Table 6.5-4. Results from Monte Carlo Simulation of Initiating Event Frequency Distributions (Continued)

Initiating Event	Equipment	Mean	Median	97.5% Value	EF	Type
Localized Fire Threatens Waste Form in Cask Preparation Room w/o SPM (No Diesel Present)	Railcar					
Localized Fire Threatens TC/TAD canister in Cask Preparation Room w/o SPM (No Diesel Present)		2.2E-06	2.0E-06	4.7E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/HLW in Cask Preparation Room w/o SPM (No Diesel Present)		2.6E-06	2.3E-06	5.6E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DOE SNF in Cask Preparation Room w/o SPM (No Diesel Present)		2.2E-06	2.0E-06	4.7E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DPC (VTC) in Cask Preparation Room (No Diesel Present)		1.9E-06	1.7E-06	4.1E-06	2.1E+00	Lognormal
Localized Fire Threatens Waste Form in AO in Vestibule/Cask Preparation Room (Diesel Present)	Site transporter					
Localized Fire Threatens TAD canister in AO in Vestibule/Cask Preparation Room (Diesel Present)		2.9E-06	2.6E-06	6.3E-06	2.2E+00	Lognormal
Localized Fire Threatens DPC (VTC) in AO in Vestibule/Cask Preparation Room (Diesel Present)		4.2E-06	3.8E-06	9.2E-06	2.1E+00	Lognormal
Localized Fire Threatens Waste Form on CTT in Cask Preparation Room	Cask transfer trolley					
Localized Fire Threatens TC/TAD canister on CTT in Cask Preparation Room		2.6E-06	2.4E-06	6.0E-06	2.1E+00	Lognormal
Localized Fire Threatens TC/HLW on CTT in Cask Preparation Room		2.3E-06	2.1E-06	5.3E-06	2.0E+00	Lognormal
Localized Fire Threatens TC/DOE SNF on CTT in Cask Preparation Room		2.5E-06	2.2E-06	5.6E-06	2.3E+00	Lognormal
Localized Fire Threatens TC/DPC (VTC) in Cask Preparation Room		2.5E-06	2.2E-06	5.6E-06	2.2E+00	Lognormal

Table 6.5-4. Results from Monte Carlo Simulation of Initiating Event Frequency Distributions (Continued)

Initiating Event	Equipment	Mean	Median	97.5% Value	EF	Type
Localized Fire Threatens Waste Form in CTM in Canister Transfer Room	Canister transfer machine					
Localized Fire Threatens TAD canister in CTM in Canister Transfer Room		1.1E-07	1.0E-07	2.5E-07	2.0E+00	Lognormal
Localized Fire Threatens HLW in CTM in Canister Transfer Room (per individual canister)		1.3E-07	1.2E-07	2.9E-07	2.0E+00	Lognormal
Localized Fire Threatens DOE SNF in CTM in Canister Transfer Room (per individual canister)		1.1E-07	1.0E-07	2.5E-07	2.0E+00	Lognormal
Localized Fire Threatens DPC in CTM in Canister Transfer Room		1.2E-07	1.1E-07	2.7E-07	1.9E+00	Lognormal
Large Fire Threatens TC/TAD canister (Diesel Present)	-	1.2E-06	1.1E-06	2.8E-06	2.3E+00	Lognormal
Large Fire Threatens TC/TAD canister (No Diesel)	-	1.9E-05	1.7E-05	4.4E-05	2.2E+00	Lognormal
Large Fire Threatens TAD canister in AO (Diesel Present)	-	6.5E-06	5.8E-06	1.5E-05	2.2E+00	Lognormal
Large Fire Threatens TAD canister in CTM	-	8.6E-07	7.7E-07	2.0E-06	2.2E+00	Lognormal
Large Fire Threatens TAD canister in WP in WPTT	-	5.9E-05	5.3E-05	1.4E-04	2.1E+00	Lognormal
Large Fire Threatens TAD canister in WP in TEV	-	1.0E-06	9.1E-07	2.3E-06	2.0E+00	Lognormal
Large Fire Threatens TC/HLW (Diesel Present)	-	1.2E-06	1.1E-06	2.8E-06	2.3E+00	Lognormal
Large Fire Threatens TC/HLW (No Diesel)	-	2.0E-05	1.7E-05	4.6E-05	2.4E+00	Lognormal
Large Fire Threatens HLW in CTM (per individual canister)	-	8.6E-07	7.7E-07	2.0E-06	2.2E+00	Lognormal
Large Fire Threatens HLW in WP	-	7.3E-06	6.6E-06	1.7E-05	2.1E+00	Lognormal
Large Fire Threatens HLW and DOE SNF in WP	-	6.1E-05	5.5E-05	1.4E-04	2.2E+00	Lognormal
Large Fire Threatens TC/DOE SNF (Diesel Present)	-	1.2E-06	1.1E-06	2.8E-06	2.3E+00	Lognormal
Large Fire Threatens TC/DOE SNF (No Diesel)	-	1.8E-05	1.7E-05	4.2E-05	2.0E+00	Lognormal
Large Fire Threatens DOE SNF in CTM (per canister)	-	6.4E-07	5.8E-07	1.5E-06	2.1E+00	Lognormal

Table 6.5-4. Results from Monte Carlo Simulation of Initiating Event Frequency Distributions (Continued)

Initiating Event	Equipment	Mean	Median	97.5% Value	EF	Type
Large Fire Threatens DOE SNF in Staging Area	-	5.8E-01	5.2E-01	1.4E+00	2.2E+00	Lognormal
Large Fire Threatens TC/DPC (VTC) (Diesel)	-	1.2E-06	1.1E-06	2.9E-06	2.0E+00	Lognormal
Large Fire Threatens TC/DPC (VTC) (No Diesel)	-	1.7E-05	1.5E-05	4.0E-05	2.1E+00	Lognormal
Large Fire Threatens DPC (VTC) in CTM	-	7.1E-07	6.3E-07	1.6E-06	2.2E+00	Lognormal
Large Fire Threatens DPC (VTC) in AO (Diesel)	-	8.5E-06	7.6E-06	2.0E-05	2.2E+00	Lognormal

NOTE: AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; DPC = dual-purpose canister; DOE = U.S. Department of Energy; EF = error factor; HLW = high-level radioactive waste; SPM = site prime mover; SNF = spent nuclear fuel; TAD = transportation, aging, and disposal; TEV = transport and emplacement vehicle; TC = transportation cask; VTC = transportation cask in vertical position; WP = waste package; WPTT = waste package transport trolley.

Source: Table F5.7-7 of Attachment F

Table 6.5-5 provides the fire analysis data for the basic events in this model.

Table 6.5-5. Basic Events Data Associated with Fire Analysis

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-DNSF-CAN-CTM-FIRE	Localized fire threatens canister in the CTM	1.10E-07	Localized Fire Threatens DOE SNF in CTM in Canister Transfer Room (per individual canister)	Section 6.3, Table 6.3-11	DSNF-5
060-DNSF-CASK-CUR-FIRE	Localized Fire Threatens TC/DOE SNF on CTT in Cask Unloading Room	7.50E-07	Localized Fire Threatens TC/DOE SNF on CTT in Cask Unloading Room	Section 6.3, Table 6.3-11	DSNF-1
060-DNSF-LARGE-FIRE	Large fire threatens DNSF anywhere in CRCF	1.96E-04	Large Fire Threatens TC/DOE SNF (diesel Present), TC/DOE SNF (No diesel), in CTM (per canister), and in Staging Area	Section 6.3, Table 6.3-11	DSNF-6
060-DPC-CASK-PREP-FIRE	Fire in Cask Preparation Room	9.09E-06	Localized Fire Threatens TC/DPC (VTC) in Vestibule/Cask Preparation Room (diesel Present), TC/DPC (VTC) in Cask Preparation Room (No diesel Present), DPC (VTC) in AO in Vestibule/Cask Preparation Room (diesel Present), and TC/DPC (VTC) on CTT	Section 6.3, Table 6.3-11	DPC-4
060-DPC-CASK-UNLOAD-FIRE	Fire in the Cask Unloading Room	1.84E-07	Localized Fire Threatens TC/DPC (VTC) or AO (diesel Present) in Cask Unloading Room	Section 6.3, Table 6.3-11	DPC-1
060-DPC-CTM-FIRE	Fire in Transfer Room Affecting Can in CTM	1.20E-07	Localized Fire Threatens DPC in CTM in Canister Transfer Room	Section 6.3, Table 6.3-11	DPC-8
060-DPC-LARGE-FIRE	Large Fire in CRCF	2.67E-05	Large Fire Threatens TC/DPC (VTC) (diesel), TC/DPC (VTC) (No diesel), DPC (VTC) in CTM, and DPC (VTC) in AO (diesel)	Section 6.3, Table 6.3-11	DPC-9
060-DSNF-CSK-CPA-FIRE	Probability of Fire in Cask Preparation Room	5.19E-06	Localized Fire Threatens TC/DOE SNF in Vestibule/Cask Preparation Room w/SPM (diesel Present), TC/DOE SNF in Cask Preparation Room w/o SPM (No diesel Present), and TC/DOE SNF on CTT (No diesel Present).	Section 6.3, Table 6.3-11	DSNF-2

