESD4-DSNF-IMPACT		
	ESD4-DSNF-DROPON		
CRCF-ESD04-HLW	ESD4-HLW-DROP	HLW-MODERATOR	060-HLW-MODERATOR
	ESD4-HLW-TIP		
	ESD4-HLW-IMPACT		
	ESD4-HLW-DROPON		
CRCF-ESD04-MCO	ESD4-MCO-DROP	ESD4-MOD	060-MODERATOR-SOURCE
	ESD4-MCO-TIP		
	ESD4-MCO-IMPACT		
	ESD4-MCO-DROPON		

Table A4.4-7. Basic Event Associated with the MODERATOR Pivotal Events of CRC-ESD-04 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD04-TAD	ESD4-TAD-DROP	ESD4-MOD	060-MODERATOR-SOURCE
	ESD4-TAD-TIP		
	ESD4-TAD-IMPACT		
	ESD4-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

A4.5 EVENT TREES FOR CRC-ESD-05

CRC-ESD-05 covers event sequences for aging overpack preparation activities associated with unbolting the aging overpack lid (Ref. 2.2.33, Figure F-5). Table A4.5-1 summarizes the event trees for CRC-ESD-05. Although all of the initiating events in the initiator event tree transfer to the same response tree, the response tree is customized within SAPHIRE for each initiating event 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 A4.5-1. Summary of Event Trees for CRC-ESD-05

Waste Form Units	Associated Event Trees	Number of Waste Form Units
Aging overpack containing a TAD canister	Initiator: CRCF-ESD05-TAD Response: RESPONSE-CANISTER1	8,143

Source: Ref. 2.2.31, Table 4

A4.5.1 Initiating Events for CRC-ESD-05

The following initiating events are associated with CRC-ESD-05. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.5-2.

Impact to Aging Overpack. This initiating event represents a potential impact to the aging overpack due to a collision of the site transporter with another vehicle or improper operation of the cask handling crane. The fault tree is described in Attachment B. The initiating event is specified as a probability of an impact per cask.

Tipover of an Aging Overpack. This initiating event represents a potential impact to the aging overpack resulting in a tipover. The probability of tipover per transfer is modeled as a single-event fault tree described in Section 6.3. The initiating event is specified as a probability of a tipover per cask.

Table A4.5-2. Initiating Event Assignments for CRC-ESD-05

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Side impact to the Aging Overpack	CRCF-ESD05-TAD	ESD5-TAD-IMPACT	060-5-ST-IMPACT
Tipover of an Aging Overpack		ESD5-TAD-TIP	060-OPTIPOVER003-HFI-NOD

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

A4.5.2 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. The pivotal events are summarized in Section A3.

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

Table A4.5-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-TAD-IMPACT-CAN	05-TAD_AO_IMPACT
	ESD5-TAD-TIP	ESD5-TAD-TIP-CAN	05-TAD_AO_TIP

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 basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-TAD-IMPACT-SHIELD	AO_SHIELDING
	ESD5-TAD-TIP	ESD5-TAD-TIP-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 A4.5-5 indicates the basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-CONF[b]	060-DP-LOSS-CRCF
	ESD5-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] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.5-6.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD05-TAD	ESD5-TAD-IMPACT	ESD5-MOD	060-MODERATOR-SOURCE
	ESD5-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.

Source: Original

A4.6 EVENT TREES FOR CRC-ESD-06

CRC-ESD-06 covers event sequences for transferring either a cask or aging overpack from the cask preparation area to the cask unloading room (Ref. 2.2.33, Figure F-6). This ESD covers aging overpacks and five types of transportation casks. Corresponding to each type of cask or aging overpack is an initiator event tree (Table A4.6-1). 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 A4.6-1. Summary of Event Trees for CRC-ESD-06

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing a DPC	Initiator: CRCF-ESD06-DPC Response: RESPONSE-TCASK2	346
Transportation cask containing DOE Standardized SNF canisters	Initiator: CRCF-ESD06-DSTD Response: RESPONSE-TCASK2	385
Rail-based Transportation cask containing HLW canisters	Initiator: CRCF-ESD06-HLW Response: RESPONSE-TCASK2	1,960

Table A4.6-1. Summary of Event Trees for CRC-ESD-06 (Continued)

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing MCOs	Initiator: CRCF-ESD06-MCO Response: RESPONSE-TCASK2	113
Transportation cask or aging overpack containing a TAD canister	Initiator: CRCF-ESD06-TAD Response: RESPONSE-TCASK2	15,121

Source: Ref. 2.2.31, Table 4

A4.6.1 Initiating Events for CRC-ESD-06

The following initiating events are associated with CRC-ESD-06. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.6-2.

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 a human error described in Section 6.4. For TAD canisters the probability of impact is coupled with the fraction of casks containing TAD canisters carried on a CTT or site transporter. The initiating event is specified as a probability of an impact 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. For TAD canisters the probability of impact is coupled with the fraction of casks containing TAD canisters carried on a CTT or site transporter. The initiating event is specified as a probability of a drop per cask.

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

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	CRCF-ESD06-DPC	ESD6-DPC-IMPACT	060-6-OP-CTT-IMPACT
	CRCF-ESD06-DSTD	ESD6-DSNF-IMPACT	
	CRCF-ESD06-HLW	ESD6-HLW-IMPACT	
	CRCF-ESD06-MCO	ESD6-MCO-IMPACT	
	CRCF-ESD06-TAD	ESD6-TAD-IMPACT-CTT	060-PROB-CTT-TAD **AND** 060-6-OP-CTT-IMPACT[b]
		ESD6-TAD-IMPACT-ST	060-PROB-ST-TAD **AND** 060-6-OP-ST-IMPACT[b]

Table A4.6-2. Initiating Event Assignments for CRC-ESD-06 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Collision of CTT or site transporter	CRCF-ESD06-DPC	ESD6-DPC-COLLIDE	060-6-CTT-COLLIDE
	CRCF-ESD06-DSTD	ESD6-DSNF-COLLIDE	
	CRCF-ESD06-HLW	ESD6-HLW-COLLIDE	
	CRCF-ESD06-MCO	ESD6-MCO-COLLIDE	
	CRCF-ESD06-TAD	ESD6-TAD-COLLIDE-CTT	060-PROB-CTT-TAD **AND** 060-6-CTT-COLLIDE[c]
		ESD6-TAD-COLLIDE-ST	060-PROB-ST-TAD **AND** 060-6-ST-COLLISION[c]

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

[b] These two basic events are combined with an AND gate.

[c] These are a basic event and a fault tree combined by an AND gate.

Source: Original

A4.6.2 System Response Event Tree RESPONSE-TCASK2

The pivotal events that appear in RESPONSE-TCASK2 are listed below and summarized in Section A3. 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. Fault Trees Associated with the CANISTER Pivotal Events of CRC-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD06-DPC	ESD6-DPC-IMPACT	ESD6-DPC-IMPACT-CAN	06-DPC-FAIL-CTT-IMPACT
	ESD6-DPC-COLLIDE	ESD6-DPC-COLLIDE-CAN	06-DPC-FAIL-CTT-COLLIDE
CRCF-ESD06-DSTD	ESD6-DSNF-IMPACT	ESD6-DSNF-IMPACT-CAN	06-DSNF-FAIL-CTT-IMPACT
	ESD6-DSNF-COLLIDE	ESD6-DSNF-COLLIDE-CAN	06-DSNF-FAIL-CTT-COLLIDE
CRCF-ESD06-HLW	ESD6-HLW-IMPACT	ESD6-HLW-IMPACT-CAN	06-HLW-FAIL-CTT-IMPACT
	ESD6-HLW-COLLIDE	ESD6-HLW-COLLIDE-CAN	06-HLW-FAIL-CTT-COLLIDE
CRCF-ESD06-MCO	ESD6-MCO-IMPACT	ESD6-MCO-IMPACT-CAN	06-MCO-FAIL-CTT-IMPACT
	ESD6-MCO-COLLIDE	ESD6-MCO-COLLIDE-CAN	06-MCO-FAIL-CTT-COLLIDE

