

The following initiating event applies only to HLW.

**Truck Trailer Rollover.** This initiating event accounts for the potential impact to the transportation cask on the truck trailer due to a rollover. The fault tree accounts for the fraction of casks received that are truck casks as opposed to rail casks. This fraction is set to 0 for naval casks because naval casks will only arrive by rail. In addition, rollover is not considered possible under the conditions inside the IHF. Therefore, the probability of truck rollover per truck cask received is modeled as a single-event fault tree with guaranteed success (Section 6.0.3).

For this ESD, the following initiating events apply only to naval SNF.

**Crane drops object 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. The initiating event is specified as a probability of object drop per cask.

**Crane drops cask from operational height or below.** 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.

**Crane drops cask 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 during transfer by the cask handling crane. The initiating event is specified as a probability of a drop per cask.

**Cask suspended from crane collides with facility structures or equipment.** 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.

**Cask tips over after having been removed from the railcar.** 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.

#### **A4.1.2 System Response Event Tree IHF-RESP-TC1**

The pivotal events that appear in IHF-RESP-TC1 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 A4.1-3 indicates the basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-01-HLW	ESD01-HLW-SPMRC DERAIL	ESD01-HLW-SPMRCDERAIL-TC	51A-HLW-TCASK-FAIL-DERAIL
	ESD01-HLW-TTROLL	ESD01-HLW-SPMTTROLL-TC	51A-HLW-TCASK-FAIL-ROLL
	ESD01-HLW-COLLIDE	ESD01-HLW-COLLIDE-TC	51A-HLW-TCASK-FAIL-COLL
IHF-ESD-01-NVL	ESD01-NVL-SPMRC DERAIL	ESD01-NVL-SPMRCDERAIL-TC	51A-NVL-TC-FAIL-DERAIL
	ESD01-NVL-COLLIDE	ESD01-NVL-COLLIDE-TC	51A-NVL-TC-FAIL-COLLIDE
	ESD01-NVL-DROPON	ESD01-NVL-DROPON-TC	51A-NVL-TC-FAIL-DROPON
	ESD01-NVL-DRP-CSK	ESD01-NVL-DRP-CSK-TC	51A-NVL-TC-FAIL-DROP
	ESD01-NVL-2BLK-CSK	ESD01-NVL-2BLK-CSK-TC	51A-NVL-TC-FAIL-2-BLOCK
	ESD01-NVL-COL-CSK	ESD01-NVL-COL-CSK-TC	51A-NVL-TC-FAIL-OFFPMTROLL
	ESD01-NVL-TIPOVER	ESD01-NVL-TIPOVER-TC	51A-NVL-TC-FAIL-TIP

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

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

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-01-HLW	ESD01-HLW-SPMRC DERAIL	HLW-CAN-INCASK	51A-CAN-FAIL-IN-TC
	ESD01-HLW-SPMTTROLL		
	ESD01-HLW-COLLIDE		
IHF-ESD-01-NVL	ESD01-NVL-SPMRC DERAIL	NVL-CAN-INCASK	51A-NVL-CAN-FAIL-IN-TC
	ESD01-NVL-COLLIDE		
	ESD01-NVL-DROPON		
	ESD01-NVL-DRP-CSK		
	ESD01-NVL-2BLK-CSK		
	ESD01-NVL-COL-CSK		
	ESD01-NVL-TIPOVER		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

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

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-01-HLW	ESD01-HLW-SPMRC DERAIL	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD01-HLW-SPMTTROLL		
	ESD01-HLW-COLLIDE		
IHF-ESD-01-NVL	ESD01-NVL-SPMRC DERAIL	NVL-TC-SHIELD8	NVL-SHIELDING-FAILS8
	ESD01-NVL-COLLIDE	NVL-TC-SHIELD8	NVL -SHIELDING-FAILS8
	ESD01-NVL-DROPON	NVL-TC-SHIELD5	NVL -SHIELDING-FAILS5
	ESD01-NVL-DRP-CSK	NVL-TC-SHIELD5	NVL -SHIELDING-FAILS5
	ESD01-NVL-2BLK-CSK	NVL-TC-SHIELD5	NVL -SHIELDING-FAILS5
	ESD01-NVL-COL-CSK	NVL-TC-SHIELD8	NVL -SHIELDING-FAILS8
	ESD01-NVL-TIPOVER	NVL-TC-SHIELD8	NVL -SHIELDING-FAILS8

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**CONFINEMENT.** Table A4.1-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-01-HLW	ESD01-HLW-SPMRC DERAIL	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD01-HLW-SPMTTROLL		
	ESD01-HLW-COLLIDE		
IHF-ESD-01-NVL	ESD01-NVL-SPMRC DERAIL	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD01-NVL-COLLIDE		
	ESD01-NVL-DROPON		
	ESD01-NVL-DRP-CSK		
	ESD01-NVL-2BLK-CSK		
	ESD01-NVL-COL-CSK		
	ESD01-NVL-TIPOVER		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.1-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-01-HLW	ESD01-HLW-SPMRC DERAIL	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD01-HLW-SPMTTROLL		
	ESD01-HLW-COLLIDE		
IHF-ESD-01-NVL	ESD01-NVL-SPMRC DERAIL	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD01-NVL-COLLIDE		
	ESD01-NVL-DROPON		
	ESD01-NVL-DRP-CSK		
	ESD01-NVL-2BLK-CSK		
	ESD01-NVL-COL-CSK		
	ESD01-NVL-TIPOVER		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

#### A4.2 EVENT TREES FOR IHF-ESD-02

IHF-ESD-02 delineates the event sequences that arise after a mechanical challenge to the transportation cask that occurs in the Cask Preparation Area during removal of impact limiters, upending and transfer of the HLW cask to the CTT, and removal of impact limiters from the naval transportation cask (Ref. 2.2.28, Figure F-2). This ESD covers two types of transportation casks: naval and HLW. Corresponding to each type of cask is an initiator event tree (Table A4.2-1). Although the initiator event trees transfer to the same system-response event tree, it is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

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

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing HLW canisters	Initiator: IHF-ESD-02-HLW Response: IHF-RESP-TC1	600
Transportation cask containing a naval canister	Initiator: IHF-ESD-02-NVL Response: IHF-RESP-TC1	400

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

### A4.2.1 Initiating Events for IHF-ESD-02

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

**Drop of HLW transportation cask from operational height or below.** This initiating event accounts for the potential impact to the transportation cask due to having been dropped from below or at normal operational height during transfer by the cask handling crane. The initiating event is specified as a probability of a drop per cask.

**Drop of HLW transportation cask from above operational height.** This initiating event accounts for the potential impact to the transportation cask due to having been dropped from above normal operational height during transfer by the cask handling crane. The initiating event is specified as a probability of a drop per cask.

**Unplanned conveyance movement causes HLW transportation cask impact due to collision with equipment or structure.** This initiating event covers the potential impact to the transportation cask on the conveyance due to a collision with another vehicle.

**Collision with equipment or structure involving side impact to HLW or naval transportation cask (during transfer by crane).** 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.

**Drop of heavy object (such as handling equipment) onto the naval or HLW transportation 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. The initiating event is specified as a probability of object drop per cask.

**HLW transportation 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.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Drop of HLW transportation cask from operational height or below	IHF-ESD-02-HLW	ESD02-HLW-DROP	(51A-#HLW-TC-LIFTS) <b>AND</b> (51A-CRN3-DROPHLW-CRN-DRP)
Drop of HLW transportation cask from above operational height	IHF-ESD-02-HLW	ESD02-HLW-2BLK	(51A-#HLW-TC-LIFTS) <b>AND</b> (51A-CRN3-2-BLOCK-CRN-TBK)
Unplanned conveyance movement	IHF-ESD-02-HLW	ESD02-HLW-SPURMOVE	ESD02-HLW-SPURMOVE

Table A4.2-2. Initiating Event Assignments for IHF-ESD-02 (Continued)

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Collision with equipment or structure during transfer by crane	IHF-ESD-02-HLW	ESD02-HLW-SIDEIMP	ESD02-HLW-SIDEIMP
	IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP	ESD02-NVL-SIDEIMP
Drop of heavy object (such as handling equipment) onto the naval or HLW transportation cask	IHF-ESD-02-HLW	ESD02-HLW-DROPON	ESD02-HLW-DROPON
	IHF-ESD-02-NVL	ESD02-NVL-DROPON	ESD02-NVL-DROPON
HLW transportation cask tipover	IHF-ESD-02-HLW	ESD02-HLW-TIP-CSK	51A-OPTIPOVER001-HFI-NOD

NOTE: <sup>a</sup> This column may contain fault trees and basic events logically connected as noted. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