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-FIRE-IN-POSITION-RM	Fire in WP Positioning/Closure Room Threatens WP	8.50E-06	Localized Fire Threatens HLW in WP in WP Positioning/Closure Room	Section 6.3, Table 6.3-11	HLW-6
060-H&D-LARGE-FIRE	Large fire threatens H&D anywhere in CRCF	6.10E-05	Large Fire Threatens HLW and DOE SNF in WP	Section 6.3, Table 6.3-11	H&D-3
060-H&D-WP-LDOUT-RM	Localized fire threatens WP in the WP Loadout Room	9.20E-07	Localized Fire Threatens HLW and DOE SNF in WP in TEV in WP Loadout Room	Section 6.3, Table 6.3-11	H&D-2
060-H&D-WP-POSIT-RM-FIRE	Localized fire threatens H&D WP in WP Positioning Room	6.60E-05	Localized Fire Threatens HLW and DOE SNF in WP and TEV in WP Positioning/Closure Room	Section 6.3, Table 6.3-11	H&D-1
060-H&M-LARGE-FIRE	Large fire threatens H&M anywhere in CRCF	6.10E-05	Large Fire Threatens HLW and MCO in WP	Section 6.3, Table 6.3-11	H&M-3
060-H&M-WP-LDOUT-RM	Localized fire threatens WP in the WP Loadout Room	9.20E-07	Localized Fire Threatens HLW and MCO in WP in TEV in WP Loadout Room	Section 6.3, Table 6.3-11	H&M-2
060-H&M-WP-POSIT-RM-FIRE	Localized fire threatens H&M WP in WP Positioning Room	6.60E-05	Localized Fire Threatens HLW and MCO in WP and TEV in WP Positioning/Closure Room	Section 6.3, Table 6.3-11	H&M-1
060-HLW-CAN-CTM-FIRE	Localized fire threatens HLW canister in CTM	1.30E-07	Localized Fire Threatens HLW in CTM in Canister Transfer Room (per individual canister)	Section 6.3, Table 6.3-11	HLW-5
060-HLW-CSK-UNLOAD-RM	Localized Fire threatens TC in Cask Unloading Room	4.70E-07	Localized Fire Threatens TC/HLW on CTT in Cask Unloading Room	Section 6.3, Table 6.3-11	HLW-1
060-HLW-CTM	Probability HLW in CTM	2.93E-02	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the CTM in a large fire.	Section 6.3, Table 6.3-11	HLW-10
060-HLW-FIRE-PREPAREA	Fire involving HLW in Cask Preparation Room	5.39E-06	Localized Fire Threatens TC/HLW in Vestibule/Cask Preparation Room w/SPM (diesel Present), w/o SPM (No diesel Present), and TC/HLW on CTT (No diesel Present).	Section 6.3, Table 6.3-11	HLW-2
060-HLW-LARGE-FIRE	Large fire threatens HLW anywhere in CRCF	2.94E-05	Large Fire Threatens TC/HLW (diesel Present), TC/HLW (No diesel), HLW in CTM (per Individual canister), and HLW in WP	Section 6.3, Table 6.3-11	HLW-7

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-HLW-TC-DIESEL	Probability HLW in TC with diesel Present	4.09E-02	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the TC when diesel fuel is present in a large fire.	Section 6.3, Table 6.3-11	HLW-8
060-HLW-TC-WO-DIESEL	Probability HLW in TC Without diesel Present	6.81E-01	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the TC when diesel fuel is not present in a large fire.	Section 6.3, Table 6.3-11	HLW-9
060-HLW-WP	Probability HLW in WP	2.49E-01	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the WP in a large fire.	Section 6.3, Table 6.3-11	HLW-11
060-MCO-CAN-CTM-FIRE	Localized fire threatens canister in the CTM	1.10E-07	Localized fire threatens MCO in CTM	Section 6.3, Table 6.3-11	MCO-5
060-MCO-CASK-CUR-FIRE	Localized fire threatens TC Cask Unloading Room	7.50E-07	Localized fire threatens TC/MCO in Cask Unloading Area	Section 6.3, Table 6.3-11	MCO-1
060-MCO-CSK-CPA-FIRE	Probability of Fire in Cask Preparation Room	5.19E-06	Localized fire threatens TC/MCO in Cask Preparation Room	Section 6.3, Table 6.3-11	MCO-2
060-MCO-LARGE-FIRE	Large fire threatens MCO anywhere in CRCF	1.98E-05	Large Fire Threatens TC/MCO (diesel Present), TC/MCO (No diesel), in CTM (per canister)	Section 6.3, Table 6.3-11	MCO-6
060-PROB-DIESEL-AO-CUR	Probability of DPC in AO & diesel in Cask Unloading Room	6.52E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the AO in the Cask Unloading Room while diesel fuel is present.	Section 6.3, Table 6.3-11	DPC-2
060-PROB-DIESEL-AO-PREP	Probability of DPC in AO & diesel in Cask Preparation Room	4.62E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the AO in the cask preparation room while diesel fuel is present.	Section 6.3, Table 6.3-11	DPC-7
060-PROB-DIESEL--TC-PREP	Probability of DPC in TC & diesel in Cask Preparation Room	5.39E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC in the cask preparation room while diesel	Section 6.3, Table 6.3-11	DPC-5

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
			fuel is present.		
060-PROB-DPC-AO-DIESEL	Probability of DPC in AO with diesel	3.10E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the AO while diesel fuel is present in a large fire.	Section 6.3, Table 6.3-11	DPC-12
060-PROB-DPC-IN-AO-LF	Probability DPC in AO in Large Fire	3.10E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the AO in a large fire.	Section 6.3, Table 6.3-11	DPC-12
060-PROB-DPC-IN-CTM	Probability DPC in CTM in Large Fire	2.59E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the CTM in a large fire.	Section 6.3, Table 6.3-11	DPC-13
060-PROB-DPC-IN-TC-LF	Probability DPC in TC in Large Fire	6.64E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC in a large fire.	Section 6.3, Table 6.3-11	DPC-10 + DPC11
060-PROB-DPC-TC-DIESEL	Probability of DPC in TC with diesel	4.38E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC while diesel fuel is present in a large fire.	Section 6.3, Table 6.3-11	DPC-10
060-PROB-DPC-TC-NODIES	Probability of DPC in TC without diesel	6.20E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC while diesel fuel is not present in a large fire.	Section 6.3, Table 6.3-11	DPC-11
060-PROB-DSTD-IN-CTM	Probability DOE Std. canister in CTM	3.27E-03	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in the CTM in a large fire.	Section 6.3, Table 6.3-11	DSNF-9