Table A4.6-3. Fault Trees Associated with the CANISTER Pivotal Events of CRC-ESD-06 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD06-TAD	ESD6-TAD-IMPACT-CTT	ESD6-TAD-IMPACT-CT-CAN	06-TAD-FAIL-CTT-IMPACT
	ESD6-TAD-IMPACT-ST	ESD6-TAD-IMPACT-ST-CAN	06-TAD_FAIL_ST_AO_IMPACT
	ESD6-TAD-COLLIDE-CTT	ESD6-TAD-COLLIDE-CT-CAN	06-TAD-FAIL-CTT-COLLIDE
	ESD6-TAD-COLLIDE-ST	ESD6-TAD-COLLIDE-ST-CAN	06-TAD_FAIL_STAO_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

SHIELDING. Table A4.6-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.6-4. Fault Trees Associated with the SHIELDING Pivotal Events of CRC-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD06-DPC	ESD6-DPC-IMPACT	ESD6-DPC-IMPACT-SHIELD	CASK-SHIELDING
	ESD6-DPC-COLLIDE	ESD6-DPC-COLLIDE-SHIELD	
CRCF-ESD06-DSTD	ESD6-DSNF-IMPACT	ESD6-DSNF-IMPACT-SHIELD	
	ESD6-DSNF-COLLIDE	ESD6-DSNF-COLLIDE-SHIELD	
CRCF-ESD06-HLW	ESD6-HLW-IMPACT	ESD6-HLW-IMPACT-SHIELD	
	ESD6-HLW-COLLIDE	ESD6-HLW-COLLIDE-SHIELD	
CRCF-ESD06-MCO	ESD6-MCO-IMPACT	ESD6-MCO-IMPACT-SHIELD	
	ESD6-MCO-COLLIDE	ESD6-MCO-COLLIDE-SHIELD	
CRCF-ESD06-TAD	ESD6-TAD-IMPACT-CTT	ESD6-TAD-IMPACT-CT-SHIE	CASK-SHIELDING
	ESD6-TAD-IMPACT-ST	ESD6-TAD-IMPACT-ST-SHIE	AO-SHIELDING
	ESD6-TAD-COLLIDE-CTT	ESD6-TAD-COLLIDE-CT-SHIE	CASK-SHIELDING
	ESD6-TAD-COLLIDE-ST	ESD6-TAD-COLLIDE-ST-SHIE	AO-SHIELDING

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 fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.6-5. Fault Trees Associated with the CONFINEMENT Pivotal Events of CRC-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD06-DPC	ESD6-DPC-IMPACT	ESD6-CONF[b]	060-DP-LOSS-CRCF
	ESD6-DPC-COLLIDE		
CRCF-ESD06-DSTD	ESD6-DSNF-IMPACT		
	ESD6-DSNF-COLLIDE		
CRCF-ESD06-HLW	ESD6-HLW-IMPACT		
	ESD6-HLW-COLLIDE		
CRCF-ESD06-MCO	ESD6-MCO-IMPACT		
	ESD6-MCO-COLLIDE		
CRCF-ESD06-TAD	ESD6-TAD-IMPACT-CTT		
	ESD6-TAD-IMPACT-ST		
	ESD6-TAD-COLLIDE-CTT		
	ESD6-TAD-COLLIDE-ST		

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

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.6-6.

Table A4.6-6. Fault Trees Associated with the MODERATOR Pivotal Events of CRC-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD06-DPC	ESD6-DPC-IMPACT	ESD6-MOD	060-MODERATOR-SOURCE
	ESD6-DPC-COLLIDE		
CRCF-ESD06-DSTD	ESD6-DSNF-IMPACT		
	ESD6-DSNF-COLLIDE		
CRCF-ESD06-HLW	ESD6-HLW-IMPACT	HLW-MODERATOR	060-HLW-MODERATOR
	ESD6-HLW-COLLIDE		
CRCF-ESD06-MCO	ESD6-MCO-IMPACT	ESD6-MOD	060-MODERATOR-SOURCE
	ESD6-MCO-COLLIDE		
CRCF-ESD06-TAD	ESD6-TAD-IMPACT-CTT		
	ESD6-TAD-IMPACT-ST		
	ESD6-TAD-COLLIDE-CTT		
	ESD6-TAD-COLLIDE-ST		

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 CRC-ESD-07

CRC-ESD-07 covers event sequences associated with collision of the shield door into the CTT, site transporter, or WPTT (Ref. 2.2.33, Figure F-7). 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. For the WPTT, the shield door involved is the shield door from the Waste Package Positioning Room (North or South) to the Waste Package Loadout Room. This ESD covers aging overpacks, transportation casks, and waste packages.

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.

A4.7.1 Initiating Events for CRC-ESD-07

Collision of Shield Door into CTT, site transporter, or WPTT. This initiating event accounts for a collision of a moving shield door with the CTT, site transporter, or WPTT. 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 A4.7-1.

Table A4.7-1. Initiating Event Assignments for CRC-ESD-07

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level
Collision of shield door with CTT, site transporter, or WPTT	CRCF-ESD07-DPC	ESD7-DPC-IMPACT	060-7-CTT-COLLIDE-SDR **OR** 060-7-ST-COLLIDE-SDRa
	CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT	060-7-CTT-COLLIDE-SDR
	CRCF-ESD07-HLW	ESD7-HLW-IMPACT	060-7-CTT-COLLIDE-SDR
	CRCF-ESD07-MCO	ESD7-MCO-IMPACT	060-7-CTT-COLLIDE-SDR
	CRCF-ESD07-TAD	ESD7-TAD-IMPACT	060-CTT-TAD-IMPACT[b] **OR** 060-ST-TAD-IMPACT[a,b]
	CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT	060-7-WPTT-COLLIDE-SDR
	CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT	060-7-WPTT-COLLIDE-SDR

Table A4.7-1. Initiating Event Assignments for CRC-ESD-07 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level
Collision of shield door with CTT, site transporter, or WPTT (Continued)	CRCF-ESD07-WP-TAD	ESD7-WP-TAD-IMPACT	060-7-WPTT-COLLIDE-SDR

NOTE: [a] Result of this fault tree is multiplied by factor of two to account for two shield doors.

[b] Split-fractions are used to account for percentage of operations involving the CTT and the site transporter.

Source: Original

A4.7.2 Pivotal Events

The pivotal events that appear in the event tree are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CELL-DOOR. Table A4.7-2 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.7-2. Basic Events Associated with the CELL-DOOR Pivotal Events of CRC-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to CELL-DOOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD07-DPC	ESD7-DPC-IMPACT	ESD7-DPC-IMPACT-DOOR	SHIELD_DOOR_FAILURE
CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT	ESD7-DSNF-IMPACT-DOORFA	
CRCF-ESD07-HLW	ESD7-HLW-IMPACT	ESD7-HLW-IMPACT-DOORFAI	
CRCF-ESD07-MCO	ESD7-MCO-IMPACT	ESD7-MCO-IMPACT-DOORFA	
CRCF-ESD07-TAD	ESD7-TAD-IMPACT	ESD7-TAD-IMPACT-DOOR	
CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT	ESD7-WP-H&D-IMPACT-DOOR	
CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT	ESD7-WP-H&M-IMPACT-DOOR	
CRCF-ESD07-WP-TAD	ESD7-WP-TAD-IMPACT	ESD7-WP-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 A4.7-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.7-3. Basic Events Associated with the CONTAINMENT Pivotal Events of CRC-ESD-07