#### A4.2.2 System Response Event Tree IHF-RESP-TC1

The pivotal events that appear in IHF-RESP-TC1 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 A4.2-3 indicates the basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-02-HLW	ESD02-HLW-DROP	ESD02-HLW-DROP-TC	51A-HLW-TC-FAIL-DROP
	ESD02-HLW-2BLK	ESD02-HLW-2BLK-TC	51A-HLW-TC-FAIL-2BLK
	ESD02-HLW-SPURMOVE	ESD02-HLW-SPUR-TC	51A-HLW-TC-FAIL-SPURMOVE
	ESD02-HLW-SIDEIMP	ESD02-HLW-SIDEIMP-TC	51A-HLW-TC-FAIL-SIMP
	ESD02-HLW-DROPON	ESD02-HLW-DROPON-TC	51A-HLW-TC-FAIL-DROPON
	ESD02-HLW-TIP-CSK	ESD02-HLW-TIP-CSK-TC	51A-HLW-TC-FAIL-TIPOVER
IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP	ESD02-NVL-SIDEIMP-TC	51A-NVL-TC-FAIL-SIMP
	ESD02-NVL-DROPON	ESD02-NVL-DROPON-TC	51A-NVL-TC-FAIL-DROPON

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

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

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-02-HLW	ESD02-HLW-DROP	HLW-CAN-INCASK	51A-CAN-FAIL-IN-TC
	ESD02-HLW-2BLK		
	ESD02-HLW-SPURMOVE		
	ESD02-HLW-SIDEIMP		
	ESD02-HLW-DROPON		
	ESD02-HLW-TIP-CSK		
IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP	NVL-CAN-INCASK	51A-CAN-FAIL-IN-TC
	ESD02-NVL-DROPON		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

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

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-02-HLW	ESD02-HLW-DROP	HLW-TC-SHIELD5	HLW-SHIELDING-FAILS5
	ESD02-HLW-2BLK	HLW-TC-SHIELD5	HLW-SHIELDING-FAILS5
	ESD02-HLW-SPURMOVE	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD02-HLW-SIDEIMP	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD02-HLW-DROPON	HLW-TC-SHIELD5	HLW-SHIELDING-FAILS5
	ESD02-HLW-TIP-CSK	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP	NVL-TC-SHIELD8	NAVAL-SHIELDING-FAILS8
	ESD02-NVL-DROPON	NVL-TC-SHIELD5	NAVAL-SHIELDING-FAILS5

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**CONFINEMENT.** Table A4.2-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-02-HLW	ESD02-HLW-DROP	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD02-HLW-2BLK		
	ESD02-HLW-SPURMOVE		
	ESD02-HLW-SIDEIMP		
	ESD02-HLW-DROPON		
	ESD02-HLW-TIP-CSK		
IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP		
	ESD02-NVL-DROPON		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.2-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-02-HLW	ESD02-HLW-DROP	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD02-HLW-2BLK		
	ESD02-HLW-SPURMOVE		
	ESD02-HLW-SIDEIMP		
	ESD02-HLW-DROPON		
	ESD02-HLW-TIP-CSK		
IHF-ESD-02-NVL	ESD02-NVL-SIDEIMP	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD02-NVL-DROPON		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

### A4.3 EVENT TREES FOR IHF-ESD-03

This ESD delineates the event sequences that arise after a mechanical challenge to the HLW transportation cask that occurs in the Cask Preparation Area during cask preparation activities involving the cask preparation crane (Ref. 2.2.28, Figure F-3). This ESD applies to the HLW transportation casks (Table A4.3-1). 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 A4.3-1. Summary of Event Trees for IHF-ESD-03

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing HLW canisters	Initiator: IHF-ESD-03-HLW Response: IHF-RESP-TC1	600

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

### A4.3.1 Initiating Events for IHF-ESD-03

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

**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.

**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. The initiating event is specified as a probability of object drop per cask.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Cask tipover	IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	ESD03-HLW-CASKTIP
Side impact		ESD03-HLW-SIMPACT	ESD03-HLW-SIMPACT
Object dropped on cask		ESD03-HLW-DROPON	ESD03-HLW-DROPON

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

### A4.3.2 System Response Event Tree IHF-RESP-TC1

The pivotal events that appear in IHF-RESP-TC1 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 IHF-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to TRANSCASK	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	ESD03-HLW-CASKTIP-TC	51A-HLW-TC-TIPOVER
	ESD03-HLW-SIMPACT	ESD03-HLW-SIMPACT-TC	51A-HLW-TC-FAIL-SIMP
	ESD03-HLW-DROPON	ESD03-HLW-DROPON-TC	51A-HLW-TC-FAIL-DROPON

NOTE: <sup>a</sup> 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 IHF-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	HLW-CAN-INCASK	51A-CAN-FAIL-IN-TC
	ESD03-HLW-SIMPACT		
	ESD03-HLW-DROPON		

NOTE: <sup>a</sup> 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 IHF-ESD-03

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD03-HLW-SIMPACT	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD03-HLW-DROPON	HLW-TC-SHIELD5	HLW-SHIELDING-FAILS5

NOTE: <sup>a</sup> 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 or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD03-HLW-SIMPACT		
	ESD03-HLW-DROPON		

NOTE: <sup>a</sup>This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.3-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-03-HLW	ESD03-HLW-CASKTIP	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD03-HLW-SIMPACT		
	ESD03-HLW-DROPON		

NOTE: <sup>a</sup>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 IHF-ESD-04

IHF-ESD-04 covers event sequences that arise after a mechanical challenge to the naval canister inside the transportation cask associated with removal of the cask lid (Ref. 2.2.28, Figure F-4). This includes event sequences that arise during removal of the lid and other actions to prepare the canister for removal from the cask (Figure F-4 and Section 6.1.2.7, Node 7). This ESD applies to the naval transportation cask containing a single naval SNF canister. 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 (Table A4.4-1). 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 IHF-ESD-04

Waste Form Units	Associated Event Trees	Number of Waste Form Units
Unsealed transportation cask containing a naval canister	Initiator: IHF-ESD-04-NVL Response: IHF-RESP-CAN1	400

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.4.1 Initiating Events for IHF-ESD-04

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

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

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

**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 (Table A4.4-2). 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.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Side impact	IHF-ESD-04-NVL	ESD04-NVL-SIMPACT	ESD04-NVL-SIMPACT
Drop of heavy load onto cask		ESD04-NVL-DROPON	ESD04-NVL-DROPON
Cask tipover		ESD04-NVL-CASKTIP	ESD04-NVL-CASKTIP

NOTE: <sup>a</sup>This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

#### A4.4.2 System Response Event Tree IHF-RESP-CAN1

The pivotal events that appear in IHF-RESP-CAN1 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 A4.4-3 indicates the basic events that are associated with this pivotal event for each initiating event.

Table A4.4-3. Basic Events Associated with the CANISTER Pivotal Events of IHF-ESD-04

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-04-NVL	ESD04-NVL-SIMPACT	ESD04-NVL-SIMPACT-TC	51A-NVL-TC-FAIL-SIMP
	ESD04-NVL-DROPON	ESD04-NVL-DROPON-CAN	51A-NVL-CAN-FAIL-DROPON
	ESD04-NVL-CASKTIP	ESD04-NVL-CASKTIP-TC	51A-NVL-TC-FAIL-TIP

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

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

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-04-NVL	ESD04-NVL-SIMPACT	NVL-TC-SHIELD8	NAVAL-SHIELDING-FAILS8
	ESD04-NVL-DROPON	NVL-TC-SHIELD5	NAVAL-SHIELDING-FAILS5
	ESD04-NVL-CASKTIP	NVL-TC-SHIELD8	NAVAL-SHIELDING-FAILS8

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**CONFINEMENT.** Table A4.4-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-04-NVL	ESD04-NVL-SIMPACT	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD04-NVL-DROPON		
	ESD04-NVL-CASKTIP		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.4-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-04-NVL	ESD04-NVL-SIMPACT	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD04-NVL-DROPON		
	ESD04-NVL-CASKTIP		

NOTE: <sup>a</sup> 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 IHF-ESD-05

IHF-ESD-05 covers event sequences that arise after a mechanical challenge to a loaded CTT that occurs during movement of the CTT from the Cask Preparation Area to the Cask Unloading Room (Ref. 2.2.28, Figure F-5). This ESD applies to the following waste forms:

- Naval SNF canister in a transportation cask
- HLW canister in a transportation cask.

Table A4.5-1 summarizes the event trees for IHF-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 IHF-ESD-05

Waste Form Units	Associated Event Trees	Number of Waste Form Units
Transportation cask containing HLW canisters	Initiator: IHF-ESD-05-HLW Response: IHF-RESP-CAN2-HLW	600
Transportation cask containing a naval canister	Initiator: IHF-ESD-05-NVL Response: IHF-RESP-CAN2-NVL	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

##### A4.5.1 Initiating Events for IHF-ESD-05

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

**CTT or cask catches crane hook or rigging resulting in impact to cask.** This initiating event addresses an impact to the cask caused by the crane operator during the movement of HLW. This is an HFE event described in Attachment E. The initiating event is specified as a probability of a side impact per cask handled.

**CTT impact collision with another vehicle, facility structures, or equipment (except shield door).** This initiating event addresses a collision either as a result of moving the CTT from the Cask Preparation Room to the Cask Unloading Room or with another vehicle operating in the IHF. The initiating event is specified as a probability of a collision with vehicle, facility structures or equipment per cask handled.

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

Initiating Event Description	Initiating Event Name	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
CTT or cask catches crane hook or rigging, resulting in impact to cask	IHF-ESD-05-HLW	ESD05-HLW-CTT-IMPACT	51A-OPIMPACT0000-HFI-NOD
CTT impact collision with another vehicle, facility structures, or equipment (except shield door)		ESD05-HLW-CTT-COLLIDE	51A-OPCTCOLLIDE2-HFI-NOD <b>OR</b> 51A CTT-FAIL-STOP

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events; CTT = cask transfer trolley.