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-PROB-DSTD-IN-CTM-LF	Probability DOE Std. canister in CTM in Large Fire	3.27E-03	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in the CTM in a large fire.	Section 6.3, Table 6.3-11	DSNF-9
060-PROB-DSTD-IN-STG-LF	Probability DOE Std. canister in Staging Area in Large Fire	8.99E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in the staging area in a large fire.	Section 6.3, Table 6.3-11	DSNF-10
060-PROB-DSTD-IN-TC-LF	Probability DOE Std. canister in TC in Large Fire	9.82E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in the TC in a large fire.	Section 6.3, Table 6.3-11	DSNF-7 + DSNF-8
060-PROB-DSTD-STAGING	Probability DOE Std. canister in Staging Area	8.99E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in the staging area in a large fire.	Section 6.3, Table 6.3-11	DSNF-10
060-PROB-DSTD-TC-DIES	Probability DOE Std. canister in TD with diesel Fire	6.14E-03	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in a TC while diesel fuel is present in a large fire.	Section 6.3, Table 6.3-11	DSNF-7
060-PROB-DSTD-TC-NODIES	Probability DOE Std. canister in TC without diesel Fire	9.20E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in a TC while diesel fuel is not present in a large fire.	Section 6.3, Table 6.3-11	DSNF-8
060-PROB-HLW-IN-CTM-LF	Probability HLW in CTM in Large Fire	2.93E-02	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the CTM in a large fire.	Section 6.3, Table 6.3-11	HLW-10
060-PROB-HLW-IN-TC-LF	Probability HLW in TC in Large Fire	7.22E-01	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the TC in a large fire.	Section 6.3, Table 6.3-11	HLW-8 + HLW-9

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-PROB-HLW-IN-WP-LF	Probability HLW in WP in Large Fire	2.49E-01	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in the WP in a large fire.	Section 6.3, Table 6.3-11	HLW-11
060-PROB-MCO-IN-CTM	Probability MCO in CTM	3.23E-02	Based on the fire frequency analysis, this value represents the fraction of time that a MCO is in the CTM. Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-9
060-PROB-MCO-IN-CTM-LF	Probability MCO in CTM in Large Fire	3.23E-02	Based on the fire frequency analysis, this value represents the fraction of time that a MCO is in the CTM in a large fire. . Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-9
060-PROB-MCO-IN-TC-LF	Probability MCO in TC in Large Fire	9.68E-01	Based on the fire frequency analysis, this value represents the fraction of time that a MCO is in the TC in a large fire. . Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-7 + MCO-8
060-PROB-MCO-TC-DIES	Probability MCO in TC with diesel Fire	6.05E-02	Based on the fire frequency analysis, this value represents the fraction of time that a MCO is in the TC while diesel fuel is present in a large fire. Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-7
060-PROB-MCO-TC-NODIES	Probability MCO in TC without diesel Fire	9.07E-01	Based on the fire frequency analysis, this value represents the fraction of time that a MCO is in the TC while diesel fuel is not present in a large fire. . Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-8
060-PROB-NODIESEL-TC-CUR	Probability of DPC in TC without diesel in Cask Unloading Room	3.48E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC in the Cask Unloading Room while diesel fuel is not present.	Section 6.3, Table 6.3-11	DPC-3

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-PROB-NODIESE-TC-PREP	Probability of DPC in TC & no diesel in Cask Preparation Room	4.84E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DPC is in the TC in the Cask Preparation Room while diesel fuel is not present.	Section 6.3, Table 6.3-11	DPC-6
060-PROB-TAD-AO-CUR	Probability TAD canister in AO in Cask Unloading Room	5.20E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in an AO in the Cask Unloading Room.	Section 6.3, Table 6.3-11	TAD-2
060-PROB-TAD-AO-CURDIES	Probability TAD canister in AO in Cask Unloading Room with diesel Fire	5.20E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in an AO in the Cask Unloading Room while diesel fuel is present.	Section 6.3, Table 6.3-11	TAD-2
060-PROB-TAD-AO-DIES	Probability TAD canister in AO in Fire with diesel	7.42E-02	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in an AO while diesel fuel is present in a large fire..	Section 6.3, Table 6.3-11	TAD-14
060-PROB-TAD-AO-PREP	Probability TAD canister in AO in Cask Preparation Room	3.55E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in an AO in the Cask Preparation Room.	Section 6.3, Table 6.3-11	TAD-7
060-PROB-TAD-CTM	Probability TAD canister in CTM in Fire	9.82E-03	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the CTM in a large fire.	Section 6.3, Table 6.3-11	TAD-15
060-PROB-TAD-IN-AO-LF	Probability TAD canister in AO in Large Fire	7.51E-02	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in an AO in a large fire.	Section 6.3, Table 6.3-11	TAD-14
060-PROB-TAD-IN-CTM-LF	Probability TAD canister in CTM in Large Fire	9.94E-03	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the CTM in large fire.	Section 6.3, Table 6.3-11	TAD-15

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-PROB-TAD-IN-TC-LF	Probability TAD canister in TC in Large Fire	2.33E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC in large fire.	Section 6.3, Table 6.3-11	TAD-12 + TAD-13
060-PROB-TAD-IN-WP-LF	Probability TAD canister in WP in Large Fire	6.82E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the WP in large fire.	Section 6.3, Table 6.3-11	TAD-16 + TAD-17
060-PROB-TAD-TC-CUR	Probability TAD canister in TC in Cask Unloading Room	4.80E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC in the Cask Unloading Room.	Section 6.3, Table 6.3-11	TAD-3
060-PROB-TAD-TC-CURND	Probability TAD canister in TC without diesel Fire	4.80E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC in the Cask Unloading Room while diesel fuel is not present.	Section 6.3, Table 6.3-11	TAD-3
060-PROB-TAD-TC-DIESEL	Probability TAD canister in TC with diesel Fire	1.37E-02	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC while diesel fuel is present in large fire.	Section 6.3, Table 6.3-11	TAD-12
060-PROB-TAD-TC-PREP	Probability TAD canister in TC in Cask Preparation Room	6.45E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC in the Cask Preparation Room.	Section 6.3, Table 6.3-11	TAD-5 + TAD-6
060-PROB-TAD-TC-WODIESEL	Probability TAD canister in TC in Fire without diesel	2.17E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the TC while diesel fuel is not present in large fire.	Section 6.3, Table 6.3-11	TAD-13
060-PROB-TAD-WP	Probability TAD canister in WP in Fire	1.14E-02	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the WP in large fire.	Section 6.3, Table 6.3-11	TAD-16

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-PROB-TAD-WPTT	Probability TAD canister in WPTT in Fire	6.74E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister is in the WP in the WPTT in large fire.	Section 6.3, Table 6.3-11	TAD-17
060-SPMRC-DNSF-DIESEL	Probability of Fire in Cask Preparation Room with diesel	9.44E-02	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in a TC in the Cask Preparation Room in a diesel fire.	Section 6.3, Table 6.3-11	DSNF-3
060-SPMRC-DNSF-WODIESEL	Probability of Fire in Cask Preparation Room without diesel	9.06E-01	Based on the fire frequency analysis, this value represents the fraction of time that a DOE Std. canister is in a TC in the Cask Preparation Room in a non-diesel fire.	Section 6.3, Table 6.3-11	DSNF-4
060-SPMRC-HLW-DIESEL	Fire in Cask Preparation Room SPMRC with diesel	9.09E-02	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in a TC in the Cask Preparation Room in a diesel fire.	Section 6.3, Table 6.3-11	HLW-3
060-SPMRC-HLW-WODIESEL	Fire in Cask Preparation Room SPMRC without diesel	9.09E-01	Based on the fire frequency analysis, this value represents the fraction of time that a HLW canister is in a TC in the Cask Preparation Room in a non-diesel fire.	Section 6.3, Table 6.3-11	HLW-4
060-SPMRC-MCO-DIESEL	Probability of Fire in Cask Preparation Room with diesel	9.44E-02	Based on the fire frequency analysis, this value represents the fraction of time that a MCO canister in a TC is in the Cask Preparation Room in a diesel fire. . Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-3
060-SPMRC-MCO-WODIESEL	Probability of Fire in Cask Preparation Room without diesel	9.06E-01	Based on the fire frequency analysis, this value represents the fraction of time that a MCO canister in a TC is in the Cask Preparation Room in a non-diesel fire. . Data for MCO is the same as for the DOE Std. canister.	Section 6.3, Table 6.3-11	MCO-4