Initiator Event Tree	Initiating Event Name	Name Assigned to CONTAINMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD07-DPC	ESD7-DPC-IMPACT	ESD7-DPC-IMPACT-CONT	07-DPC-FAIL-SD-IMPACT
CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT	ESD7-DSNF-IMPACT-CONTAI	07-DSTD-FAIL-CTT-IMPACT
CRCF-ESD07-HLW	ESD7-HLW-IMPACT	ESD7-HLW-IMPACT-CONTAIN	07-HLW-FAIL-CTT-IMPACT
CRCF-ESD07-MCO	ESD7-MCO-IMPACT	ESD7-MCO-IMPACT-CONTAI	07-MCO-FAIL-CTT-IMPACT
CRCF-ESD07-TAD	ESD7-TAD-IMPACT	ESD7-TAD-IMPACT-CONT	07-TAD-FAIL-SD-IMPACT
CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT	ESD7-WP-H&D-IMPACT-CONT	07-WP_FAIL_IMPACT
CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT	ESD7-WP-H&M-IMPACT-CONT	07-WP_FAIL_IMPACT
CRCF-ESD07-WP-TAD	ESD7-WP-TAD-IMPACT	ESD7-WP-TAD-IMPACT-CONT	07-WP_FAIL_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 A4.7-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD07-DPC	ESD7-DPC-IMPACT	ESD7-DPC-IMPACT-SHIELD	ESD7-DPC-IMPACT-SHIELD[b]
CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT	ESD7-DSNF-IMPACT- SHIELD	CASK-SHIELDING[b]
CRCF-ESD07-HLW	ESD7-HLW-IMPACT	ESD7-HLW-IMPACT- SHIELD	CASK-SHIELDING[b]
CRCF-ESD07-MCO	ESD7-MCO-IMPACT	ESD7-MCO-IMPACT- SHIELD	CASK-SHIELDING[b]
CRCF-ESD07-TAD	ESD7-TAD-IMPACT	ESD7-TAD-IMPACT-SHI	ESD7-TAD-IMPACT-SHI[b]
CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT	ESD7-WP-H&D-IMPACT-SHI	10-WP_SHIELDING
CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT	ESD7-WP-H&M-IMPACT-SHI	10-WP_SHIELDING
CRCF-ESD07-WP-TAD	ESD7-WP-TAD-IMPACT	ESD7-WP-TAD-IMPACT-SHI	10-WP_SHIELDING

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

[b] Fault trees described in Attachment B, Section B9.

Source: Original

CONFINEMENT. Table A4.7-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD07-DPC	ESD7-DPC-IMPACT	ESD7-CONF	060-DP-LOSS-CRCF
CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT		
CRCF-ESD07-HLW	ESD7-HLW-IMPACT		
CRCF-ESD07-MCO	ESD7-MCO-IMPACT		
CRCF-ESD07-TAD	ESD7-TAD-IMPACT		
CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT		
CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT		
CRCF-ESD07-WP-TAD	ESD7-WP-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. Table A4.7-6 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD07-DPC	ESD7-DPC-IMPACT	ESD7-MOD	060-MODERATOR-SOURCE
CRCF-ESD07-DSTD	ESD7-DSNF-IMPACT		
CRCF-ESD07-HLW	ESD7-HLW-IMPACT	HLW-MODERATOR	060-HLW-MODERATOR
CRCF-ESD07-MCO	ESD7-MCO-IMPACT	ESD7-MOD	060-MODERATOR-SOURCE
CRCF-ESD07-TAD	ESD7-TAD-IMPACT		
CRCF-ESD07-WP-H&D	ESD7-WP-H&D-IMPACT		
CRCF-ESD07-WP-H&M	ESD7-WP-H&M-IMPACT		
CRCF-ESD07-WP-TAD	ESD7-WP-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

A4.8 EVENT TREES FOR CRC-ESD-08

CRC-ESD-08 covers event sequences associated with collision of two CTMs (Ref. 2.2.33, Figure F-8). A single initiating event, collision of two CTMs, is associated with CRC-ESD-08. Because there is only one initiating event, the event trees are self contained (Table A4.8-1). Although the event trees for the different waste form units have the same pivotal event names, the pivotal events are customized within SAPHIRE for each 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 CRC-ESD-08

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
DPC	Initiator:CRCF-ESD08-DPC Response: RESPONSE-CANISTER1	346[a]
DOE standardized SNF canister	Initiator: CRCF-ESD08-DSTD Response: RESPONSE-CANISTER1	6,215[a]
HLW canister	Initiator: CRCF-ESD08-HLW Response: RESPONSE-CANISTER1	9,801[b]
MCO	Initiator: CRCF-ESD08-MCO Response: RESPONSE-CANISTER1	451[a]
TAD canister	Initiator: CRCF-ESD08-TAD Response: RESPONSE-CANISTER1	6,978[a]

Source: [a,b] Ref. 2.2.31, [a]Table 4, [b]Table 3

A4.8.1 Initiating Events for CRC-ESD-08

Collision of Two CTMs. This initiating event accounts for the potential impact to the canisters from a collision of two CTMs. The probability of impact 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 collision per canister transferred. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.8-2. Because there is only one initiating event, there is no separate initiator event tree.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Collision of two CTMs	CRCF-ESD08-DPC	ESD8-DPC-COLLIDE	060-8-TWO-CTMS-COLLIDE
	CRCF-ESD08-DSTD	ESD8-DSNF-COLLIDE	
	CRCF-ESD08-HLW	ESD8-HLW-COLLIDE	
	CRCF-ESD08-MCO	ESD8-MCO-COLLIDE	
	CRCF-ESD08-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-CANISTER1

The pivotal events that appear in RESPONSE-MULTI-CAN are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.8-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD08-DPC	ESD8-DPC-COLLIDE	ESD8-DPC-COLLIDE-2CAN	08-2DPCS_BREACHED
CRCF-ESD08-DSTD	ESD8-DSNF-COLLIDE	ESD8-DSNF-COLLIDE-2CAN	08-2DSNFS_BREACHED
CRCF-ESD08-HLW	ESD8-HLW-COLLIDE	ESD8-HLW-COLLIDE-2CAN	08-2HLWS_BREACHED
CRCF-ESD08-MCO	ESD8-MCO-COLLIDE	ESD8-MCO-COLLIDE-2CAN	08-2MCOS_BREACHED
CRCF-ESD08-TAD	ESD8-TAD-COLLIDE	ESD8-TAD-COLLIDE-2CAN	08-2TADS_BREACHED

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 fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD08-DPC	ESD8-DPC-COLLIDE	ESD8-DPC-COLLIDE-SHIELD	CTM_SHIELDING
CRCF-ESD08-DSTD	ESD8-DSNF-COLLIDE	ESD8-DSNF-COLLIDE-SHIEL	
CRCF-ESD08-HLW	ESD8-HLW-COLLIDE	ESD8-HLW-COLLIDE-SHIELD	
CRCF-ESD08-MCO	ESD8-MCO-COLLIDE	ESD8-MCO-COLLIDE-SHIEL	
CRCF-ESD08-TAD	ESD8-TAD-COLLIDE	ESD8-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 A4.8-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD08-DPC	ESD8-DPC-COLLIDE	ESD8-CONF[b]	060-DP-LOSS-CRCF
CRCF-ESD08-DSTD	ESD8-DSNF-COLLIDE		
CRCF-ESD08-HLW	ESD8-HLW-COLLIDE		
CRCF-ESD08-MCO	ESD8-MCO-COLLIDE		
CRCF-ESD08-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.8-6.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD08-DPC	ESD8-DPC-COLLIDE	ESD8-MOD	060-MODERATOR-SOURCE
CRCF-ESD08-DSTD	ESD8-DSNF-COLLIDE		
CRCF-ESD08-HLW	ESD8-HLW-COLLIDE	HLW-MODERATOR	060-HLW-MODERATOR
CRCF-ESD08-MCO	ESD8-MCO-COLLIDE	ESD8-MOD	060-MODERATOR-SOURCE
CRCF-ESD08-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

A4.9 EVENT TREES FOR CRC-ESD-09

CRC-ESD-09 covers event sequences associated with CTM transfers (Ref. 2.2.33, Figure F-9). This ESD covers all canister types. Corresponding to each canister type is an initiator event tree (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 CRC-ESD-09

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
DPC	Initiator: CRCF-ESD09-DPC Response: RESPONSE-CANISTER1	346[a]
DOE standardized SNF canister	Initiator: CRCF-ESD09-DSTD Response: RESPONSE-CANISTER1	6,215[a]
HLW canister	Initiator: CRCF-ESD09-HLW Response: RESPONSE-CANISTER1	9,801[b]
MCO	Initiator: CRCF-ESD09-MCO Response: RESPONSE-CANISTER1	451[a]
TAD canister	Initiator: CRCF-ESD09-TAD Response: RESPONSE-CANISTER1	15,121[a]

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.

Source: [a,b]Ref. 2.2.31, [a]Table 4, [b]Table 3

A4.9.1 Initiating Events for CRC-ESD-09

The following initiating events are associated with CRC-ESD-09. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.9-2. The initiating events are specified as frequency of occurrence per canister.