Source: Original

#### A4.5.2 System Response Event Tree IHF-RESP-CAN2-HLW and IHF-RESP-CAN2-NVL

The pivotal events that appear in IHE-RESP-CAN2-HLW and IHF-RESP-NVL 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 IHF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-05-HLW	ESD05-HLW-CTT-IMPACT	ESD05-HLW-IMPACT-TC	51A-HLW-CANTC-FAIL-IMP
	ESD05-HLW-CTT-COLLIDE	ESD05-HLW-COLLIDE-TC	51A-HLW-CANTC-FAIL-COLL
IHF-ESD-05-NVL	ESD05-NVL-CTT-IMPACT	ESD05-NVL-IMPACT-TC	51A-NVL-CANTC-FAIL-IMP
	ESD05-NVL-CTT-COLLIDE	ESD05-NVL-COLLIDE-TC	51A-NVL-CANTC-FAIL-COLL

NOTE: <sup>a</sup> 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 IHF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-05-HLW	ESD05-HLW-CTT-IMPACT	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
	ESD05-HLW-CTT-COLLIDE		
IHF-ESD-05-NVL	ESD05-NVL-CTT-IMPACT	NVL-TC-SHIELD8	NAVAL-SHIELDING-FAILS8
	ESD05-NVL-CTT-COLLIDE		

NOTE: <sup>a</sup> 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 IHF-ESD-05

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-05-HLW	ESD05-HLW-CTT-IMPACT	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD05-HLW-CTT-COLLIDE		
IHF-ESD-05-NVL	ESD05-NVL-CTT-IMPACT		
	ESD05-NVL-CTT-COLLIDE		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.5-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-05-HLW	ESD05-HLW-CTT-IMPACT	MOD-NOFIRE	MOD-NOFIRE-HLW-NOIMP
	ESD05-HLW-CTT-COLLIDE		
IHF-ESD-05-NVL	ESD05-NVL-CTT-IMPACT	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-OTHER-WATER) <b>OR</b> (51A-FIRE-SUPPRESSION)
	ESD05-NVL-CTT-COLLIDE		

NOTE: <sup>a</sup> 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 IHF-ESD-06

IHF-ESD-06 covers event sequence for a mechanical challenge from a CTT moving either a HLW or NVL transportation cask and colliding with the Cask Unloading Room shield door (Ref. 2.2.28, Figure F-6). For the CTT, the shield door involved is the door from the Cask Preparation Area to the Cask Unloading Room. Corresponding to each type of cask is an initiator event tree (Table A4.6-1).

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. 2.2.9) 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.

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 IHF-ESD-06

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing multiple HLW canisters	Initiator: IHF-ESD-06-HLW Response: IHF-ESD-06-HLW	100
Transportation cask containing a single HLW canister	Initiator: IHF-ESD-06-HLW Response: IHF-ESD-06-HLW	500
Transportation cask containing a Naval canister	Initiator: IHF-ESD-06-NVL Response: IHF-ESD-06-NVL	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

##### A4.6.1 Initiating Events for IHF-ESD-06

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

**Mechanical Challenge to a Transportation Cask.** This initiating event represents a potential impact to the transportation cask from a CTT collision with the Cask Unloading Room shield door. The probability of impact per transfer is described in Attachment B. The initiating event is specified as a probability of a drop per cask.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Mechanical challenge from CTT collision with shield door	IHF-ESD-06-HLW	ESD06-HLW-IMPACT	51A-CTT-COLLIDE-SDR
	IHF-ESD-06-NVL	ESD06-NVL-IMPACT	

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events; CTT = cask transfer trolley.

Source: Original

### A4.6.2 System Response Event Tree IHF-ESD-06

The pivotal events that appear in IHF-ESD-06 are listed and summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

**CELL-DOOR.** The conditional probability that the CTT collides with shield door for all waste forms and initiating events as shown in Table A4.6-3.

Table A4.6-3. Fault Trees Associated with the CELL-DOOR Pivotal Events of IHF-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to CELL-DOOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-06-HLW	ESD06-HLW-IMPACT	ESD06-HLW-IMPACT-DOORFAI	51A-DOORFAIL-IMPACT
IHF-ESD-06-NVL	ESD06-NVL-IMPACT	ESD06-NVL-IMPACT-DOORFAI	51A-NVL-DOOR-FAILS

NOTE: <sup>a</sup> 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 A4.6-4 indicates the basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONTAINMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-06-HLW	ESD6-HLW-IMPACT	ESD6-HWL-IMPACT-CONT	51A-HLW-CONT-FAIL-IMP
IHF-ESD-06-NVL	ESD6-NVL-IMPACT	ESD6-NVL-IMPACT-CONT	51A-NVL-CONT-FAIL-IMP

NOTE: <sup>a</sup> 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 A4.6-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-06-HLW	ESD06-HLW-IMPACT	HLW-TC-SHIELD8	HLW-SHIELDING-FAILS8
IHF-ESD-06-NVL	ESD06-NVL-IMPACT	NVL-TC-SHIELD8	NVL-SHIELDING-FAILS8

NOTE: <sup>a</sup> 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 A4.6-6 indicates the basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-06-HLW	ESD06-HLW-IMPACT	HVAC-CONF	HVAC-CONFINEMENT-FAILS
IHF-ESD-06-NVL	ESD06-NVL-IMPACT		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.6-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.6-7. Fault Trees Associated with the MODERATOR Pivotal Events of IHF-ESD-06

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-06-HLW	ESD06-HLW-IMPACT	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
IHF-ESD-06-NVL	ESD06-NVL-IMPACT	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-OTHER-WATER) <b>OR</b> (51A-FIRE-SUPPRESSION)

NOTE: <sup>a</sup> 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 IHF-ESD-07

IHF-ESD-07 covers event sequences associated with the transfer of a canister from a TC to WP with the CTM (Ref. 2.2.28, Figure F-7). This ESD covers all canister types. Corresponding to each canister type is an initiator event tree (Table A4.7-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

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

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Transportation cask containing multiple HLW canisters	Initiator: IHF-ESD-07-HLW Response: IHF-RESP-CAN1	100
Transportation cask containing a single HLW canister	Initiator: IHF-ESD-07-HLW Response: IHF-RESP-CAN1	500
Transportation cask containing a naval canister	Initiator: IHF-ESD-07-NVL Response: IHF-RESP-CAN1	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.7.1 Initiating Events for IHF-ESD-07

The following initiating events are associated with IHF-ESD-07. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.7-2. The initiating events are specified as frequency of occurrence per canister.

**Impact Associated with Lid Removal.** This initiating event covers the potential impact during HLW cask 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 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.

**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 during transfer by the CTM.

**Canister Collision or Impact.** This initiating event accounts for a potential canister collision or impact.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Transfer of a Canister from a TC to a WP with CTM	IHF-ESD-07-HLW	ESD07-HLW-DROPON	51A-CTMOBJLIFTNUMBER-HLW <b>AND</b> 51A-CTM-HLW-DROPON
		ESD07-HLW-IMPACT	51A-7-CTT-SPURMOVE <b>OR</b> 51A-7-WPTT-SPURMOVE <b>OR</b> CTM-SHEAR
		ESD07-HLW-DROP	51A-LIFTS-PER-HLW-CAN <b>AND</b> 51A-CTM-DROP
		ESD07-HLW-2BLK	51A-LIFTS-PER-HLW-CAN <b>AND</b> CTM-2-BLOCK
		ESD07-HLW-SIDEIMP	51A-LIFTS-PER-HLW-CAN <b>AND</b> 51A-SLIDEGATECLOSES-CAN
		ESD07-HLW-COLLISION	CTM-COLLISION
		ESD07-HLW-DROPIN	ESD07-HLW-DROPIN
		ESD07-HLWW-LIDIMP	ESD07-HLW-LIDIMP
	IHF-ESD-07-NVL	ESD07-NVL-DROPON	ESD07-NVL-DROPON
		ESD07-NVL-IMPACT	51A-7-CTT-SPURMOVE <b>OR</b> 51A-7-WPTT-SPURMOVE <b>OR</b> CTM-SHEAR
		ESD07-NVL-DROP	51A-LIFTS-PER-NVL-CAN <b>AND</b> 51A-CTM-DROP
		ESD07-NVL-2BLK	51A-LIFTS-PER-NVL-CAN <b>AND</b> CTM-2-BLOCK
		ESD07-NVL-SIDEIMP	51A-LIFTS-PER-NVLCAN <b>AND</b> 51A-SLIDEGATECLOSES-CAN
		ESD07-NVL-COLLISION	CTM-COLLISION
		ESD07-NVL-DROPIN	ESD07-NVL-DROPIN

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events; CTM = canister transfer machine; TC = transportation cask; WP = waste package.

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.