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-SPMRC-TAD-DIESEL	Fire in Cask Preparation Room SPMRC with diesel	5.75E-02	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in a TC is in the Cask Preparation Room in a diesel fire.	Section 6.3, Table 6.3-11	TAD-5
060-SPMRC-TAD-WODIES	Fire in Cask Preparation Room SPMRC without diesel	5.88E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in a TC is in the Cask Preparation Room in a non-diesel fire.	Section 6.3, Table 6.3-11	TAD-6
060-TADAO-CUR-DIESEL	Localized fire threatens TAD canister in Cask Unloading Room	2.50E-07	Localized Fire Threatens TAD canister in WP or TAD canister in AO (with diesel present) in Cask Unloading Room (diesel Present) in WP Loadout Room	Section 6.3, Table 6.3-11	TAD-1
060-TAD-AO-DIESEL	Fire in Cask Preparation Room with diesel - TAD canister in AO	3.55E-01	Based on the fire frequency analysis, this value represents the fraction of time that a TAD canister in an AO is in the Cask Preparation Room in a diesel fire.	Section 6.3, Table 6.3-11	TAD-7
060-TAD-CAN-CTM-FIRE	Localized fire threatens canister in the CTM	1.10E-07	Localized Fire Threatens TAD canister in CTM in Canister Transfer Room	Section 6.3, Table 6.3-11	TAD-10
060-TAD-FIRE-PREP-AREA	Probability of Fire Affecting TAD canister in Cask Preparation Room	8.17E-06	Localized Fire Threatens TC/TAD canister in Vestibule/Cask Preparation Room w/SPM (diesel Present), TC/TAD canister without SPM (No diesel Present), TAD canister in AO (diesel Present), and TC/TAD canister on CTT (No diesel Present).	Section 6.3, Table 6.3-11	TAD-4

Table 6.5-5. Basic Events Data Associated with Fire Analysis (Continued)

Basic Event (BE) ID	Basic Event Description	BE Value	Bases	References	Index Table 6.3-11
060-TAD-LARGE-FIRE	Large fire threatens TAD canister anywhere in CRCF	8.76E-05	Large Fire Threatens TC/TAD canister (diesel Present), TC/TAD canister (No diesel), TAD canister in AO (diesel Present), TAD canister in CTM, TAD canister in WP in WPTT, and TAD canister in WP in TEV	Section 6.3, Table 6.3-11	TAD-11
060-TAD-WP-LOADOUT-RM	Localized fire threatens TAD canister in WP in WP Loadout Room	9.20E-07	Localized Fire Threatens TAD canister in WP and TEV in WP Loadout Room	Section 6.3, Table 6.3-11	TAD-8
060-TAD-WP-POSIT-RM-FIRE	Localized fire threatens TAD canister in WP in WP Positioning Room	6.50E-05	Mean probability that a Localized Fire Threatens TAD canister in WP in WP Positioning/Closure Room	Section 6.3, Table 6.3-11	TAD-9

NOTE: AO = aging overpack; CRCF = Canister Receipt and Closure Facility; CTM = canister transfer machine; CTT = cask transfer trolley; DOE = U.S. Department of Energy; DPC = dual-purpose canister; HLW = high-level radioactive waste; MCO = multicanister overpack; SNF = spent nuclear fuel; SPM = site prime mover; SPMRC = site prime mover railcar; SPMTT = site prime mover truck trailer; TAD = transportation, aging, and disposal; TEV = transport and emplacement vehicle; TC transportation cask; VTC = a transportation cask that is upended on a railcar; WP = waste package; waste package transfer trolley.

Source: Original

INTENTIONALLY LEFT BLANK

6.6 NOT USED

6.7 EVENT SEQUENCE FREQUENCY RESULTS

This section provides the results of the event sequence quantification as produced from the SAPHIRE (Section 4.2) analyses. Quantification of an event sequence consists of calculating its number of occurrences over the preclosure period by combining the frequency of a single initiating event with the conditional probabilities of pivotal events that comprise the sequence. The quantification results are presented as an expression of the mean and median number of occurrences of each event sequence over the preclosure period, and the standard deviation as a measure of uncertainty. Section 6.8 describes the process for aggregation of similar event sequences to permit categorization as Category 1, Category 2, or beyond Category 2 event sequences.

The section presents a summary of how the quantification is performed by linking of event trees, fault trees, and basic event input parameters. The discussion includes the rationale for truncating low values and the analysis of uncertainties.

The results include a summary of all event sequences that are quantified and a table summarizing the results of the final quantification (found in Attachment G).

6.7.1 Process for Event Sequence Quantification

Internal event sequences that are based on the event trees presented in Section 6.1 and fault trees presented in Section 6.2 are quantified using SAPHIRE (Section 4.2). In SAPHIRE, the quantification of an event sequence is always labeled as a "frequency" in the output formats.

The event sequence quantification methodology is presented in Section 4.3.6. An event sequence frequency is the product of several factors, as follows (with examples):

- The number of times the operation or activity that gives rise to the event sequence is performed over the preclosure period, for example, the total number of transfers of a TAD canister by a CTM in the CRCF over the preclosure period. In SAPHIRE, this number is entered in the first event of the initiator event tree from which the event sequence arises or in the first event of the system-response event tree if no initiator event tree exists.

- The probability of occurrence of the initiating event for the event sequence considered. Continuing with the previous example, this could be the probability of dropping a TAD canister during its transfer by the CTM in the CRCF, or the probability of occurrence of a fire that could affect the TAD canister during its transfer by the CTM. The initiating event probability is modeled in SAPHIRE with a fault tree or with a basic event. In an initiator event tree, this probability is assigned on the branch associated with that initiating event, through the use of SAPHIRE rules (i.e., textual logic instructions that determine which fault tree or basic event is to be used). If no initiator event tree exists, this probability is entered in the second event of the system-response event tree.

- The conditional probability of each of the pivotal events of the event sequence, which appear in the system-response event tree. The pivotal event may represent a passive failure such as the breach of the containment boundary of the TAD canister or an active system failure such as the unavailability of the HVAC system. The conditional event probabilities of pivotal events are linked to the event sequence in SAPHIRE through the linkage to basic events in a fault tree that represents the pivotal event. The selection of pivotal event models and the associated basic event values may be determined by SAPHIRE rules.

Uncertainties in input parameters such as throughput rates, equipment failure rates, passive failure probabilities, and HFEs used to calculate basic event probabilities are propagated through the fault tree and event sequence logic to quantify the uncertainty in the event sequence quantification.

To quantify an event sequence, SAPHIRE (Section 4.2) first establishes the logic of the event sequence (i.e., the combination of individual successes and failures of pivotal events after the initiating event). SAPHIRE then links together the fault trees that support the initiating event and the pivotal events and uses Boolean logic to identify dependencies between the initiating event and the pivotal events and between pivotal events. SAPHIRE finally develops minimal cut sets for the event sequence considered. A minimal cut set for an event sequence is a Boolean reduced combination of a set of basic events that, if it occurs, will cause the event sequence to occur. The event sequence frequency is calculated as the sum of frequencies of the cut sets. No cutoff probability was used to ensure that event sequences are grouped properly.

As an illustration of the above process, the quantification of the event sequence initiated by a drop of a TAD canister during a transfer in the CRCF, followed by the breach of the canister, the subsequent failure of the HVAC confinement to perform its confinement and filtering function over its mission time, but no moderator entry into the canister, is outlined in the following paragraphs.

The event sequence, which leads to an unfiltered radionuclide release that is not important to criticality, starts with an initiator event tree that depicts the number of TAD canisters that are transferred by the CTM in the CRCF over the preclosure period. Based on *Waste Form Throughputs for Preclosure Safety Analysis* (Ref. 2.2.31, Table 4), there are 15,121 such transfers. Next, the branch on the initiator event tree that deals with the drop of a canister is selected. In practice, this is done by SAPHIRE through the use of rules, which are assigned to the pivotal event called "INIT-EVENT," the fault tree whose top event models the probability of a TAD canister drop. Multiplying the number of TAD canister transfers by the probability of a drop yields the number of occurrences, over the preclosure period, of the initiating event for the event sequence considered.