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 CTT, site transporter, or WPTT 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.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact with lid removal	CRCF-ESD09-DPC	ESD9-DPC-LIDIMP	060-OPNOUNBOLT00-HFI-NOD
	CRCF-ESD09-DSTD	ESD9-DSNF-LIDIMP	060-OPNOUNBOLT00-HFI-NOD **AND** (060-CTM--HOLDBRK-BRK-FOD[b], 060-CTM--HOLDBRK-BRK-FOH[b], 060-CTM--IMEC125-IEL-FOD[b], 060-CTM--WT0125--SRP-FOD[b], 060-CTM--WTSW125-ZS--FOD[b])
	CRCF-ESD09-HLW	ESD9-HLW-LIDIMP	060-OPNOUNBOLT00-HFI-NOD **AND** (060-CTM--HOLDBRK-BRK-FOD[b], 060-CTM--HOLDBRK-BRK-FOH[b], 060-CTM--IMEC125-IEL-FOD[b], 060-CTM--WT0125--SRP-FOD[b], 060-CTM--WTSW125-ZS--FOD[b])
	CRCF-ESD09-MCO	ESD9-MCO-LIDIMP	060-OPNOUNBOLT00-HFI-NOD **AND** (060-CTM--HOLDBRK-BRK-FOD[b], 060-CTM--HOLDBRK-BRK-FOH[b], 060-CTM--IMEC125-IEL-FOD[b], 060-CTM--WT0125--SRP-FOD[b], 060-CTM--WTSW125-ZS--FOD[b])

Table A4.9-2. Initiating Event Assignments for CRC-ESD-09 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact with lid removal (Continued)	CRCF-ESD09-TAD	ESD9-TAD-LIDIMP	060-OPNOUNBOLT00-HFI-NOD **AND** (060-CTM--HOLDBRK-BRK-FOD[b], 060-CTM--HOLDBRK-BRK-FOH[b], 060-CTM--IMEC125-IEL-FOD[b], 060-CTM--WT0125--SRP-FOD[b], 060-CTM--WTSW125-ZS--FOD[b])
Canister drop (from operational height)	CRCF-ESD09-DPC	ESD9-DPC-DROP	CTM-DROP---ALL-HEIGHTS **AND** 060-LIFTS-PER-DPC-CAN
	CRCF-ESD09-DSTD	ESD9-DSNF-DROP	CTM-DROP---ALL-HEIGHTS **AND** 060-LIFTS-PER-DSNF-CAN
	CRCF-ESD09-HLW	ESD9-HLW-DROP	CTM-DROP---ALL-HEIGHTS **AND** 060-LIFTS-PER-HLW-CAN
	CRCF-ESD09-MCO	ESD9-MCO-DROP	CTM-DROP---ALL-HEIGHTS **AND** 060-LIFTS-PER-MCO-CAN
	CRCF-ESD09-TAD	ESD9-TAD-DROP	CTM-DROP---ALL-HEIGHTS **AND** 060-LIFTS-PER-TAD-CAN
Spurious movement	CRCF-ESD09-DPC	ESD9-DPC-SPUR	CTM-SHEAR, 060-9-ST-SPURMOVE, 060-9-CTT-SPUR-MOVE[c]
	CRCF-ESD09-DSTD	ESD9-DSNF-SPUR	CTM-SHEAR, 060-9-WPTT-SPURMOVE, 060-9-CTT-SPUR-MOVE[c]
	CRCF-ESD09-HLW	ESD9-HLW-SPUR	CTM-SHEAR, 060-9-WPTT-SPURMOVE, 060-9-CTT-SPUR-MOVE[c]
	CRCF-ESD09-MCO	ESD9-MCO-SPUR	CTM-SHEAR, 060-9-WPTT-SPURMOVE, 060-9-CTT-SPUR-MOVE[c,d]
	CRCF-ESD09-TAD	ESD9-TAD-SPUR	CTM-SHEAR, 060-9-WPTT-SPURMOVE, 060-9-ST-SPURMOVE 060-9-CTT-SPUR-MOVE[c,d]
Side impact	CRCF-ESD09-DPC	ESD9-DPC-SIMPACT	(CTM-COLLISION **OR** 060-SLIDEGATECLOSES-CAN) **AND** 060-LIFTS-PER-DPC-CAN
	CRCF-ESD09-DSTD	ESD9-DSNF-	(CTM-COLLISION

Table A4.9-2. Initiating Event Assignments for CRC-ESD-09 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
		SIMPACT	**OR** 060-SLIDEGATECLOSES-CAN) **AND** 060-LIFTS-PER-DSNF-CAN
	CRCF-ESD09-HLW	ESD9-HLW-SIMPACT	(CTM-COLLISION **OR** 060-SLIDEGATECLOSES-CAN) **AND** 060-LIFTS-PER-HLW-CAN
	CRCF-ESD09-MCO	ESD9-MCO-SIMPACT	(CTM-COLLISION **OR** 060-SLIDEGATECLOSES-CAN) **AND** 060-LIFTS-PER-MCO-CAN
	CRCF-ESD09-TAD	ESD9-TAD-SIMPACT	(CTM-COLLISION **OR** 060-SLIDEGATECLOSES-CAN) **AND** 060-LIFTS-PER-TAD-CAN
Object drop on canister	CRCF-ESD09-DPC	ESD9-DPC-DROPON	CTM-DROP-ONTO-CASK **AND** 060-CTMOBJLIFTNUMBERD
	CRCF-ESD09-DSTD	ESD9-DSNF-DROPON	CTM-DROP-ONTO-CASK **AND** 060-CTMOBJLIFTNUMBER
	CRCF-ESD09-HLW	ESD9-HLW-DROPON	CTM-DROP-ONTO-CASK **AND** 060-CTMOBJLIFTNUMBER
	CRCF-ESD09-MCO	ESD9-MCO-DROPON	CTM-DROP-ONTO-CASK **AND** 060-CTMOBJLIFTNUMBER
	CRCF-ESD09-TAD	ESD9-TAD-DROPON	CTM-DROP-ONTO-CASK **AND** 060-CTMOBJLIFTNUMBER
Canister drop inside bell	CRCF-ESD09-DPC	ESD9-DPC-CTMBELL	CTM-DROP-IN-SHIELD-BELL **AND** 060-LIFTS-PER-DPC-CAN
	CRCF-ESD09-DSTD	ESD9-DSNF-CTMBELL	CTM-DROP-IN-SHIELD-BELL **AND** 060-LIFTS-PER-DSNF-CAN
	CRCF-ESD09-HLW	ESD9-HLW-CTMBELL	CTM-DROP-IN-SHIELD-BELL **AND** 060-LIFTS-PER-HLW-CAN
	CRCF-ESD09-MCO	ESD9-MCO-CTMBELL	CTM-DROP-IN-SHIELD-BELL **AND** 060-LIFTS-PER-MCO-CAN

Table A4.9-2. Initiating Event Assignments for CRC-ESD-09 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
	CRCF-ESD09-TAD	ESD9-TAD-CTMBELL	CTM-DROP-IN-SHIELD-BELL **AND** 060-LIFTS-PER-TAD-CAN
Canister drop (above operational height)	CRCF-ESD09-DPC	ESD9-DPC-2BLK	060-LIFTS-PER-DPC-CAN **AND** CTM-2-BLOCK
	CRCF-ESD09-DSTD	ESD9-DSNF-2BLK	060-LIFTS-PER-DSNF-CAN **AND** CTM-2-BLOCK
	CRCF-ESD09-HLW	ESD9-HLW-2BLK	060-LIFTS-PER-HLW-CAN **AND** CTM-2-BLOCK
	CRCF-ESD09-MCO	ESD9-MCO-2BLK	060-LIFTS-PER-MCO-CAN **AND** CTM-2-BLOCK
	CRCF-ESD09-TAD	ESD9-TAD-2BLK	060-LIFTS-PER-TAD-CAN **AND** CTM-2-BLOCK

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 events connected to top level through an OR gate.
[c] Fault trees connected to top level through an OR gate.
[d] Fault tree includes split fraction for fraction of TADs on CTT or ST