**CANISTER.** Table A4.7-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiator Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-07-HLW	ESD07-HLW-DROPON	ESD07-HLW-DROPON-CAN	51A-HLW-CAN-FAIL-DROPON
	ESD07-HLW-IMPACT	ESD07-HLW-IMPACT-CAN	51A-HLW-CAN-FAIL-IMPACT
	ESD07-HLW-DROP	ESD07-HLW-DROP-CAN	51A-HLW-CAN-FAIL-DROP
	ESD07-HLW-2BLK	ESD07-HLW-2BK-CAN	51A-HLW-CAN-FAIL-2BLK
	ESD07-HLW-SIDEIMP	ESD07-HLW-SIDEIMP-CAN	51A-HLW-CAN-FAIL-SIMP
	ESD07-HLW-COLLISION	ESD07-HLW-COLLISION-CAN	51A-HLW-CAN-FAIL-COLL
	ESD07-HLW-DROPIN	ESD07-HLW-DROPIN-CAN	51A-HLW-CAN-FAIL-DROPIN
	ESD07-HLWW-LIDIMP	ESD07-HLW-LIDIMP-CAN	51A-HLW-CAN-FAIL-LID
IHF-ESD-07-NVL	ESD07-NVL-DROPON	ESD07-NVL-DROPON-CAN	51A-NVL-CAN-FAIL-DROPON
	ESD07-NVL-IMPACT	ESD07-NVL-IMPACT-CAN	51A-NVL-CAN-FAIL-IMPACT
	ESD07-NVL-DROP	ESD07-NVL-DROP-CAN	51A-NVL-CAN-FAIL-DROP
	ESD07-NVL-2BLK	ESD07-NVL-2BLK-CAN	51A-NVL-CAN-FAIL-2BLK
	ESD07-NVL-SIDEIMP	ESD07-NVL-SIDEIMP-CAN	51A-NVL-CAN-FAIL-SIMP
	ESD07-NVL-COLLISION	ESD07-NVL-COLLISION-CAN	51A-NVL-CAN-FAIL-COLL
	ESD07-NVL-DROPIN	ESD07-NVL-DROPIN-CAN	51A-NVL-CAN-FAIL-DROPIN

NOTE: <sup>a</sup> 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 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiator Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-07-HLW	ESD07-HLW-DROPON	CTM-SHIELDING	51A-CTM-SHIELD-DEGRADE
	ESD07-HLW-IMPACT		
	ESD07-HLW-DROP		
	ESD07-HLW-2BLK		
	ESD07-HLW-SIDEIMP		
	ESD07-HLW-COLLISION		
	ESD07-HLW-DROPIN		
IHF-ESD-07-NVL	ESD07-NVL-DROPON	CTM-SHIELDING	51A-CTM-SHIELD-DEGRADE
	ESD07-NVL-IMPACT		
	ESD07-NVL-DROP		
	ESD07-NVL-2BLK		
	ESD07-NVL-SIDEIMP		
	ESD07-NVL-COLLISION		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**CONFINEMENT.** Table A4.7-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiator Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-07-HLW	ESD07-HLW-DROPON	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD07-HLW-IMPACT		
	ESD07-HLW-DROP		
	ESD07-HLW-2BLK		
	ESD07-HLW-SIDEIMP		
	ESD07-HLW-COLLISION		
	ESD07-HLW-DROPIN		
IHF-ESD-07-NVL	ESD07-NVL-DROPON		
	ESD07-NVL-IMPACT		
	ESD07-NVL-DROP		
	ESD07-NVL-2BLK		
	ESD07-NVL-SIDEIMP		
	ESD07-NVL-COLLISION		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.7-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiator Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-07-HLW	ESD07-HLW-DROPON	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD07-HLW-IMPACT		
	ESD07-HLW-DROP		
	ESD07-HLW-2BLK		
	ESD07-HLW-SIDEIMP		
	ESD07-HLW-COLLISION		
	ESD07-HLW-DROPIN		

Table A4.7-6. Basic Events Associated with the MODERATOR Pivotal Events of IHF-ESD-07  
(Continued)

Initiator Event Tree	Initiator Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD07-NVL	ESD07-NVL-DROPON	MOD-NOFIRE	(51A-OIL-MODERATOR) OR (51A-OTHER-WATER) OR (51A-FIRE-SUPPRESSION)
	ESD07-NVL-IMPACT		
	ESD07-NVL-DROP		
	ESD07-NVL-2BLK		
	ESD07-NVL-SIDEIMP		
	ESD07-NVL-COLLISION		

NOTE: <sup>a</sup>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 IHF-ESD-08

IHF-ESD-08 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. 2.2.28, Figure F-8). This ESD covers all canister types that are loaded into waste packages in the IHF. Corresponding to each waste form unit is an initiator event tree (Table A4.8-1). Although the initiator event trees transfer to the same response tree, the response tree is customized within SAPHIRE for each initiator event tree by the use of basic rules. The rules instruct SAPHIRE where to look for the fault tree that models each pivotal event. The assignments made in the rules files are indicated in this section.

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

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing 5 HLW canisters	Initiator: IHF-ESD-08-HLW Response: IHF-RESP-WP1	200
Waste package containing 1 naval waste canister	Initiator: IHF-ESD-08-NVL Response: IHF-RESP-WP1	400

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.8.1 Initiating Events for IHF-ESD-08

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

**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 A4.8-2. Initiating Event Assignments for IHF-ESD-08

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
WPTT derailment	IHF-ESD-08-HLW	ESD08-HLW-DERAIL	51A-WPTT-DERAIL-DER-FOM <b>AND</b> 51A-WPTT-MILES-IN-IHF
	IHF-ESD-08-NVL	ESD08-NVL-DERAIL	
WPTT collision	IHF-ESD-08-HLW	ESD08-HLW-COLLIDE	51A-OPWPCOLLIDE1-HFI-NOD <b>OR</b> WPTT-FAIL-TO-STOP
	IHF-ESD-08-NVL	ESD08-NVL-COLLIDE	
Premature tilt-down	IHF-ESD-08-HLW	ESD08-HLW-TILT	ESD08-HLW-TILT
	IHF-ESD-08-NVL	ESD08-NVL-TILT	ESD08-NVL-TILT

NOTE: <sup>a</sup> 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 IHF-RESP-WP1

The pivotal events that appear in IHF-RESP-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 A4.8-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-08-HLW	ESD08-HLW-DERAIL	ESD08-HLW-DERAIL-CAN	51A-HLW-CAN-FAIL-DERAIL
	ESD08-HLW-COLLIDE	ESD08-HLW-COLLIDE-CAN	51A-HLW-CAN-FAIL-COLL
	ESD08-HLW-TILT	ESD08-HLW-TILT-CAN	51A-HLW-CAN-FAIL-TILT
IHF-ESD-08-NVL	ESD08-NVL-DERAIL	ESD08-NVL-DERAIL-CAN	51A-NVL-CAN-FAIL-DERAIL
	ESD08-NVL-COLLIDE	ESD08-NVL-COLLIDE-CAN	51A-NVL-CAN-FAIL-COLL
	ESD08-NVL-TILT	ESD08-NVL-TILT-CAN	51A-NVL-CAN-FAIL-TILT

NOTE: <sup>a</sup> 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 A4.8-4 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-08-HLW	ESD08-HLW-DETRAIL	ESD08-HLW-DETRAIL-SHIELD	51A-HLW-WPSHLD-FAIL-DETRL
	ESD08-HLW-COLLIDE	ESD08-HLW-COLLIDE-SHIELD	51A-HLW-SHIELD-FAIL-COLL
	ESD08-HLW-TILT	ESD08-HLW-TILT-SHIELD	51A-HLW-SHIELD-FAIL-TILT
IHF-ESD-08-NVL	ESD08-NVL-DETRAIL	ESD08-NVL-DETRAIL-SHIELD	51A-NVL-SHIELD-FAIL-DETRL
	ESD08-NVL-COLLIDE	ESD08-NVL-COLLIDE-SHIELD	51A-NVL-SHIELD-FAIL-COLL
	ESD08-NVL-TILT	ESD08-NVL-TILT-SHIELD	51A-NVL-SHIELD-FAIL-TILT

NOTE: <sup>a</sup> 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 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event
IHF-ESD-08-HLW	ESD08-HLW-DETRAIL	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD08-HLW-COLLIDE		
	ESD08-HLW-TILT		
IHF-ESD-08-NVL	ESD08-NVL-DETRAIL		
	ESD08-NVL-COLLIDE		
	ESD08-NVL-TILT		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.8-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-08-HLW	ESD08-HLW-DERAIL	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD08-HLW-COLLIDE		
	ESD08-HLW-TILT		
IHF-ESD-08-NVL	ESD08-NVL-DERAIL	MOD-NOFIRE	(51A-OIL-MODERATOR) OR (51A-FIRE-SUPPRESSION) OR (51A-OTHER-WATER)
	ESD08-NVL-COLLIDE		
	ESD08-NVL-TILT		

NOTE: <sup>a</sup>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 IHF-ESD-09

IHF-ESD-09 covers event sequences associated with the assembly and closure of the waste package (Ref. 2.2.28, Figure F-9). This ESD covers waste packages. Corresponding to each waste form unit 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 IHF-ESD-09

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing 5 HLW canisters	Initiator: IHF-ESD-09-HLW Response: IHF-RESP-WP2	200
Waste package containing 1 naval waste canister	Initiator: IHF-ESD-09-NVL Response: IHF-RESP-WP2	400