SAPHIRE (Section 4.2) continues the construction of event sequence logic via a transfer to the system-response event tree which provides the basis for quantifying the rest of the event sequence through the use of the pivotal events described in Section 6.1 and Attachment B. First, the breach of the canister, given its drop, is evaluated under the pivotal event called "CANISTER." SAPHIRE rules are used to ensure that the probability assigned to this pivotal event pertains to the waste form considered in this event sequence–a TAD canister. The next pivotal event that appears in the system-response event tree is called "SHIELDING." This pivotal event has a probability of one, indicating that a loss of shielding is considered to occur if the canister breaches. This modeling conforms to the approach taken in the PCSA, where event sequences that lead to a radionuclide release also embed direct exposure of personnel to radiation that could result from a LOS. The next pivotal event is called "CONFINEMENT." This event models the failure of HVAC to maintain confinement and perform filtering of the radionuclide release. This pivotal event is quantified with a fault tree. The mission time for the system is 720 hours (i.e., 30 days). Finally, the last pivotal event is called "MODERATOR." This event models moderator intrusion into the breached canister. In the event sequence analyzed, no moderator entry occurs, that is, the success branch is followed.

Two fault trees appear in this example event sequence: one models the drop of the canister and the other models the loss of the HVAC system. These fault trees are linked by SAPHIRE and a Boolean reduction is applied to identify dependencies (such as a loss of power, which is a contributor to both a load drop by the CTM and the loss of the HVAC system), and remove nonminimal cut sets.

The SAPHIRE event sequence quantification report includes the number of occurrences of each cut set that contributes to an event sequence, and the summation over the cut set to yield a number of occurrences of the event sequence over the preclosure period. The internal processes of SAPHIRE provides quantification of cut sets that represent combinations of basic events from respective initiating event trees and pivotal event tress, the summation over such cut sets represents the cumulative frequency of an initiating event (e.g., drop), containment (e.g., canister) breach, confinement unavailability, and moderator availability.

As noted, uncertainties in input parameters are propagated through the fault tree and event sequence logic to quantify the uncertainty in the event sequence quantification. The uncertainty analysis uses the Monte Carlo method that is built into SAPHIRE. Each event sequence was analyzed using 10,000 trials. The number of trials is considered sufficient to ensure accurate results for the distribution parameters.

6.7.2 Event Sequence Quantification Summary

Table G-1 of Attachment G presents the result of the event sequence quantification. Table G-1 summarizes the results of the final quantification and lists the following elements: (1) event tree from which the sequence is generated, (2) SAPHIRE event sequence designator, (3) initiating event description, (4) event sequence logic, (5) event sequence end state, (6) event sequence mean value, (7) event sequence median value, and (8) event sequence variance.

INTENTIONALLY LEFT BLANK

6.8 EVENT SEQUENCE GROUPING AND CATEGORIZATION

An aggregation grouping process is applied prior to a categorization of event sequences as was described in Section 4.3.1. It is appropriate for purposes of categorization, to add the frequencies of event sequences that are derived from the same ESD, that elicits the same combination of failure and success of pivotal events, and have the same end state. This is termed final event sequence quantification, discussed in Section 6.8.1, and the results give the final frequency of occurrence. Using the final frequency of occurrence, the event sequences are categorized according to the definition of Category 1 and Category 2 event sequences given in 10 CFR 63.2 (Ref. 2.3.2). Dose consequences for Category 1 and Category 2 event sequences are subject to the performance objectives of 10 CFR 63.111 (Ref. 2.3.2), which is performed in *Preclosure Consequence Analyses* (Ref. 2.2.38). Event sequences with a frequency of occurrence less than one chance in 10,000 of occurring before permanent closure of the repository are designated as beyond Category 2 event sequences and are not analyzed for dose consequences.

Rather than calculate dose consequences for each Category 2 event sequence identified in the categorization process, dose consequences are performed for a set of bounding events that encompass the end states and material at risk for event sequences. Therefore, dose consequences are determined for a representative set of postulated Category 2 event sequences, identified in Table 6.8-1 (Ref. 2.2.38, Table 2 and Section 7). Because all waste form types and configurations that are applicable to the repository are included in Table 6.8.1, some of the bounding event sequences do not apply to the present analysis. Once event sequence categorization is complete, Category 2 event sequences are cross referenced with the bounding event number given in Table 6.8-1, thus ensuring that Category 2 event sequences have been evaluated for dose consequences and compared to the 10 CFR 63.111 (Ref. 2.3.2) performance objectives.

Table 6.8-1. Bounding Category 2 Event Sequences

Bounding Event Number	Affected Waste Form	Description of End State	Material At Risk
2-01	LLWF inventory and HEPA filters	Seismic event resulting in LLWF collapse and failure of HEPA filters and ductwork in other facilities.	HEPA filters LLWF inventory
2-02	HLW canister in transportation cask	Breach of sealed HLW canisters in a sealed transportation cask	5 HLW canisters
2-03	HLW canister	Breach of sealed HLW canisters in an unsealed waste package	5 HLW canisters
2-04	HLW canister	Breach of sealed HLW canister during transfer (one drops onto another)	2 HLW canisters
2-05*	Uncanistered commercial SNF in transportation cask	Breach of uncanistered commercial SNF in a sealed truck transportation cask in air	4 PWR or 9 BWR commercial SNF
2-06*	Uncanistered commercial SNF in pool	Breach of uncanistered commercial SNF in an unsealed truck transportation cask in pool	4 PWR or 9 BWR commercial SNF
2-07	DPC in air	Breach of a sealed DPC in air	36 PWR or 74 BWR commercial SNF

Table 6.8-1. Bounding Category 2 Event Sequences (Continued)

Bounding Event Number	Affected Waste Form	Description of End State	Material At Risk
2-08*	DPC in pool	Breach of commercial SNF in unsealed DPC in pool	36 PWR or 74 BWR commercial SNF
2-09	TAD canister in air	Breach of a sealed TAD canister in air within facility	21 PWR or 44 BWR commercial SNF
2-10*	TAD canister in pool	Breach of commercial SNF in unsealed TAD canister in pool	21 PWR or 44 BWR commercial SNF
2-11*	Uncanistered commercial SNF	Breach of uncanistered commercial SNF assembly in pool (one drops onto another)	2 PWR or 2 BWR commercial SNF
2-12*	Uncanistered commercial SNF	Breach of uncanistered commercial SNF in pool	1 PWR or 1 BWR commercial SNF
2-13*	Combustible and non combustible LLW	Fire involving LLWF inventory	Combustible and non combustible LLW
2-14*	Uncanistered commercial SNF in truck transportation cask	Breach of a sealed truck transportation cask due to a fire	4 PWR or 9 BWR commercial SNF

NOTE: BWR = boiling water reactor; DPC = dual-purpose canister; HEPA = high-efficiency particulate air; HLW = high-level radioactive waste; LLWF = Low-Level Waste Facility; PWR = pressurized water reactor; SNF = spent nuclear fuel; TAD = transportation, aging and disposal.

Items marked with an asterisk (*) are not applicable to the CRCF.

Source: Ref. 2.2.38, Table 2

6.8.1 Event Sequence Grouping and Final Quantification

Event sequences are modeled to represent the GROA operations and SSCs. Accordingly, an event sequence is unique to a given operational activity in a given operational area, which is depicted in an ESD. When more than one initiating event (for example, the drop, collision, or other structural challenges that could affect the canister) share the same ESD (and therefore elicit the same pivotal events and the same end states), it may be necessary to quantify the event sequence for each initiating event individually because the conditional probabilities of the pivotal events depend on the specific initiating event. In such cases, the frequencies of event sequences that are represented in the same ESD, having the same path through the event tree, and having the same end state, are added together thus comprising an event sequence grouping.

For example, an ESD may show event sequences that could occur during the transfer of a canister from one container to another by the CTM in the CRCF. More than one initiating event (for example, the drop, collision, or other structural challenges that could affect the canister) may share the same ESD (and therefore elicit the same pivotal events and the same end states), but give rise to event sequences that are quantified for each initiating event because the conditional probabilities of their pivotal events depend on the specific initiating event.

By contrast, some ESDs indicate a single initiating event. Such initiating events may be composites of several individual initiating events, but because the conditional probabilities of pivotal events and the end states are the same for each of the constituents, the initiators are grouped before the event sequence quantification.