Source: Original

A4.9.2 System Response Event Tree RESPONSE-CANISTER1

The pivotal events that appear in RESPONSE-CANISTER1 are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.9-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.9-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-DPC	ESD9-DPC-LIDIMP	ESD9-DPC-LIDIMP-CAN	09-CAN-FAIL-LID-IMPACT
	ESD9-DPC-DROP	ESD9-DPC-DROP-CAN	09-CAN-FAIL-DROP
	ESD9-DPC-SPUR	ESD9-DPC-SPUR-CAN	09-CAN-FAIL-SPURMOVE
	ESD9-DPC-SIMPACT	ESD9-DPC-SIMPACT-CAN	09-CAN-FAIL-SIMPACT
	ESD9-DPC-DROPON	ESD9-DPC-DROPON-CAN	09-CAN-FAIL-DROPON
	ESD9-DPC-CTMBELL	ESD9-DPC-CTMBELL-CAN	09-CAN-FAIL-IN-BELL
	ESD9-DPC-2BLK	ESD9-DPC-2BLK-CAN2	09-CAN_FAIL_IN_CTM_2BL
CRCF-ESD09-DSTD	ESD9-DSNF-LIDIMP	ESD9-DSNF-LIDIMP-CAN	09-DSTD-FAIL-LID-IMPACT
	ESD9-DSNF-DROP	ESD9-DSNF-DROP-CAN	09-DSTD-FAIL-DROP
	ESD9-DSNF-SPUR	ESD9-DSNF-SPUR-CAN	09-CAN-FAIL-SPURMOVE
	ESD9-DSNF-SIMPACT	ESD9-DSNF-SIMPACT-CAN	09-DSTD-FAIL-SIMPACT
	ESD9-DSNF-DROPON	ESD9-DSNF-DROPON-CAN	09-DSTD-FAIL-DROPON
	ESD9-DSNF-CTMBELL	ESD9-DSNF-CTMBELL-CAN	09-DSTD-FAIL-IN-BELL
	ESD9-DSNF-2BLK	ESD9-DSNF-2BLK-CAN2	09-DSTD_FAIL_IN_CTM_2BL
CRCF-ESD09-HLW	ESD9-HLW-LIDIMP	ESD9-HLW-LIDIMP-CAN	09-HLW-FAIL-LID-IMPACT
	ESD9-HLW-DROP	ESD9-HLW-DROP-CAN	09-HLW-FAIL-DROP
	ESD9-HLW-SPUR	ESD9-HLW-SPUR-CAN	09-HLW-FAIL-SPURMOVE
	ESD9-HLW-SIMPACT	ESD9-HLW-SIMPACT-CAN	09-HLW-FAIL-SIMPACT
	ESD9-HLW-DROPON	ESD9-HLW-DROPON-CAN	09-HLW-FAIL-DROPON
	ESD9-HLW-CTMBELL	ESD9-HLW-CTMBELL-CAN	09-HLW-FAIL-IN-BELL
	ESD9-HLW-2BLK	ESD9-HLW-2BLK-CAN2	09-HLW_FAIL_IN_CTM_2BL
CRCF-ESD09-MCO	ESD9-MCO-LIDIMP	ESD9-MCO-LIDIMP-CAN	09-MCO-FAIL-LID-IMPACT
	ESD9-MCO-DROP	ESD9-MCO-DROP-CAN	09-MCO-FAIL-DROP
	ESD9-MCO-SPUR	ESD9-MCO-SPUR-CAN	09-MCO-FAIL-SPURMOVE
	ESD9-MCO-SIMPACT	ESD9-MCO-SIMPACT-CAN	09-MCO-FAIL-SIMPACT
	ESD9-MCO-DROPON	ESD9-MCO-DROPON-CAN	09-MCO-FAIL-DROPON
	ESD9-MCO-CTMBELL	ESD9-MCO-CTMBELL-CAN	09-MCO-FAIL-IN-BELL
	ESD9-MCO-2BLK	ESD9-MCO-2BLK-CAN2	09-MCO_FAIL_IN_CTM_2BL
CRCF-ESD09-TAD	ESD9-TAD-LIDIMP	ESD9-TAD-LIDIMP-CAN	09-CAN-FAIL-LID-IMPACT
	ESD9-TAD-DROP	ESD9-TAD-DROP-CAN	09-CAN-FAIL-DROP

Table A4.9-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-09 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-TAD	ESD9-TAD-SPUR	ESD9-TAD-SPUR-CAN	09-CAN-FAIL-SPURMOVE
	ESD9-TAD-SIMPACT	ESD9-TAD-SIMPACT-CAN	09-CAN-FAIL-SIMPACT
	ESD9-TAD-DROPON	ESD9-TAD-DROPON-CAN	09-CAN-FAIL-DROPON
	ESD9-TAD-CTMBELL	ESD9-TAD-CTMBELL-CAN	09-CAN-FAIL-IN-BELL
	ESD9-TAD-2BLK	ESD9-TAD-2BLK-CAN2	09-CAN_FAIL_IN_CTM_2BL

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 A4.9-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.9-4. Basic Events Associated with the SHIELDING Pivotal Events of CRC-ESD-09

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-DPC	ESD9-DPC-LIDIMP	ESD9-DPC-LIDIMP-SHIELD	CTM_SHIELDING
	ESD9-DPC-DROP	ESD9-DPC-DROP-SHIELD	
	ESD9-DPC-SPUR	ESD9-DPC-SPUR-SHIELD	
	ESD9-DPC-SIMPACT	ESD9-DPC-SIMPACT-SHIELD	
	ESD9-DPC-DROPON	ESD9-DPC-DROPON-SHIELD	
	ESD9-DPC-CTMBELL	ESD9-DPC-CTMBELL-SHIELD	
	ESD9-DPC-2BLK	ESD9-DPC-2BLK-SHIELD	
CRCF-ESD09-DSTD	ESD9-DSNF-LIDIMP	ESD9-DSNF-LIDIMP-SHIELD	
	ESD9-DSNF-DROP	ESD9-DSNF-DROP-SHIELD	
	ESD9-DSNF-SPUR	ESD9-DSNF-SPUR-SHIELD	
	ESD9-DSNF-SIMPACT	ESD9-DSNF-SIMPACT-SHIELD	
	ESD9-DSNF-DROPON	ESD9-DSNF-DROPON-SHIELD	
	ESD9-DSNF-CTMBELL	ESD9-DSNF-CTMBELL-SHIELD	
	ESD9-DSNF-2BLK	ESD9-DSNF-2BLK-SHIELD	
CRCF-ESD09-HLW	ESD9-HLW-LIDIMP	ESD9-HLW-LIDIMP-SHIELD	
	ESD9-HLW-DROP	ESD9-HLW-DROP-SHIELD	
	ESD9-HLW-SPUR	ESD9-HLW-SPUR-SHIELD	
	ESD9-HLW-SIMPACT	ESD9-HLW-SIMPACT-SHIELD	
	ESD9-HLW-DROPON	ESD9-HLW-DROPON-SHIELD	

Table A4.9-4. Basic Events Associated with the SHIELDING Pivotal Events of CRC-ESD-09 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-HLW	ESD9-HLW-CTMBELL	ESD9-HLW-CTMBELL-SHIELD	CTM_SHIELDING
	ESD9-HLW-2BLK	ESD9-HLW-2BLK-SHIELD	
CRCF-ESD09-MCO	ESD9-MCO-LIDIMP	ESD9-MCO-LIDIMP-SHIELD	
	ESD9-MCO-DROP	ESD9-MCO-DROP-SHIELD	
	ESD9-MCO-SPUR	ESD9-MCO-SPUR-SHIELD	
	ESD9-MCO-SIMPACT	ESD9-MCO-SIMPACT-SHIELD	
	ESD9-MCO-DROPON	ESD9-MCO-DROPON-SHIELD	
	ESD9-MCO-CTMBELL	ESD9-MCO-CTMBELL-SHIELD	
	ESD9-MCO-2BLK	ESD9-MCO-2BLK-SHIELD	
CRCF-ESD09-TAD	ESD9-TAD-LIDIMP	ESD9-TAD-LIDIMP-SHIELD	
	ESD9-TAD-DROP	ESD9-TAD-DROP-SHIELD	
	ESD9-TAD-SPUR	ESD9-TAD-SPUR-SHIELD	
	ESD9-TAD-SIMPACT	ESD9-TAD-SIMPACT-SHIELD	
	ESD9-TAD-DROPON	ESD9-TAD-DROPON-SHIELD	
	ESD9-TAD-CTMBELL	ESD9-TAD-CTMBELL-SHIELD	
	ESD9-TAD-2BLK	ESD9-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 A4.9-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-DPC	ESD9-DPC-LIDIMP	ESD9-CONF[b]	060-DP-LOSS-CRCF
	ESD9-DPC-DROP		
	ESD9-DPC-SPUR		
	ESD9-DPC-SIMPACT		
	ESD9-DPC-DROPON		
	ESD9-DPC-CTMBELL		
	ESD9-DPC-2BLK		