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.9.1 Initiating Events for IHF-ESD-09

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

**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 A4.9-2. Initiating Event Assignments for IHF-ESD-09

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Welding damages canister	IHF-ESD-09-HLW	ESD09-HLW-WELD	51A-WELD-DAMAGE
	IHF-ESD-09-NVL	ESD09-NVL-WELD	
RHS drops object	IHF-ESD-09-HLW	ESD09-HLW-DROPON	ESD09-HLW-DROPON
	IHF-ESD-09-NVL	ESD09-NVL-DROPON	ESD09-NVL-DROPON

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

### A4.9.2 System Response Event Tree RESPONSE-WP2

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

**CANISTER.** Table A4.9-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-09-HLW	ESD09-HLW-WELD	ESD09-HLW-WELD-CAN	51A-HLW-WPCAN-FAIL-WELD
	ESD09-HLW-DROPON	ESD09-HLW-DROPON-CAN	51A-HLW-CAN-FAIL-DRPONWP
IHF-ESD-09-NVL	ESD09-NVL-WELD	ESD09-NVL-WELD-CAN	51A-NVL-CAN-FAIL-WELD
	ESD09-NVL-DROPON	ESD09-NVL-DROPON-CAN	51A-NVL-CAN-FAIL-DRPONWP

NOTE: <sup>a</sup> 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 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-09-HLW	ESD09-HLW-WELD	ESD09-HLW-WELD-WP	51A-HLW-WP-FAIL-WELD
	ESD09-HLW-DROPON	ESD09-HLW-DROPON-WP	51A-HLW-WP-FAILS-DROPON
IHF-ESD-09-NVL	ESD09-NVL-WELD	ESD09-NVL-WELD-WP	51A-NVL-WP-FAILS-WELD
	ESD09-NVL-DROPON	ESD09-NVL-DROPON-WP	51A-NVL-WP-FAIL-DROPON

NOTE: <sup>a</sup> 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 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-09-HLW	ESD09-HLW-WELD	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD09-HLW-DROPON		
IHF-ESD-09-NVL	ESD09-NVL-WELD		
	ESD09-NVL-DROPON		

NOTE: <sup>a</sup>This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.9-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

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

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-09-HLW	ESD09-HLW-WELD	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD09-HLW-DROPON		
IHF-ESD-09-NVL	ESD09-NVL-WELD	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD09-NVL-DROPON		

NOTE: <sup>a</sup>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 IHF-ESD-10

IHF-ESD-10 covers event sequences associated with the transfer of a waste package from the Waste Package Positioning Room to the WPTT docking station (Ref. 2.2.28, Figure F-10). This ESD covers all waste forms that are loaded into waste packages in the IHF. 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 IHF-ESD-10

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing 5 HLW canisters	Initiator: IHF-ESD-10-HLW Response: IHF-RESP-WP3	200
Waste package containing 1 naval waste canister	Initiator: IHF-ESD-10-NVL Response: IHF-RESP-WP3	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.10.1 Initiating Events for IHF-ESD-10

The following initiating events are associated with IHF-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 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 A4.10-2. Initiating Event Assignments for IHF-ESD-10

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
WPTT derailment	IHF-ESD-10-HLW	ESD10-HLW-DERAIL	51A-WPTT-DERAIL-DER-FOM <b>AND</b> 51A-WPTT-MILES-IN-IHF
	IHF-ESD-10-NVL	ESD10-NVL-DERAIL	
WPTT collision	IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	51A-OPWPCOLLIDE1-HFI-NOD <b>OR</b> WPTT-T2-FAIL-TO-STOP
	IHF-ESD-10-NVL	ESD10-NVL-COLLIDE	
Premature tilt-down	IHF-ESD-10-HLW	ESD10-HLW-TILT	ESD10-HLW-TILT
	IHF-ESD-10-NVL	ESD10-NVL-TILT	ESD10-NVL-TILT

NOTE: <sup>a</sup>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 IHF-RESP-WP3

The pivotal events that appear in IHF-RESP-WP3 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 A4.10-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.10-3. Basic Event Associated with the Waste Package Pivotal Events of IHF-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to WP	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	ESD10-HLW-COLLIDE-WP	51A-HLW-WP-FAIL-COLLIDE
	ESD10-HLW-DERAIL	ESD10-HLW-DERAIL-WP	51A-HLW-WP-FAIL-DERAIL
	ESD10-HLW-TILT	ESD10-HLW-TILT-WP	51A-HLW-WP-FAIL-TILT
IHF-ESD-10-NVL	ESD10-NVL-COLLIDE	ESD10-NVL-COLLIDE-WP	51A-NVL-WP-FAIL-COLLIDE
	ESD10-NVL-DERAIL	ESD10-NVL-DERAIL-WP	51A-NVL-WP-FAIL-DERAIL
	ESD10-NVL-TILT	ESD10-NVL-TILT-WP	51A-NVL-WP-FAIL-TILT

NOTE: <sup>a</sup> 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 A4.10-4 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.10-4. Basic Events Associated with the CANISTER Pivotal Events of IHF-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	ESD10-HLW-COLLIDE-CAN	51A-HLW-CANWP-FAIL-COLL
	ESD10-HLW-DERAIL	ESD10-HLW-DERAIL-CAN	51A-HLW-CANWP-FAIL-DERAIL
	ESD10-HLW-TILT	ESD10-HLW-TILT-CAN	51A-HLW-CANWP-FAIL-TILT
IHF-ESD-10-NVL	ESD10-NVL-COLLIDE	ESD10-NVL-COLLIDE-CAN	51A-NVL-CANWP-FAIL-COLL
	ESD10-NVL-DERAIL	ESD10-NVL-DERAIL-CAN	51A-NVL-CANWP-FAIL-DERAIL
	ESD10-NVL-TILT	ESD10-NVL-TILT-CAN	51A-NVL-CANWP-FAIL-TILT

NOTE: <sup>a</sup> 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 A4.10-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.10-5. Basic Events Associated with the SHIELDING Pivotal Events of IHF-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	ESD10-HLW-COLLIDE-SHIELD	51A-HLW-SHLDWP-FAIL-COLL
	ESD10-HLW-DERAIL	ESD10-HLW-DERAIL-SHIELD	51A-HLW-WPSHLD-FAIL-DERL
	ESD10-HLW-TILT	ESD10-HLW-TILT-SHIELD	51A-HLW-SHLDWP-FAIL-TILT
IHF-ESD-10-NVL	ESD10-NVL-COLLIDE	ESD10-NVL-COLLIDE-SHIELD	51A-NVL-WPSHLD-FAIL-COLL
	ESD10-NVL-DERAIL	ESD10-NVL-DERAIL-SHIELD	51A-NVL-WPSHLD-FAIL-DERL
	ESD10-NVL-TILT	ESD10-NVL-TILT-SHIELD	51A-NVL-SHLDWP-FAIL-TILT

NOTE: <sup>a</sup> 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 A4.10-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.10-6. Basic Event Associated with the CONFINEMENT Pivotal Events of IHF-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD10-HLW-DERAIL		
	ESD10-HLW-TILT		
IHF-ESD-10-NVL	ESD10-NVL-COLLIDE		
	ESD10-NVL-DERAIL		
	ESD10-NVL-TILT		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.10-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.10-7. Basic Event Associated with the MODERATOR Pivotal Events of IHF-ESD-10

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-10-HLW	ESD10-HLW-COLLIDE	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD10-HLW-DERAIL		
	ESD10-HLW-TILT		
IHF-ESD-10-NVL	ESD10-NVL-COLLIDE	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD10-NVL-DERAIL		
	ESD10-NVL-TILT		

NOTE: <sup>a</sup> 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 IHF-ESD-11

This ESD delineates the event sequences that arise after a mechanical challenge to the waste package that occurs during the export of a waste package from the IHF (Ref. 2.2.28, Figure F-11). This includes event sequences associated with the waste package handling crane, the waste package transfer carriage, and the TEV. This ESD applies to the following waste forms:

- Naval SNF in a waste package
- HLW in a waste package.

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 IHF-ESD-11

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
Waste package containing HLW canisters	Initiator: IHF-ESD-11-HLW Response: IHF-RESP-WP3	200
Waste package containing a naval canister	Initiator: IHF-ESD-11-NVL Response: IHF-RESP-WP3	400

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.11.1 Initiating Events for IHF-ESD-11

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

**TEV collision.** This initiating event refers to a TEV in motion in the Waste Package Loadout Room.

**Impact due to object dropped on waste package.** The waste package handling crane could drop the waste package shield ring on a loaded waste package in the WPTT.