In the PCSA, event sequence grouping is performed for a given waste form configuration at the ESD level. The waste container configurations considered are as follows. Note that not all waste form configurations are applicable to the CRCF:

- Waste package
- Naval SNF canister, by itself or in a transportation cask (not applicable to CRCF)
- HLW canister, by itself or in a transportation cask
- DOE standardized canister, containing DOE owned SNF, by itself or in a transportation cask
- MCO, by itself or in a transportation cask
- TAD canister, by itself, in a transportation cask, or in an aging overpack
- DPC, by itself, in a transportation cask, or an aging overpack
- Transportation cask containing bare SNF assemblies (not applicable to CRCF)
- SNF assembly (handled in the pool of the WHF and not applicable to CRCF)
- Low-level waste (not applicable to CRCF).

In SAPHIRE (Ref. 2.2.80), the grouping of event sequences is carried out using textual instructions, designated as partitioning rules. Partitioning rules gather into a single end state the minimal cut sets from the relevant individual event sequences that need to be grouped together, and further apply a Boolean reduction to ensure that nonminimal cut sets are removed. The event sequence frequencies from this step comprise the final event sequence quantification.

An illustration of the grouping of event sequences is described in the following. The potential structural challenges to a given canister during its transfer by the CTM into the CRCF are partitioned among seven different initiating events such as canister drop, collision, drop of a heavy load on the canister, etc. The event sequences involving the canister are quantified separately seven times, once for each initiating event. After an initiating event, the event sequences that elicit the same system response and lead to the same end state (i.e., those event sequences that follow the same path on the system-response event tree) are grouped together for purposes of categorization. Thus, the seven individual event sequences initiated by a TAD canister drop, collision, etc., that eventually result in a specific end state (i.e., a filtered mitigated radionuclide release), are grouped together for the purposes of categorization as a single aggregated event sequence with a unique name termed the "event sequence group ID." Since there are five different end states that can lead to exposure of personnel to radiation (i.e., result in an end state other than "OK"), there are five aggregated event sequences involving the TAD canister, each having a unique name. The frequency of each of the five aggregated event sequences represents the sum of frequencies of the seven individual event sequences.

The uncertainties in the grouped event sequences are generated by SAPHIRE as described in Section 6.7. The logic of the grouped event sequences is applied to recalculate the output probability distribution from the input parameters such as throughput rates, equipment failure rates, passive failure probabilities, and HFEs used to calculate basic event probabilities. These probability distributions are propagated through the fault tree and event sequence logic to quantify the uncertainty in the event sequence quantification.

6.8.2 Event Sequence Categorization

Based on the resultant frequency of occurrence, the event sequences are categorized as Category 1 or Category 2, per the definitions in 10 CFR 63.2 (Ref. 2.3.2), or beyond Category 2. The categorization is done on the basis of the expected number of occurrences of each event sequence during the preclosure period. For purposes of this discussion, the expected number of occurrences of a given event sequence over the preclosure period is represented by the quantity m.

Some event sequences are not directly dependent on the duration of the preclosure period. For example, the expected number of occurrences of TAD canister drops in the CRCF over the preclosure period is essentially controlled, among other things, by the number of TAD canisters and the number of lifts of these canisters. The duration of the preclosure period is not directly relevant for this event sequence, but is implicitly built into the operations. In contrast, for other event sequences, time is a direct input. For example, seismically induced event sequences are evaluated over a period of time. In such cases, event sequences are evaluated and categorized for the time during which they are relevant.

Using the parameter m for a given event sequence, categorization is performed using the screening criteria set out in 10 CFR 63.2 (Ref. 2.3.2), as follows:

- Those event sequences that are expected to occur one or more times before permanent closure of the GROA are referred to as Category 1 event sequences (Ref. 2.3.2). Thus, a value of m greater than or equal to one means the event sequence is a Category 1 event sequence.

- Other event sequences that have at least one chance in 10,000 of occurring before permanent closure are referred to as Category 2 event sequences (Ref. 2.3.2) Thus, a value of m less than one but greater than or equal to 10^{-4}, means the event sequence is a Category 2 event sequence.

- A measure of the probability of occurrence of the event sequence over the preclosure period is given by a Poisson distribution that has a parameter taken equal to m. The probability, P, that the event sequence occurs at least one time before permanent closure is the complement to one that the event sequence occurs exactly zero times during the preclosure period. Using the Poisson distribution, $P = 1 - \exp(-m)$ (Ref. 2.2.12, p. A-3). A value of P greater than or equal to 10^{-4} implies the value of m is greater than or equal to $-\ln(1 - P) = -\ln(1 - 10^{-4})$, which is approximately equal to 10^{-4}. Thus, a value of m greater than or equal to 10^{-4}, but less than one, implies the corresponding event sequence is a Category 2 event sequence.

- Event sequences that have a value of *m* less than 10^{-4} are designated as beyond Category 2.

An uncertainty analysis is performed on *m* to determine the main characteristics of its associated probability distribution, specifically the mean 50th percentile (i.e., the median), and the standard deviation. The uncertainty analysis is performed in SAPHIRE (Section 4.2), using Monte Carlo with 10,000 samples as described in Section 4.3.6.2.

The calculations carried out to quantify an event sequence are performed using the full precision of the individual probability estimates that are used in the event sequence. However, the categorization of event sequences is based upon the expected number of occurrences over the preclosure period with one significant digit.

6.8.3 Final Event Sequence Quantification Summary

Initially, the results of the SAPHIRE event sequence gathering and quantification process are reported in a single table of all event sequences for the CRCF (Attachment G, Table G-2). Following the final categorization, the event sequences for the respective Category 2 (Table 6.8-3) and beyond Category 2 (Attachment G, Table G-3) are tabulated separately. There are no Category 1 (Table 6.8-2) events for the CRCF. As desired, other sorting may be performed. For example, event sequences that have end states important to criticality are tabulated separately (Attachment G, Table G-4).The format of the table headings and content are the same for each table as follows:

1. Event sequence group ID – assigned during the grouping process in SAPHIRE. It is composed of the event tree name (less the facility identifier, CRCF), a sequence identifier such as SEQ2 (which indicates the associated branch of the response tree), and an abbreviated end-state designator (as explained in Section 4.3-8 and in the End State column of the table).

2. End state – taken from the event tree.

3. Event sequence description – narrative to describe the initiating event(s) and pivotal events that are involved.

4. Material at risk – describes the quantity and type of waste form involved

5. Mean event sequence frequency (number of occurrences over the preclosure period).

6. Median event sequence frequency (number of occurrences over the preclosure period).

7. Standard deviation of the event sequence frequency (number of occurrences over the preclosure period).

8. Event sequence category – declaration of Category 1, Category 2, or Beyond Category 2.

9. Basis for categorization (e.g., categorization by mean frequency, or from sensitivity study for mean frequencies near a threshold as described in Section 4.3.6.2).

10. Consequence analysis – cross-reference to the bounding event number in the dose consequence analysis (Table 6.8-1) (Ref. 2.2.38, Table 2 and Section 7).

Table 6.8-2. Category 1 Final Event Sequences Summary

Event Sequence Group ID	End State	Description	Material-At-Risk	Mean	Median	Std. Dev	Event Sequence Category	Basis for Categorization	Consequence Analysis
None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Original