Table A4.9-5. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-09 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-DSTD	ESD9-DSNF-LIDIMP	ESD9-CONF[b]	060-DP-LOSS-CRCF
	ESD9-DSNF-DROP		
	ESD9-DSNF-SPUR		
	ESD9-DSNF-SIMPACT		
	ESD9-DSNF-DROPON		
	ESD9-DSNF-CTMBELL		
	ESD9-DSNF-2BLK		
CRCF-ESD09-HLW	ESD9-HLW-LIDIMP		
	ESD9-HLW-DROP		
	ESD9-HLW-SPUR		
	ESD9-HLW-SIMPACT		
	ESD9-HLW-DROPON		
	ESD9-HLW-CTMBELL		
	ESD9-HLW-2BLK		
CRCF-ESD09-MCO	ESD9-MCO-LIDIMP		
	ESD9-MCO-DROP		
	ESD9-MCO-SPUR		
	ESD9-MCO-SIMPACT		
	ESD9-MCO-DROPON		
	ESD9-MCO-CTMBELL		
	ESD9-MCO-2BLK		
CRCF-ESD09-TAD	ESD9-TAD-LIDIMP		
	ESD9-TAD-DROP		
	ESD9-TAD-SPUR		
	ESD9-TAD-SIMPACT		
	ESD9-TAD-DROPON		
	ESD9-TAD-CTMBELL		
	ESD9-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and all initiating events as shown in Table A4.9-6.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD09-DPC	ESD9-DPC-LIDIMP	ESD9-MOD	060-MODERATOR-SOURCE
	ESD9-DPC-DROP		
	ESD9-DPC-SPUR		
	ESD9-DPC-SIMPACT		
	ESD9-DPC-DROPON		
	ESD9-DPC-CTMBELL		
	ESD9-DPC-2BLK		
CRCF-ESD09-DSTD	ESD9-DSNF-LIDIMP		
	ESD9-DSNF-DROP		
	ESD9-DSNF-SPUR		
	ESD9-DSNF-SIMPACT		
	ESD9-DSNF-DROPON		
	ESD9-DSNF-CTMBELL		
	ESD9-DSNF-2BLK		
CRCF-ESD09-HLW	ESD9-HLW-LIDIMP	HLW-MODERATOR	060-HLW-MODERATOR
	ESD9-HLW-DROP		
	ESD9-HLW-SPUR		
	ESD9-HLW-SIMPACT		
	ESD9-HLW-DROPON		
	ESD9-HLW-CTMBELL		
	ESD9-HLW-2BLK		
CRCF-ESD09-MCO	ESD9-MCO-LIDIMP	ESD9-MOD	060-MODERATOR-SOURCE
	ESD9-MCO-DROP		
	ESD9-MCO-SPUR		
	ESD9-MCO-SIMPACT		
	ESD9-MCO-DROPON		
	ESD9-MCO-CTMBELL		
	ESD9-MCO-2BLK		
CRCF-ESD09-TAD	ESD9-TAD-LIDIMP		
	ESD9-TAD-DROP		
	ESD9-TAD-SPUR		
	ESD9-TAD-SIMPACT		
	ESD9-TAD-DROPON		
	ESD9-TAD-CTMBELL		
	ESD9-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

A4.10 EVENT TREES FOR CRC-ESD-10

CRC-ESD-10 covers event sequences associated with movement of the WPTT within the Waste Package Positioning Room from the waste package loading position to the waste package closure position (Ref. 2.2.33, Figure F-10). This ESD covers all canister types that are loaded into waste packages in the CRCF. 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 CRC-ESD-10

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing 1 DOE standardized canister and 4 to 5 HLW canisters	Initiator: CRCF-ESD10-WP-H&D Response: RESPONSE-WP1	3,300
Waste package containing 2 HLW canisters and 2 MCOs	Initiator: CRCF-ESD10-WP-H&M Response: RESPONSE-WP1	225
Waste package loaded with a TAD canister	Initiator: CRCF-ESD10-WP-TAD Response: RESPONSE-WP1	8,143

Source: *Waste Form Throughputs for Preclosure Safety Analysis*, (Ref. 2.2.31, Table 4)

A4.10.1 Initiating Events for CRC-ESD-10

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

WPTT Derailment. This initiating event accounts for the potential derailment of the WPTT.

WPTT Collision with Facility Structures or Facility Equipment. This initiating event accounts for the potential impact to the waste package due to a WPTT collision with facility structures or facility equipment.

Premature Tilt-down of the WPTT. This initiating event accounts for the potential impact to the waste package due to a premature tilt-down of the WPTT.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
WPTT derailment	CRCF-ESD10-WP-H&D	ESD10-WP-H&D-DERAIL	060-WPTT-DERAIL
	CRCF-ESD10-WP-H&M	ESD10-WP-H&M-DERAIL	
	CRCF-ESD10-WP-TAD	ESD10-WP-TAD-DERAIL	
WPTT collision	CRCF-ESD10-WP-H&D	ESD10-WP-H&D-COLLIDE	060-WPTT-IMPACT
	CRCF-ESD10-WP-H&M	ESD10-WP-H&M-COLLIDE	
	CRCF-ESD10-WP-TAD	ESD10-WP-TAD-COLLIDE	
Premature tilt-down	CRCF-ESD10-WP-H&D	ESD10-WP-H&D-TILT	060-WPTT-PRE-TIL
	CRCF-ESD10-WP-H&M	ESD10-WP-H&M-TILT	
	CRCF-ESD10-WP-TAD	ESD10-WP-TAD-TILT	

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 RESPONSE-WP1

The pivotal events that appear in RESPONSE-WP1 are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.10-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.10-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-10

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD10-WP-H&D	ESD10-WP-H&D-DERAIL	ESD10-WP-H&D-DERAIL-CAN	10-H&D-FAIL-WPTT-DERAIL
	ESD10-WP-H&D-COLLIDE	ESD10-WP-H&D-COLLIDE-CAN	10-H&D-FAIL-WPTT-COLLIDE
	ESD10-WP-H&D-TILT	ESD10-WP-H&D-TILT-CAN	10-H&D-FAIL-WPTT-TILT
CRCF-ESD10-WP-H&M	ESD10-WP-H&M-DERAIL	ESD10-WP-H&M-DERAIL-CAN	10-H&M-FAIL-WPTT-DERAIL
	ESD10-WP-H&M-COLLIDE	ESD10-WP-H&M-COLLIDE-CAN	10-H&M-FAIL-WPTT-COLLIDE
	ESD10-WP-H&M-TILT	ESD10-WP-H&M-TILT-CAN	10-H&M-FAIL-WPTT-TILT
CRCF-ESD10-WP-TAD	ESD10-WP-TAD-DERAIL	ESD10-WP-TAD-DERAIL-CAN	10-CAN-FAIL-WPTT-DERAIL
	ESD10-WP-TAD-COLLIDE	ESD10-WP-TAD-COLLIDE-CA	10-CAN-FAIL-WPTT-COLLIDE
	ESD10-WP-TAD-TILT	ESD10-WP-TAD-TILT-CAN	10-CAN-FAIL-WPTT-TILT

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 (waste package lid, shield ring, and WPTT shielding) to provide its shielding function after the impact caused by the initiating event. Failure of shielding in this instance refers to an unspecified degree of shielding degradation due to the impact. Table A4.10-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.10-4. Basic Events Associated with the SHIELDING Pivotal Events of CRC-ESD-10

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD10-WP-H&D	ESD10-WP-H&D-DERAIL	ESD10-WP-H&D-DERAIL-SHIE	10-WPTT_SHIELDING
	ESD10-WP-H&D-COLLIDE	ESD10-WP-H&D-COLLIDE-SHI	
	ESD10-WP-H&D-TILT	ESD10-WP-H&D-TILT-SHIELD	10-WP_SHIELDING
CRCF-ESD10-WP-H&M	ESD10-WP-H&M-DERAIL	ESD10-WP-H&M-DERAIL-SHIE	10-WPTT_SHIELDING
	ESD10-WP-H&M-COLLIDE	ESD10-WP-H&M-COLLIDE-SHI	
	ESD10-WP-H&M-TILT	ESD10-WP-H&M-TILT-SHIELD	10-WP_SHIELDING
CRCF-ESD10-WP-TAD	ESD10-WP-TAD-DERAIL	ESD10-WP-TAD-DERAIL-SHI	10-WPTT_SHIELDING
	ESD10-WP-TAD-COLLIDE	ESD10-WP-TAD-COLLIDE-SH	
	ESD10-WP-TAD-TILT	ESD10-WP-TAD-TILT-SHIEL	10-WP_SHIELDING

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 A4.10-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.10-5. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD10-WP-H&D	ESD10-WP-H&D-DERAIL	ESD10-CONF[b]	060-DP-LOSS-CRCF
	ESD10-WP-H&D-COLLIDE		
	ESD10-WP-H&D-TILT		
CRCF-ESD10-WP-H&M	ESD10-WP-H&M-DERAIL		
	ESD10-WP-H&M-COLLIDE		
	ESD10-WP-H&M-TILT		
CRCF-ESD10-WP-TAD	ESD10-WP-TAD-DERAIL		
	ESD10-WP-TAD-COLLIDE		
	ESD10-WP-TAD-TILT		

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

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.10-6.