**Crane interference with TEV or WPTT.** Improper operation of a crane could cause an impact to a waste package.

**Impact due to malfunction of the WPTT or the waste package transfer carriage.** This initiating event refers to an impact that could be caused by an improper tilting or lateral motion of the WPTT or improper operation of the transfer carriage.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
TEV collision	IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	51A-TEV-COLLISION
	IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL	
Impact due to object dropped on waste package	IHF-ESD-11-HLW	ESD11-HLW-DROPON	ESD11-HLW-DROPON
	IHF-ESD-11-NVL	ESD11-NVL-DROPON	ESD11-NVL-DROPON
Crane interference with TEV or WPTT	IHF-ESD-11-HLW	ESD11-HLW-CRANE	51A-OPCRANEINTFR-HFI-NOD
	IHF-ESD-11-NVL	ESD11-NVL-CRANE	
Impact due to malfunction of the WPTT or the waste package transfer carriage	IHF-ESD-11-HLW	ESD11-HLW-COLLISION	51A-OPTEVDRCLOSD-HFI-NOD <b>OR</b> 51A-WP-SHEAR <b>OR</b> 51A-WPTT-PRE-DEPARTURE
	IHF-ESD-11-NVL	ESD11-NVL-COLLISION	

NOTE: <sup>a</sup>This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

#### A4.11.2 System Response Event Tree IHF-RESP-WP3

The pivotal events that appear in IHF-RESP-WP3 are summarized below. The accompanying tables show the association of pivotal event names with basic event or fault tree names.

**WP-CONTAIN.** Table A4.11-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.11-3. Basic Event Associated with the Waste Package Pivotal Events of IHF-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to WP-CONTAIN	Associated Fault Tree or Basic Event
IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	ESD11-HLW-WP	51A-FAIL-EXPORT
	ESD11-HLW-DROPON		
	ESD11-HLW-CRANE		
	ESD11-HLW-COLLISION		
IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL	ESD11-NVL-WP	
	ESD11-NVL-DROPON		
	ESD11-NVL-CRANE		
	ESD11-NVL-COLLISION		

NOTE: <sup>a</sup> 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 A4.11-4 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.11-4. Basic Events Associated with the CANISTER Pivotal Events of IHF-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to CANISTER	Associated Fault Tree or Basic Event
IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	ESD11-HLW-CAN	51A-CAN-FAIL-EXPORT
	ESD11-HLW-DROPON		
	ESD11-HLW-CRANE		
	ESD11-HLW-COLLISION		
IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL	ESD11-NVL-CAN	
	ESD11-NVL-DROPON		
	ESD11-NVL-CRANE		
	ESD11-NVL-COLLISION		

NOTE: <sup>a</sup> 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 A4.11-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.11-5. Basic Events Associated with the SHIELDING Pivotal Events of IHF-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to WP-SHIELDING	Associated Fault Tree or Basic Event
IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	ESD11-HLW-SHIELD	51A-WPSHIELD-FAIL-EXPORT
	ESD11-HLW-DROPON		
	ESD11-HLW-CRANE		
	ESD11-HLW-COLLISION		
IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL	ESD11-NVL-SHIELD	
	ESD11-NVL-DROPON		
	ESD11-NVL-CRANE		
	ESD11-NVL-COLLISION		

NOTE: <sup>a</sup> 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 A4.11-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.11-6. Basic Event Associated with the CONFINEMENT Pivotal Events of IHF-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event
IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	HVAC-CONF	HVAC-CONFINEMENT-FAILS
	ESD11-HLW-DROPON		
	ESD11-HLW-CRANE		
	ESD11-HLW-COLLISION		
IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL		
	ESD11-NVL-DROPON		
	ESD11-NVL-CRANE		
	ESD11-NVL-COLLISION		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.11-7 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.11-7. Basic Event Associated with the MODERATOR Pivotal Events of IHF-ESD-11

Initiator Event Tree	Initiating Event	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-11-HLW	ESD11-HLW-TEV-COLL	MOD-NOFIRE-HLW	MOD-NOFIRE-HLW-NOIMP
	ESD11-HLW-DROPON		
	ESD11-HLW-CRANE		
	ESD11-HLW-COLLISION		
IHF-ESD-11-NVL	ESD11-NVL-TEV-COLL	MOD-NOFIRE	(51A-OIL-MODERATOR) <b>OR</b> (51A-FIRE-SUPPRESSION) <b>OR</b> (51A-OTHER-WATER)
	ESD11-NVL-DROPON		
	ESD11-NVL-CRANE		
	ESD11-NVL-COLLISION		

NOTE: <sup>a</sup> 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 IHF-ESD-12

IHF-ESD-12 covers event sequences associated with direct exposure during various operations (Ref. 2.2.28, Figure F-12). This ESD covers all waste forms. Basic rules instruct SAPHIRE where to look for the fault tree that models each initiating event (Table A4.12-1). The assignments made in the rules files are indicated in this section.

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

Waste Form Unit	Associated Self-Contained Initiating Event Trees	Number of Waste Form Units
HLW canister	IHF-ESD-12A-HLW	1000
Naval canister	IHF-ESD-12A-NVL	400
HLW waste package	IHF-ESD-12B-HLW	200
Naval cask or waste package	IHF-ESD-12B-NVL	400
HLW waste package	IHF-ESD-12C-HLW	200
Naval waste package	IHF-ESD-12C-NVL	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.12.1 Initiating Events for IHF-ESD-12

The following initiating events are associated with IHF-ESD-12. There are no pivotal events associated with IHF-ESD-12. The assignments made within SAPHIRE for quantification of these initiating events are indicated in Table A4.12-2.

**Temporary loss of shielding of the CTM shield bell while the canister is being lifted from a transportation cask.** A loss of shielding could occur if the shield skirt is inadvertently lifted during canister transfer or if canister transfer proceeds before the shield skirt is lowered. A loss of shielding could also occur if the canister is lifted so high that it protrudes from the top of the shield bell. Because the elevation of the shield bell is fixed due to its rigid attachment to the shield bell trolley, it is not possible to cause a loss of shielding by inadvertently lifting the shield bell.

**Inadvertent displacement of the naval cask shield ring from cask or waste package or improper installation of waste package shield ring on waste package.** These event sequences could occur in the Cask Preparation Area or the Waste Package Loadout Room.

**Direct exposure during waste package closure.** This could occur due to the inadvertent opening of a personnel or equipment shield door.

**Direct exposure during exporting a loaded waste package.** This could occur due to the inadvertent opening of a personnel or equipment shield door.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Temporary loss of shielding of the CTM shield bell while the canister is being lifted from a transportation cask	IHF-ESD-12A-HLW	ESD12A-HLW-SHLD	ESD12A-HLW-SHLD
	IHF-ESD-12A-NVL	ESD12A-NVL-SHLD	ESD12A-NVL-SHLD
Loss of shielding during preparation activities or during WP closure	IHF-ESD-12B-HLW	ESD12B-HLW-SHLD	ESD12B-HLW-SHLD-DE <b>OR</b> ESD12B-HLW-SHLD-RING
	IHF-ESD-12B-NVL	ESD12B-NVL-SHLD	ESD12B-NVL-SHLD-DE <b>OR</b> ESD12B-HLW-SHLD-RING
Direct exposure during exporting a loaded waste package	IHF-ESD-12C-HLW	ESD12C-HLW-SHLD-FACDR	51A-OPDIREXPOSE3-HFI-NOD
	IHF-ESD-12C-NVL	ESD12C-NVL-SHLD-FACDR	

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events; CTM = canister transfer machine.

Source: Original

### A4.13 EVENT TREES FOR IHF-ESD-13

IHF-ESD-13 covers event sequences associated with fires in the IHF (Ref. 2.2.28, Figure F-13). This ESD covers all applicable waste forms (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 IHF-ESD-13

Waste Form Unit	Associated Event Trees	Number of Waste Form Units
HLW canisters except when in a sealed or unsealed transportation cask or a sealed or unsealed waste package	Initiator: IHF-ESD-13-HLW-CAN Response: IHF-RESP-FIRE	1,000
HLW canister in a sealed or unsealed transportation cask	Initiator: IHF-ESD-13-HLW-CSK Response: IHF-RESP-FIRE	600
HLW canister in a sealed or unsealed waste package	Initiator: IHF-ESD-13-HLW-WP Response: IHF-RESP-FIRE	200
Naval canister anywhere in the facility	Initiator: IHF-ESD-13-NVL Response: IHF-RESP-FIRE	400

NOTE: HLW = high-level radioactive waste.

Source: *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.26, Table 4)

#### A4.13.1 Initiating Events for IHF-ESD-13

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

**Localized fire affecting a canister in the CTM.** This initiating event accounts for the potential impact from a fire that threatens a canister being transferred by the CTM.

**Localized fire in Cask Unloading Room.** This initiating event accounts for the potential impact from a fire in the Cask Unloading Room.

**Localized fire in Cask Preparation Area.** This initiating event accounts for the potential impact from a fire in the Cask Preparation Area.

**Localized fire in Waste Package Loadout Room.** This initiating event accounts for the potential impact from a fire in the Waste Package Loadout Room.

**Localized fire in Waste Package Loading Room.** This initiating event accounts for the potential impact from a fire in the Waste Package Loading Room.

**Localized fire in Waste Package Positioning Room.** This initiating event accounts for the potential impact from a fire in the Waste Package Positioning Room.