Table 6.8-3. Category 2 Final Event Sequences Summary

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD18-DSTD-SEQ2	Direct exposure, loss of shielding	This event sequence represents a temporary loss of shielding during CTM operations, while a DOE standardized canister is being transferred. In this sequence there are no pivotal events.	1 DOE standardized canister	3.E-01	3.E-01	1.E-01	Category 2	Mean of distribution for number of occurrences of event sequence near a category threshold. Categorization confirmed by alternative distribution	N/A[e]
ESD19-WP-TAD-SEQ3	Direct exposure, loss of shielding	This event sequence represents a direct exposure during export of a waste package containing a TAD canister. In this event sequence there are no pivotal events.	1 TAD canister	2.E-01	9.E-02	5.E-01	Category 2	Mean of distribution for number of occurrences of event sequence near a category threshold. Categorization confirmed by alternative distribution	N/A[e]
ESD20-TAD-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a thermal challenge to a TAD canister inside a transportation cask, due to a fire, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	2.E-01	2.E-01	7.E-02	Category 2	Mean of distribution for number of occurrences of event sequence near a category threshold. Categorization confirmed by alternative distribution	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD17-DPC-SEQ2	Direct exposure, loss of shielding	This event sequence represents a direct exposure during preparation activities of a transportation cask containing a DPC. In this sequence there are no pivotal events.	1 DPC	1.E-01	5.E-02	3.E-01	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD18-TAD-SEQ2	Direct exposure, loss of shielding	This event sequence represents a temporary loss of shielding during CTM operations, while a TAD canister is being transferred. In this sequence there are no pivotal events.	1 TAD canister	1.E-01	1.E-01	3.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD19-WP-H&D-SEQ3	Direct exposure, loss of shielding	This event sequence represents a direct exposure during export of a waste package containing a combination of a DOE standardized canister and HLW canisters. In this event sequence there are no pivotal events.	5 HLW canisters and 1 DOE standardized canister	9.E-02	4.E-02	2.E-01	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD18-HLW-SEQ2	Direct exposure, loss of shielding	This event sequence represents a temporary loss of shielding during CTM operations, while an HLW canister is being transferred. In this sequence there are no pivotal events.	1 HLW canister	8.E-02	8.E-02	2.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD10-WP-H&M-SEQ03-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to a combination of MCOs and HLW canisters inside a waste package, during WPTT transfer to the Waste Package Positioning Room, resulting in a filtered radionuclide release. In this sequence a canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	2 HLW canisters and 2 MCOs	7.E-02	4.E-02	9.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a and e]
ESD19-WP-TAD-SEQ2	Direct exposure, loss of shielding	This event sequence represents a direct exposure during assembly and closure of a waste package containing a TAD canister. In this event sequence there are no pivotal events.	1 TAD canister	6.E-02	3.E-02	1.E-01	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD20-HLW-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a thermal challenge to an HLW canister inside a transportation cask, due to a fire, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	5 HLW canisters	5.E-02	5.E-02	2.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD19-WP-H&D-SEQ2	Direct exposure, loss of shielding	This event sequence represents a direct exposure during assembly and closure of a waste package containing a combination of a DOE standardized canister and HLW canisters. In this event sequence there are no pivotal events.	5 HLW canisters and 1 DOE standardized canister	2.E-02	1.E-02	5.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD09-HLW-SEQ3-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to an HLW canister, during canister transfer by a CTM, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	2 HLW canisters	1.E-02	1.E-02	1.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	2-04
ESD20-DSTD-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a thermal challenge to a DOE standardized canister inside a transportation cask, due to a fire, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	9 DOE standardized canisters	1.E-02	1.E-02	4.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD06-MCO-SEQ3-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to an MCO inside a transportation cask, during CTT transfer to the Cask Unloading Room, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	4 MCOs	1.E-02	7.E-03	1.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD20-DPC-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a thermal challenge to a DPC inside a transportation cask, due to a fire, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 DPC	9.E-03	9.E-03	3.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD11-WP-H&M-SEQ03-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to a combination of MCOs and HLW canisters inside a waste package, during waste package assembly and closure, resulting in a filtered radionuclide release. In this sequence a canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	2 HLW canisters and 2 MCOs	7.E-03	6.E-03	3.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD19-WP-H&M-SEQ3	Direct exposure, loss of shielding	This event sequence represents a direct exposure during export of a waste package containing a combination of MCOs and HLW canisters. In this event sequence there are no pivotal events.	2 HLW canisters and 2 MCOs	6.E-03	3.E-03	1.E-02	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a and e]
ESD18-MCO-SEQ2	Direct exposure, loss of shielding	This event sequence represents a temporary loss of shielding during CTM operations, while an MCO is being transferred. In this sequence there are no pivotal events.	1 MCO	4.E-03	4.E-03	8.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a and e]
ESD18-DPC-SEQ2	Direct exposure, loss of shielding	This event sequence represents a temporary loss of shielding during CTM operations, while a DPC is being transferred. In this sequence there are no pivotal events.	1 DPC	3.E-03	3.E-03	6.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD20-MCO-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a thermal challenge to an MCO inside a transportation cask, due to a fire, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	4 MCOs	3.E-03	3.E-03	1.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a and e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD10-WP-H&M-SEQ05-RRU	Unfiltered radionuclide release	This event sequence represents a structural challenge to a combination of MCOs and HLW canisters inside a waste package, during WPTT transfer to the Waste Package Positioning Room, resulting in an unfiltered radionuclide release. In this sequence a canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	2 HLW canisters and 2 MCOs	3.E-03	1.E-03	6.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD09-MCO-SEQ3-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to an MCO, during canister transfer by a CTM, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	1 MCO and 1 HLW canister	2.E-03	2.E-03	2.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD19-WP-H&M-SEQ2	Direct exposure, loss of shielding	This event sequence represents a direct exposure during assembly and closure of a waste package containing a combination of MCOs and HLW canisters. In this event sequence there are no pivotal events.	2 HLW canisters and 2 MCOs	2.E-03	7.E-04	3.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a and e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD08-MCO-SEQ03-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to an MCO, due to collision between two CTMs during canister transfer, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	1 MCO and another canister	1.E-03	7.E-04	2.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD20-MCO-SEQ5-RRU	Unfiltered radionuclide release	This event sequence represents a thermal challenge to an MCO, due to a fire, resulting in an unfiltered radionuclide release. In this sequence the canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	4 MCOs	9.E-04	8.E-04	4.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD09-HLW-SEQ5-RRU	Unfiltered radionuclide release	This event sequence represents a structural challenge to an HLW canister, during canister transfer by a CTM, resulting in an unfiltered radionuclide release. In this sequence the canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	2 HLW canisters	6.E-04	3.E-04	1.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	2-04

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD05-TAD-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister, during aging overpack preparation activities, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	5.E-04	2.E-04	1.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD06-MCO-SEQ5-RRU	Unfiltered radionucli de release	This event sequence represents a structural challenge to an MCO inside a transportation cask, during CTT transfer to the Cask Unloading Room, resulting in an unfiltered radionuclide release. In this sequence the canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	4 MCOs	5.E-04	2.E-04	1.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]
ESD12-TAD-SEQ02-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister inside an aging overpack, during aging overpack assembly and closure, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	4.E-04	1.E-04	1.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD06-TAD-SEQ2-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister inside a transportation cask or aging overpack, during CTT or site transporter transfer to the Cask Unloading Room, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	4.E-04	7.E-05	2.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD11-WP-H&M-SEQ05-RRU	Unfiltered radionuclide release	This event sequence represents a structural challenge to a combination of MCOs and HLW canisters inside a waste package, during waste package assembly and closure, resulting in an unfiltered radionuclide release. In this sequence a canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	2 HLW canisters and 2 MCOs	3.E-04	2.E-04	4.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD14-TAD-SEQ02-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister inside an aging overpack, during transfer from Cask Unloading Room to Cask Preparation Room, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	3.E-04	6.E-05	4.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD02-TAD-SEQ02-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister inside an aging overpack, during receipt activities, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	3.E-04	7.E-05	2.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]
ESD16-TAD-SEQ02-DE	Direct exposure, loss of shielding	This event sequence represents a structural challenge to a TAD canister inside an aging overpack, during export activities, resulting in a direct exposure from loss of shielding. In this sequence the canister remains intact, and the shielding fails.	1 TAD canister	3.E-04	6.E-05	2.E-03	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[e]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD09-TAD-SEQ3-RRF	Filtered radionuclide release	This event sequence represents a structural challenge to a TAD canister, during canister transfer by a CTM, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	1 TAD canister	1.E-04	5.E-05	2.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	2-09
ESD09-MCO-SEQ5-RRU	Unfiltered radionuclide release	This event sequence represents a structural challenge to an MCO, during canister transfer by a CTM, resulting in an unfiltered radionuclide release. In this sequence the canister fails, the confinement boundary fails, and a moderator is excluded from entering the canister.	1 MCO and 1 HLW canister	1.E-04	5.E-05	2.E-04	Category 2	Mean of distribution for number of occurrences of event sequence	N/A[a]

Table 6.8-3. Category 2 Final Event Sequences Summary (Continued)

Event Sequence Group ID[a]	End State	Description	Material-At-Risk[b]	Mean[c]	Median[c]	Std. Dev[c]	Event Sequence Cat.	Basis for Categorization	Consequence Analysis[d]
ESD20-MCO-SEQ3-RRF	Filtered radionuclide release	This event sequence represents a thermal challenge to an MCO, due to a fire, resulting in a filtered radionuclide release. In this sequence the canister fails, the confinement boundary remains intact, and a moderator is excluded from entering the canister.	4 MCOs	7.E-05	7.E-05	3.E-05	Category 2	Mean of distribution for number of occurrences of event sequence near a category threshold. Recategorization to higher category by alternative distribution	N/A[a]

NOTE: [a] The expected number of occurrences, over the preclosure period, of event sequences involving MCOs may not lead to an acceptable categorization with regard to 10 CFR 63.111 (Ref. 2.3.2180319) performance objectives. Therefore, further investigation of these event sequences may be needed. As a consequence, the categorization of event sequences involving MCOs is considered to be preliminary and no bounding event number for consequence analyses is provided.