Table A4.10-6. Basic Event Associated with the MODERATOR Pivotal Events of CRC-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD10-WP-H&D	ESD10-WP-H&D-DERAIL	ESD10-MOD	060-MODERATOR-SOURCE
	ESD10-WP-H&D-COLLIDE		
	ESD10-WP-H&D-TILT		
CRCF-ESD10-WP-H&M	ESD10-WP-H&M-DERAIL		
	ESD10-WP-H&M-COLLIDE		
	ESD10-WP-H&M-TILT		
CRCF-ESD10-WP-TAD	ESD10-WP-TAD-DERAIL		
	ESD10-WP-TAD-COLLIDE		
	ESD10-WP-TAD-TILT		

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

A4.11 EVENT TREES FOR CRC-ESD-11

CRC-ESD-11 covers event sequences associated with the assembly and closure of the waste package (Ref. 2.2.33, Figure F-11). This ESD covers waste packages. 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 CRC-ESD-11

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing 1 DOE standardized canister and 4 to 5 HLW canisters	Initiator: CRCF-ESD11-WP-H&D Response: RESPONSE-WP1	3,300
Waste package containing 2 HLW canisters and 2 MCOs	Initiator: CRCF-ESD11-WP-H&M Response: RESPONSE-WP1	225
Waste package loaded with a TAD canister	Initiator: CRCF-ESD11-WP-TAD Response: RESPONSE-WP1	8,143

Source: Ref. 2.2.31 Table 4

A4.11.1 Initiating Events for CRC-ESD-11

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

Welding Damages Canister. This initiating event accounts for the potential impact to the waste package due to a thermal challenge from the welding equipment.

Remote Handling System Drops Object. This initiating event accounts for the potential impact to the waste package due to the drop of an object by the RHS.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Welding damages canister	CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DAMAGE	WELD_DAMAGE
	CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DAMAGE	
	CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DAMAGE	
RHS drops object	CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DROPON	060-11-RHS-H&D-DROP-ON **AND** 060-RHSLIFTNUMBER-000001 [b]
	CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DROPON	060-11-RHS-H&M-DROP-ON **AND** 060-RHSLIFTNUMBER-000001 [b]
	CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DROPON	060-11-RHS-TAD-DROP-ON **AND** 060-RHSLIFTNUMBER-000001 [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 are discussed in Attachment B, Section B9.

Source: Original

A4.11.2 System Response Event Tree RESPONSE-WP1

The pivotal events that appear in RESPONSE-WP1 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.11-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.11-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-11

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DAMAGE	ESD11-WP-H&D-DAMAGE-CAN	11-H&D-FAIL-WP-WELD
	ESD11-WP-H&D-DROPON	ESD11-WP-H&D-DROPON-CAN	11-H&D-FAIL-WP-DROPON
CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DAMAGE	ESD11-WP-H&M-DAMAGE-CAN	11-H&M-FAIL-WP-WELD
	ESD11-WP-H&M-DROPON	ESD11-WP-H&M-DROPON-CAN	11-H&M-FAIL-WP-DROPON

Table A4.11-3. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-11 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DAMAGE	ESD11-WP-TAD-DAMAGE-CAN	11-CAN-FAIL-WP-WELD
	ESD11-WP-TAD-DROPON	ESD11-WP-TAD-DROPON-CAN	11-CAN-FAIL-WP-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 A4.11-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.11-4. Basic Events Associated with the SHIELDING Pivotal Events of CRC-ESD-11

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DAMAGE	ESD11-WP-H&D-DAMAGE–SHI	11-WP_SHIELDING
	ESD11-WP-H&D-DROPON	ESD11-WP-H&D-DROPON-SHI	
CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DAMAGE	ESD11-WP-H&M-DAMAGE–SHI	
	ESD11-WP-H&M-DROPON	ESD11-WP-H&M-DROPON-SHI	
CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DAMAGE	ESD11-WP-TAD-DAMAGE–SHI	
	ESD11-WP-TAD-DROPON	ESD11-WP-TAD-DROPON-SHI	

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 A4.11-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.11-5. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DAMAGE	ESD11-CONF[b]	060-DP-LOSS-CRCF
	ESD11-WP-H&D-DROPON		
CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DAMAGE		
	ESD11-WP-H&M-DROPON		
CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DAMAGE		
	ESD11-WP-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.

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.11-6.

Table A4.11-6. Basic Event Associated with the MODERATOR Pivotal Events of CRC-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD11-WP-H&D	ESD11-WP-H&D-DAMAGE	ESD11-MOD	060-MODERATOR-SOURCE
	ESD11-WP-H&D-DROPON		
CRCF-ESD11-WP-H&M	ESD11-WP-H&M-DAMAGE		
	ESD11-WP-H&M-DROPON		
CRCF-ESD11-WP-TAD	ESD11-WP-TAD-DAMAGE		
	ESD11-WP-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

A4.12 EVENT TREES FOR CRC-ESD-12

CRC-ESD-12 covers event sequences associated with assembly and closure of an aging overpack (Ref. 2.2.33, Figure F-12). This ESD covers the two waste forms that are placed in aging overpacks in the CRCF; TAD canisters and DPCs. Corresponding to each waste form unit is an initiator event tree (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 CRC-ESD-12

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Aging overpack containing DPC	Initiator: CRCF-ESD12-DPC Response: RESPONSE-AO1	346
Aging overpack containing TAD canister	Initiator: CRCF-ESD12-TAD Response: RESPONSE-AO1	6,978

Source: Ref. 2.2.31, Table 4

A4.12.1 Initiating Events for CRC-ESD-12

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

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.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Impact to an Aging Overpack.	CRCF-ESD12-DPC	ESD12-DPC-IMPACT	060-12-ST-IMPACT
	CRCF-ESD12-TAD	ESD12-TAD-IMPACT	
Tipover of an Aging Overpack	CRCF-ESD12-DPC	ESD12-DPC-TIP	060-OPTIPOVER003-HFI-NOD
	CRCF-ESD12-TAD	ESD12-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.

Source: Original

A4.12.2 System Response Event Tree RESPONSE-AO1

The pivotal events that appear in RESPONSE-AO1 are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

CANISTER. Table A4.12-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD12-DPC	ESD12-DPC-IMPACT	ESD12-DPC-IMPACT-CAN	12-DPC_AO_IMPACT
	ESD12-DPC-TIP	ESD12-DPC-TIP-CAN	12-DPC_AO_TIPOVER
CRCF-ESD12-TAD	ESD12-TAD-IMPACT	ESD12-TAD-IMPACT-CAN	12-TAD_AO_IMPACT
	ESD12-TAD-TIP	ESD12-TAD-TIP-CAN	12-TAD_AO_TIP

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 A4.12-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.12-4. Basic Event Associated with the SHIELDING Pivotal Events of CRC-ESD-12

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD12-DPC	ESD12-DPC-IMPACT	ESD12-DPC-IMPACT-SHIELD	AO_SHIELDING
	ESD12-DPC-TIP	ESD12-DPC-TIP-SHIELD	
CRCF-ESD12-TAD	ESD12-TAD-IMPACT	ESD12-TAD-IMPACT-SHIELD	
	ESD12-TAD-TIP	ESD12-TAD-TIP-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 A4.12-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD12-DPC	ESD12-DPC-IMPACT	ESD12-CONF[b]	060-DP-LOSS-CRCF
	ESD12-DPC-TIP		
CRCF-ESD12-TAD	ESD12-TAD-IMPACT		
	ESD12-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] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.12-6.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD12-DPC	ESD12-DPC-IMPACT	ESD12-MOD	060-MODERATOR-SOURCE
	ESD12-DPC-TIP		
CRCF-ESD12-TAD	ESD12-TAD-IMPACT		
	ESD12-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.