**Large fire in IHF.** This initiating event accounts for the potential impact from a large fire in the IHF.

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

Initiating Event Description	Initiator Event Tree	SAPHIRE Assignment by Basic Rules	SAPHIRE Assignment at Fault Tree Level <sup>a</sup>
Localized fire affecting a canister in the CTM	IHF-ESD-13-HLW-CAN	ESD13-HLW-CAN-CTM-FIRE	51A-HLW-CAN-CTM-FIRE
	IHF-ESD-13-HLW-CSK	N/A	N/A
	IHF-ESD-13-HLW-WP	N/A	N/A
	IHF-ESD-13-NVL	ESD13-NVL-CAN-CTM-FIRE	51A-HLW-CAN-CTM-FIRE
Localized fire in Cask Unloading Room	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CUR-FIRE	51A-HLW-CSK-CUR-FIRE
	IHF-ESD-13-HLW-WP	N/A	N/A
	IHF-ESD-13-NVL	ESD13-NVL-CSK-CUR-FIRE	51A-NVL-CSK-CUR-FIRE
Localized fire in Cask Preparation Area	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CPA-FIRE	51A-HLW-CSK-CPA-FIRE
	IHF-ESD-13-HLW-WP	N/A	N/A
	IHF-ESD-13-NVL	ESD13-NVL-CSK-CPA-FIRE	51A-NVL-CSK-CPA-FIRE
Localized fire in Waste Package Loadout Room	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	N/A	N/A
	IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LOR-FIRE	51A-HLW-WP-LOR-FIRE
	IHF-ESD-13-NVL	ESD13-NVL-WP-LOR-FIRE	51A-NVL-WP-LOR-FIRE
Localized fire in Waste Package Loading Room	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	N/A	N/A
	IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LR-FIRE	51A-HLW-WP-LR-FIRE
	IHF-ESD-13-NVL	ESD13-NVL-WP-LR-FIRE	51A-NVL-WP-LR-FIRE
Localized fire in Waste Package Positioning Room	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	N/A	N/A
	IHF-ESD-13-HLW-WP	ESD13-HLW-WP-PR-FIRE	51A-HLW-WP-PR-FIRE
	IHF-ESD-13-NVL	ESD13-NVL-WP-PR-FIRE	51A-NVL-WP-PR-FIRE
Large fire in IHF	IHF-ESD-13-HLW-CAN	N/A	N/A
	IHF-ESD-13-HLW-CSK	N/A	N/A
	IHF-ESD-13-HLW-WP	ESD13-HLW-LG-FIRE	51A-HLW-LG-FIRE
	IHF-ESD-13-NVL	ESD13-NVL-LG-FIRE	51A-NVL-LARGE-FIRE

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

CTM = canister transfer machine; IHF – Initial Handling Facility.

Source: Original

#### A4.13.2 System Response Event Tree IHF-RESP-FIRE

The pivotal events that appear in IHF-RESP-FIRE 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 A4.13-3 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.13-3. Basic Events Associated with the CANISTER Pivotal Events of IHF-ESD-13

<b>Initiator Event Tree</b>	<b>Initiating Event Name</b>	<b>Name Assigned to CANISTER</b>	<b>Associated Fault Tree or Basic Event<sup>a</sup></b>
IHF-ESD-13-HLW-CAN	ESD13-HLW-CAN-CTM-FIRE	ESD13-HLW-CANF-CTM-FIRE	51A-HLW-CAN-CONT-CTM-FIR
IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CUR-FIRE	ESD13-HLW-CANF-CUR-FIRE	51A-HLW-CAN-CONT-CUR-FIR
	ESD13-HLW-CSK-CPA-FIRE	ESD13-HLW-CANF-CPA-FIRE	[(51A-HLW-SPMRC-DIESEL) <b>AND</b> (51A-HLW-CAN-DIESEL)] <b>OR</b> [(51A-HLW-SPMRC-WODIESEL) <b>AND</b> (51A-HLW-FAILCAN-WODIESEL)]
IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LOR-FIRE	ESD13-HLW-CANF-LOR-FIRE	[(51A-PROB-HLWCAN-WPTT-LOR) <b>AND</b> (51A-HLWCAN-WPTT-FAIL-FIR)] <b>OR</b> [(51A-PROB-HLWCAN-WP-LOR) <b>AND</b> (51A-HLWCAN-WP-FAIL-FIRE)]
	ESD13-HLW-WP-LR-FIRE	ESD13-HLW-CANF-LR-FIRE	51A-HLW-CAN-CONT-LR-FIR
	ESD13-NVL-WP-PR-FIRE	ESD13-NVL-CANF-PR-FIRE	51A-HLW-CAN-CONT-PR-FIR
	ESD13-HLW-LG-FIRE	ESD13-HLW-CANF-LG-FIRE	[(51A-HLW-FREQ-DIESEL) <b>AND</b> (51A-HLW-CAN-WDIESEL)] <b>OR</b> [(51A-HLW-LARGE-FIRE-CTM) <b>AND</b> (51A-HLW-CAN-FAILS-CTM)] <b>OR</b> [(51A-HLW-FREQ-NO-DIESEL) <b>AND</b> (51A-HLW-CAN-FAIL-NOD)] <b>OR</b> [(51A-HLW-FREQ-WP-FAILS) <b>AND</b> (51A-HLW-CAN-FAIL-IN-WP)]

Table A4.13-3. Basic Events Associated with the CANISTER Pivotal Events of IHF-ESD-13 (Continued)

Initiator Event Tree	Initiating Event Name	Name Assigned to CANISTER	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-13-NVL	ESD13-NVL-CAN-CTM-FIRE	ESD13-NVL-CANF-CTM-FIRE	51A-NVL-CAN-CONT-CTM-FIRE
	ESD13-NVL-CSK-CUR-FIRE	ESD13-NVL-CANF-CUR-FIRE	51A-NVL-CAN-CONT-CUR-FIRE
	ESD13-NVL-CSK-CPA-FIRE	ESD13-NVL-CANF-CPA-FIRE	[(51A-NVL-SPMRC-DIESEL) <b>AND</b> (51A-NVL-FAIL-CAN-DIESEL)] <b>OR</b> [(51A-NVL-SPMRC-WODIESEL) <b>AND</b> (51A-NVL-FAILCAN-WODIESEL)]
	ESD13-NVL-WP-LOR-FIRE	ESD13-NVL-CANF-LOR-FIRE	[(51A-PROB-NVLCAN-WPTT-LOR) <b>AND</b> (51A-NVLCAN-FAILWPTT-LOR)] <b>OR</b> [(51A-PROB-NVLCAN-WP-LOR) <b>AND</b> (51A-NVLCAN-WP-FAIL-LOR)]
	ESD13-NVL-WP-LR-FIRE	ESD13-NVL-CANF-LR-FIRE	51A-NVL-CAN-CONT-LR-FIRE
	ESD13-NVL-WP-PR-FIRE	ESD13-NVL-CANF-PR-FIRE	51A-NVL-CAN-CONT-PR-FIRE
	ESD13-NVL-LG-FIRE	ESD13-NVL-CANF-LG-FIRE	[(51A-NVL-CAN-FAIL-NOD) <b>AND</b> (51A-NVL-FREQ-NO-DIESEL)] <b>OR</b> [(51A-NVL-CAN-FAIL-IN-WP) <b>AND</b> (51A-NVL-FREQ-WP-FAILS)] <b>OR</b> [(51A-NVL-CAN-FAILS-CTM) <b>AND</b> (51A-NVL-LARGE-FIRE-CTM)] <b>OR</b> [(51A-FREQ-DIESEL-PRESENT) <b>AND</b> (51A-NVL-CAN-WDIESEL)]

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**SHIELDING.** This pivotal event represents the success or failure of the shielding provided by the transportation cask, CTM shield bell, WPTT shield compartment, TEV shield compartment, or shield doors as a result of the initiating event. Table A4.13-4 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.13-4. Fault Tree Associated with the SHIELDING Pivotal Events of IHF-ESD-13

Initiator Event Tree	Initiating Event Name	Name Assigned to SHIELDING	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-13-HLW-CAN	ESD13-HLW-CAN-CTM-FIRE	ESD13-HLW-SHLD-FIRE	51A-HLW-CAN-SHIELD-CTM
IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CUR-FIRE	ESD13-HLW-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS
	ESD13-HLW-CSK-CPA-FIRE	ESD13-HLW-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS
IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LOR-FIRE	ESD13-HLW-SHLD-FIRE	51A-HLW-CAN-SHIELD-CTM
	ESD13-HLW-WP-LR-FIRE	ESD13-HLW-SHLD-FIRE	51A-HLW-CAN-SHIELD-CTM
	ESD13-NVL-WP-PR-FIRE	ESD13-HLW-SHLD-FIRE	51A-HLW-CAN-SHIELD-CTM
	ESD13-HLW-LG-FIRE	ESD13-HLW-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS
IHF-ESD-13-NVL	ESD13-NVL-CAN-CTM-FIRE	ESD13-NVL-SHLD-FIRE	51A-NVL-SHLD-FIRE-FAILS
	ESD13-NVL-CSK-CUR-FIRE	ESD13-NVL-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS
	ESD13-NVL-CSK-CPA-FIRE	ESD13-NVL-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS
	ESD13-NVL-WP-LOR-FIRE	ESD13-NVL-SHLD-FIRE	51A-NVL-SHLD-FIRE-FAILS
	ESD13-NVL-WP-LR-FIRE	ESD13-NVL-SHLD-FIRE	51A-NVL-SHLD-FIRE-FAILS
	ESD13-NVL-WP-PR-FIRE	ESD13-NVL-SHLD-FIRE	51A-NVL-SHLD-FIRE-FAILS
	ESD13-NVL-LG-FIRE	ESD13-NVL-TC-SHLD-FIRE	51A-TC-SHLD-FIRE-FAILS

NOTE: <sup>a</sup> 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 A4.13-5 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event.

Table A4.13-5. Fault Tree Associated with the CONFINEMENT Pivotal Events of IHF-ESD-13

Initiator Event Tree	Initiating Event Name	Name Assigned to CONFINEMENT	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-13-HLW-CAN	ESD13-HLW-CAN-CTM-FIRE	HVAC-CONF	HVAC-CONFINEMENT-FAILS
IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CUR-FIRE		
	ESD13-HLW-CSK-CPA-FIRE		
IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LOR-FIRE		
	ESD13-HLW-WP-LR-FIRE		
	ESD13-NVL-WP-PR-FIRE		
	ESD13-HLW-LG-FIRE		
IHF-ESD-13-NVL	ESD13-NVL-CAN-CTM-FIRE		
	ESD13-NVL-CSK-CUR-FIRE		
	ESD13-NVL-CSK-CPA-FIRE		
	ESD13-NVL-WP-LOR-FIRE		
	ESD13-NVL-WP-LR-FIRE		
	ESD13-NVL-WP-PR-FIRE		
	ESD13-NVL-LG-FIRE		

NOTE: <sup>a</sup> This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

**MODERATOR.** Table A4.13-6 specifies the fault tree or basic event that is associated with this pivotal event for each initiating event (introduction of liquid moderator).

Table A4.13-6. Basic Event Associated with the MODERATOR Pivotal Events of IHF-ESD-13

Initiator Event Tree	Initiating Event Name	Name Assigned to MODERATOR	Associated Fault Tree or Basic Event <sup>a</sup>
IHF-ESD-13-HLW-CAN	ESD13-HLW-CAN-CTM-FIRE	MOD-FIRE-HLW	51A-MOD-FIRE-HLW-NOIMP
IHF-ESD-13-HLW-CSK	ESD13-HLW-CSK-CUR-FIRE		
	ESD13-HLW-CSK-CPA-FIRE		
IHF-ESD-13-HLW-WP	ESD13-HLW-WP-LOR-FIRE		
	ESD13-HLW-WP-LR-FIRE		
	ESD13-NVL-WP-PR-FIRE		
	ESD13-HLW-LG-FIRE		
IHF-ESD-13-NVL	ESD13-NVL-CAN-CTM-FIRE	MOD-FIRE	51A-MODERATOR-ENTERS-CAN
	ESD13-NVL-CSK-CUR-FIRE		
	ESD13-NVL-CSK-CPA-FIRE		
	ESD13-NVL-WP-LOR-FIRE		
	ESD13-NVL-WP-LR-FIRE		
	ESD13-NVL-WP-PR-FIRE		
	ESD13-NVL-LG-FIRE		

NOTE: <sup>a</sup>This column may contain fault trees and basic events. See Attachment B for fault trees and Attachment C for basic events.

Source: Original

### A5 EVENT TREES

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

Refer to Table A5-1 for the relationship between the ESDs, initiating event trees and system response event trees.

Number of waste forms processed over facility	Identify initiating events			
NUMBER-WAS	INIT-EVENT	#		XFER-TO-RESP-TREE
	Drop of waste form	1		
	Waste form collision	2	T => 2	RESPONSE-SAMPLE
	Heavy load drop on waste form	3	T => 2	RESPONSE-SAMPLE
		4	T => 2	RESPONSE-SAMPLE

Indicates transfer to the system response event tree on Sheet 2

Indicates the name of the system response event tree

Sheet number appears here on each sheet

INIT-EVENT - Sample Initiating Event Tree

2007/10/24 Sheet 1

Source: Original

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

Table A5-1. Relation of Event Sequence Diagrams to Event Trees

ESD#	ESD Title	IE Event Tree Name	IE Event Tree Location	Response Tree Name	Response Tree Location
IHF-ESD-01	Event Sequences for Activities Associated with Receipt of Naval or HLW TC on RC or TT in Cask Preparation Area and Upending and Transfer of Naval TC to CTT	ESD-01-HLW ESD-01-NVL	Figure A5-2 Figure A5-4	IHF-RESP-TC1 IHF-RESP-TC1	Figure A5-3
IHF-ESD-02	Event Sequences for Activities Associated with Removal of Impact Limiters, Upending and Transfer of HLW Cask to CTT and Removal of Impact Limiters from Naval TC	ESD-02-HLW ESD-02-NVL	Figure A5-5 Figure A5-6	IHF-RESP-TC1 IHF-RESP-TC1	Figure A5-3 Figure A5-3
IHF-ESD-03	Event Sequences for Activities Associated with Cask Preparation Activities Associated with Unbolting and Lid Adapter Installation for the HLW Cask	ESD-03-HLW	Figure A5-7	IHF-RESP-TC1	Figure A5-3
IHF-ESD-04	Event Sequences for Activities Associated with Removal of the Naval Cask Lid and Installing the Naval Canister Lifting Adapter	ESD-04-NVL	Figure A5-8	IHF-RESP-CAN1	Figure A5-9
IHF-ESD-05	Event Sequences for Activities Associated with Transfer of a Cask on CTT from Cask Preparation Area to Cask Unloading Room	ESD-05-HLW ESD-05-NVL	Figure A5-10 Figure A5-12	IHF-RESP-CAN2-HLW IHF-RESP-CAN2-NVL	Figure A5-11 Figure A5-13
IHF-ESD-06	Event Sequences for Activities Associated with Collision of CTT with Cask Unloading Room Shield Door	ESD-06-HLW ESD-06-NVL	Figure A5-14 Figure A5-15	N/A	N/A
IHF-ESD-07	Event Sequences for Activities Associated with the Transfer of a Canister to or from a TC to a WP with CTM	ESD-07-HLW ESD-07-NVL	Figure A5-16 Figure A5-17	IHF-RESP-CAN1 IHF-RESP-CAN1	Figure A5-9 Figure A5-9
IHF-ESD-08	Event Sequences for Activities Associated with WP Transfer from WP Loading Room to Closing Position in WP Positioning Room below WP Closure Room	ESD-08-HLW ESD-08-NVL	Figure A5-18 Figure A5-20	IHF-RESP-WP1 IHF-RESP-WP1	Figure A5-19 Figure A5-19

Table A5-1. Relation of Event Sequence Diagrams to Event Trees (Continued)

ESD#	ESD Title	IE Event Tree Name	IE Event Tree Location	Response Tree Name	Response Tree Location
IHF-ESD-09	Event Sequences for Activities Associated with Assembly and Closure of the WP	ESD-09-HLW ESD-09-NVL	Figure A5-21 Figure A5-23	IHF-RESP-WP2 IHF-RESP-WP2	Figure A5-22 Figure A5-22
IHF-ESD-10	Event Sequences for Activities Associated with the Transfer of the WP from the WP Positioning Room to the WPTT Docking Station	ESD-10-HLW ESD-10-NVL	Figure A5-24 Figure A5-26	IHF-RESP-WP3 IHF-RESP-WP3	Figure A5-25 Figure A5-25
IHF-ESD-11	Event Sequences for Activities Associated with Exporting a WP	ESD-11-HLW ESD-11-NVL	Figure A5-27 Figure A5-28	IHF-RESP-WP3 IHF-RESP-WP3	Figure A5-25 Figure A5-25
IHF-ESD-12	Event Sequences for Activities Associated with Direct Exposure During Various Activities	ESD-12A-HLW ESD-12A-NVL ESD-12B-HLW ESD-12B-NVL ESD-12C-HLW ESD-12C-NVL	Figure A5-29 Figure A5-30 Figure A5-31 Figure A5-32 Figure A5-33 Figure A5-34	N/A	N/A
IHF-ESD-13	Event Sequences Associated with Fires Occurring in the IHF	ESD-13-HLW-CAN ESD-13-HLW-CSK ESD-13-HLW-WP ESD-13-NVL	Figure A5-35 Figure A5-37 Figure A5-38 Figure A5-39	IHF-RESP-FIRE IHF-RESP-FIRE IHF-RESP-FIRE IHF-RESP-FIRE	Figure A5-36 Figure A5-36 Figure A5-36 Figure A5-36

NOTE: CAN = canister; CTM = canister transfer machine; CTT = cask transfer trolley; ESD = event sequence diagram; HLW = high-level radioactive waste; IHF = Initial Handling Facility; NVL = naval; RC = railcar; RESP = response; TC = transportation cask; TT = truck trailer; WP = waste package; WPTT = waste package transfer trolley.

Source: Original

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Number of HLW casks received by IHF during preclosure period	Identify initiating events		
NUM-HLW-CSK	INIT-EVENT	#	XFER-TO-RESP-TREE
		1	OK
	Railcar derailment	2	T => 2 IHF-RESP-TC1
	HLW TT rollover	3	T => 2 IHF-RESP-TC1
	RC/TT collision	4	T => 2 IHF-RESP-TC1

IHF-ESD-01-HLW - Receipt of HLW TC in the Cask Preparation Area

2007/12/04 Sheet 1

Source: Original

Figure A5-2. Event Tree IHF-ESD-01-HLW –  
Receipt of HLW TC in the Cask  
Preparation Area

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