Source: Original

A4.13 EVENT TREES FOR CRC-ESD-13

CRC-ESD-13 covers event sequences associated with the transfer of a waste package from the Waste Package Positioning Room to the WPTT docking station (Ref. 2.2.33, Figure F-13). This

ESD covers all waste forms that are loaded into waste packages. Corresponding to each waste form unit is an initiator event tree (Table A4.13-1). 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 A4.13-1. Summary of Event Trees for CRC-ESD-13

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing HLW and Standardized DOE SNF canisters	Initiator: CRCF-ESD13-WP-H&D Response: RESPONSE-WP2	3,300
Waste package containing HLW and MCOs	Initiator: CRCF-ESD13-WP-H&M Response: RESPONSE-WP2	225
Waste package containing TAD canister	Initiator: CRCF-ESD13-WP-TAD Response: RESPONSE-WP2	8,143

Source: Ref. 2.2.31 Table 4

A4.13.1 Initiating Events for CRC-ESD-13

The following initiating events are associated with CRC-ESD-13. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.13-2.

WPTT Derailment. This initiating event accounts for the potential derailment of the WPTT during movement.

WPTT Collision. This initiating event accounts for the potential impact to the transportation cask due to a WPTT collision.

WPTT Premature Tilt-down. This initiating event accounts for the potential tilt-down of the WPTT during movement.

Table A4.13-2. Initiating Event Assignments for CRC-ESD-13

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
WPTT derailment	CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	060-WPTT-DERAIL
	CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL	
	CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL	
WPTT collision	CRCF-ESD13-WP-H&D	ESD13-WP-H&D-SIMPACT	060-13-WPTT-IMPACT
	CRCF-ESD13-WP-H&M	ESD13-WP-H&M-SIMPACT	
	CRCF-ESD13-WP-TAD	ESD13-WP-TAD-SIMPACT	

Table A4.13-2. Initiating Event Assignments for CRC-ESD-13 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level[a]
Premature WPTT tilt-down	CRCF-ESD13-WP-H&D	ESD13-WP-H&D-TILT	060-WPTT-PRE-TIL
	CRCF-ESD13-WP-H&M	ESD13-WP-H&M-TILT	
	CRCF-ESD13-WP-TAD	ESD13-WP-TAD-TILT	

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

A4.13.2 System Response Event Tree RESPONSE-WP2

The pivotal events that appear in RESPONSE-WP2 are listed below and summarized in Section A3. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

WP. Table A4.13-3 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.13-3. Basic Event Associated with the Waste Package Pivotal Events of CRC-ESD-13

Initiator Event Tree	Initiating Event	Name Assigned to WP	Associated Fault Tree or Basic Event[a]
CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	ESD13-WP-H&D-DERAIL-WP	13-WP_FAILURE_DERAIL
	ESD13-WP-H&D-SIMPACT	ESD13-WP-H&D-SIMPACT-WP	13-WP_FAIL_COLLISION
	ESD13-WP-H&D-TILT	ESD13-WP-H&D-TILT-WP	13-WP_FAIL_TILT
CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL	ESD13-WP-H&M-DERAIL-WP	13-WP_FAILURE_DERAIL
	ESD13-WP-H&M-SIMPACT	ESD13-WP-H&M-SIMPACT-WP	13-WP_FAIL_COLLISION
	ESD13-WP-H&M-TILT	ESD13-WP-H&M-TILT-WP	13-WP_FAIL_TILT
CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL	ESD13-WP-TAD-DERAIL-WP	13-WP_FAILURE_DERAIL
	ESD13-WP-TAD-SIMPACT	ESD13-WP-TAD-SIMPACT-WP	13-WP_FAIL_COLLISION
	ESD13-WP-TAD-TILT	ESD13-WP-TAD-TILT-WP	13-WP_FAIL_TILT

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 A4.13-4 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.13-4. Basic Events Associated with the CANISTER Pivotal Events of CRC-ESD-13

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event[a]
CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	ESD13-WP-H&D-DERAIL-CAN	13-H&D-FAIL-IN-WP
	ESD13-WP-H&D-SIMPACT	ESD13-WP-H&D-SIMPACT-CAN	
	ESD13-WP-H&D-TILT	ESD13-WP-H&D-TILT-CAN	
CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL	ESD13-WP-H&M-DERAIL-CAN	13-H&M-FAIL-IN-WP
	ESD13-WP-H&M-SIMPACT	ESD13-WP-H&M-SIMPACT-CAN	
	ESD13-WP-H&M-TILT	ESD13-WP-H&M-TILT-CAN	
CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL	ESD13-WP-TAD-DERAIL-CAN	13-TAD-FAIL-IN-WP
	ESD13-WP-TAD-SIMPACT	ESD13-WP-TAD-SIMPACT-CA	
	ESD13-WP-TAD-TILT	ESD13-WP-TAD-TILT-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 A4.13-5 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.13-5. Basic Events Associated with the SHIELDING Pivotal Events of CRC-ESD-13

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event[a]
CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	ESD13-WP-H&D-DERAIL-SHIE	13-WPTT_SHIELDING
	ESD13-WP-H&D-SIMPACT	ESD13-WP-H&D-SIMPACT-SHI	
	ESD13-WP-H&D-TILT	ESD13-WP-H&D-TILT-SHIELD	13-WP_SHIELDING
CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL	ESD13-WP-H&M-DERAIL-SHIE	13-WPTT_SHIELDING
	ESD13-WP-H&M-SIMPACT	ESD13-WP-H&M-SIMPACT-SHI	
	ESD13-WP-H&M-TILT	ESD13-WP-H&M-TILT-SHIELD	13-WP_SHIELDING
CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL	ESD13-WP-TAD-DERAIL-SHI	13-WPTT_SHIELDING
	ESD13-WP-TAD-SIMPACT	ESD13-WP-TAD-SIMPACT-SH	
	ESD13-WP-TAD-TILT	ESD13-WP-TAD-TILT-SHIEL	13-WP_SHIELDING

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 A4.13-6 indicates the fault trees or basic events that are associated with this pivotal event for each initiating event.

Table A4.13-6. Basic Event Associated with the CONFINEMENT Pivotal Events of CRC-ESD-13

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event[a]
CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	ESD13-CONF[b]	060-DP-LOSS-CRCF
	ESD13-WP-H&D-SIMPACT		
	ESD13-WP-H&D-TILT		
CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL		
	ESD13-WP-H&M-SIMPACT		
	ESD13-WP-H&M-TILT		
CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL		
	ESD13-WP-TAD-SIMPACT		
	ESD13-WP-TAD-TILT		

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

[b] This passes through a transfer tree named CONFINEMENT.

Source: Original

MODERATOR. The conditional probability of failure (introduction of liquid moderator) is the same for all waste forms and initiating events as shown in Table A4.13-7.

Table A4.13-7. Basic Event Associated with the MODERATOR Pivotal Events of CRC-ESD-13

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event[a]
CRCF-ESD13-WP-H&D	ESD13-WP-H&D-DERAIL	ESD13-MOD	060-MODERATOR-SOURCE
	ESD13-WP-H&D-SIMPACT		
	ESD13-WP-H&D-TILT		
CRCF-ESD13-WP-H&M	ESD13-WP-H&M-DERAIL		
	ESD13-WP-H&M-SIMPACT		
	ESD13-WP-H&M-TILT		
CRCF-ESD13-WP-TAD	ESD13-WP-TAD-DERAIL		
	ESD13-WP-TAD-SIMPACT		
	ESD13-WP-TAD-TILT		

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

A4.14 EVENT TREES FOR CRC-ESD-14

CRC-ESD-14 covers event sequences associated with the transfer of an aging overpack from the Cask Unloading Room to the Cask Preparation Room (Ref. 2.2.33, Figure F-14). This ESD covers both waste forms that are received in aging overpacks at CRCF; DPCs and TAD canisters. Corresponding to each waste form unit is an initiator event tree (Table A4.14-1). 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