[b] The material at risk is, as relevant, based upon the nominal capacity of the waste form container involved in the event sequence under consideration, or accounts for the specific operation covered by the event sequence.

[c] The mean, median, and standard deviation displayed are for the number of occurrences, over the preclosure period, of the event sequence under consideration.

[d] The bounding event number provided in this column identifies the bounding Category 2 event sequence identified in Table 6.8-1 from Preclosure Consequence Analyses Ref. 2.2.38,18011 Table 2 that results in dose consequences that bound the event sequence under consideration.

[e] Because of the great distances to the locations of the offsite receptors, doses to members of the public from direct radiation after a Category 2 event sequence are reduced by more than 13 orders of magnitude to insignificant levels (GROA External Dose Rate Calculation, Ref. 2.2.25). (Preclosure Consequence Analyses)

CTM = canister transfer machine; CTT = cask transfer trolley; DOE = U.S. Department of Energy; DPC = dual-purpose canister; HLW = high-level radioactive waste; MCO = multicanister overpack; ST = site transporter; TAD = transportation, aging, and disposal; TC = transportation cask; WP = waste package; WPTT = waste package transfer trolley.

Source: Original

6.9 IMPORTANT TO SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS AND PROCEDURAL SAFETY CONTROL REQUIREMENTS

The results of the PCSA are used to define design bases for repository SSCs to prevent or mitigate event sequences that could lead to the release of radioactive material and/or result in radiological exposure of workers or the public. Potential releases of radioactive material are minimized to ensure resulting worker and public exposures to radiation are below the limits established by 10 CFR 63.111 Ref. 2.3.2. This strategy requires using prevention features in the repository design wherever reasonable. This strategy is implemented by performing the PCSA as an integral part of the design process in a manner consistent with a performance-based, risk-informed philosophy. This integral design approach ensures the ITS design features and operational controls are selected in a manner that ensures safety while minimizing design and operational complexity through the use of proven technology. Using this strategy, design rules are developed to provide guidance on the safety classification of SSCs. The following information is developed in order to implement this strategy:

- Essential safety functions needed to ensure worker and public safety
- SSCs relied upon to ensure essential safety functions
- Design criteria that will ensure that the essential safety functions will be performed with a high degree of reliability and margin of safety
- Administrative and procedural safety controls that, in conjunction with the repository design ensure operations are conducted within the limits of the PCSAs.

Section 6.9.1 identifies ITS SSCs and Section 6.9.2 identifies the procedural safety controls.

6.9.1 Important to Safety Structures, Systems, and Components

Table 6.9-1 contains the nuclear safety design bases for the CRCF ITS SSCs. The first three columns identify the ITS system or facility, subsystem and component. The fourth column identifies the safety function relied upon in the event sequence analysis. The fifth column provides the characteristics of the safety function (i.e., controlling parameter or value) that is demonstrated to occur or exist in the design. The sixth column provides an event sequence in which, the safety function and the characteristic is relied upon. The seventh column provides the source, usually a fault tree, for the controlling parameter or value. The seventh column provides the source for the controlling parameter or value. It is either a fault tree or basic event. If it is a fault tree, it can be found in the reliability model provided in Attachment A. If it is a basic event, it can be traced to section 6.3 of this report.

6.9.2 Procedural Safety Controls

Procedural safety controls (PSCs) are the controls that are relied upon to limit or prevent potential event sequences or mitigate their consequences. For this analysis, all PSCs were derived to reduce the initiating event sequence to an acceptable level.

Table 6.9-2 lists the PSCs that are required to support the event sequence analysis and categorization. The event sequence column identifies a representative event sequence that relies upon the PSC.

Table 6.9-1 Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
Aging facility (AP)	Aging Handling / Cask Transfer	Site Transporter (170-HAT0-MEQ-00001)	Protect against[a] spurious movement	1. The mean probability of spurious movement of the ST while the canister is being lifted or lowered shall be less than or equal to 1E-9[b] per transfer.	CRCF-ESD09-TAD (Seq. 4-3)	060-9-ST-SPURMOVE
			Limit speed	2. The speed of the site transporter shall be limited to 2.5 mi/hr.	CRCF-ESD06-TAD (Seq. 4-4)	This parameter limits the conditional probability of cask breach given a collision to the appropriate value from Table 6.3-7.
			Preclude fuel tank explosion	3. The site transporter fuel tank shall preclude fuel tank explosions.	Initiating event does not require further analysis[c].	Table 6.0-2.
			Reduce severity of a drop	4. The site transporter shall preclude a drop of an aging overpack from a height greater than 3 ft measured from the equipment base.	CRCF-ESD16-DPC (Seq. 3-3)	This parameter limits the conditional probability of canister breach given a drop to the appropriate value from Table 6.3-7.
	Aging Handling/Aging Overpack	Aging Overpack (TAD: [170-HAC0-ENCL-00003])	Protect against direct exposure to personnel[a]	5. The mean conditional probability of loss of shielding of the aging overpack resulting from an impact or collision shall be less than or equal to 1E-5 per impact.	CRCF-ESD02-TAD (Seq. 2-2)	AO_SHIELDING
		(Vertical DPC:[170-HAC0-INCL-00002])		6. The mean conditional probability of loss of shielding of the aging overpack resulting from a drop shall be less than or equal to 5E-6 per drop.	CRCF-ESD16-TAD (Seq. 3-2)	AO_SHIELDING

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
Canister Receipt and Closure Facility (CR)	Canister Receipt and Closure Facility (CRCF)	Shield doors (including anchorages) and equipment confinement doors	Protect against[a] direct exposure of personnel	7. Equipment and personnel shield doors shall have a mean probability of inadvertent opening of less than or equal to 1E-7 per waste container handled.	CRCF-ESD18-TAD (Seq. 2)	060-18-SHLDDR-DIRCT-EXP
			Preclude collapse onto waste containers	8. An equipment shield door falling onto a waste container as a result of impact from a conveyance shall be precluded.	Initiating event does not require further analysis[c]	Table 6.0-2
			Mitigate the consequences of radionuclide release	9. The mean probability that the HVAC system in the CRCF confinement areas becomes unavailable (during a 30-day mission time following a radionuclide release) due to the simultaneous opening of an equipment confinement door and a cask unloading room shield door, shall be less than or equal to 3E-07.	CRCF-ESD09-TAD (Seq. 3-5)	HAVAC013
		DOE Canister Slide Gates (060-HTC0-HTCH-00005, 6, 7, 8, 9)	Protect against[a] dropping a canister due to a spurious closure of the slide gate	10. The mean probability of a canister drop resulting from a spurious closure of the slide gate shall be less than or equal to 2E-6 per transfer.	CRCF-ESD09-DSTD (Seq. 3-3)	GATE-36-109 OF CTM-DROP---ALL-HEIGHTS
			Protect against[a] direct exposure to personnel	11. The mean probability of occurrence of an inadvertent opening of a slide gate shall be less than or equal to 4E-9 per transfer.	CRCF-ESD18-DSTD (Seq. 2)	060-18-SLIDE-GATE-DIR-EX

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases: Safety Function	Nuclear Safety Design Bases: Controlling Parameters and Values	Representative Affiliated Event Sequence (Sequence Number)	Source
Canister Receipt and Closure Facility (CR) (Continued)	Canister Receipt and Closure Facility (CRCF) (Continued)	DOE Canister Slide Gates (060-HTC0-HTCH-00005, 6, 7, 8, 9) (Continued)	Preclude canister breach	12. Closure of the slide gate shall be incapable of breaching a canister.	Initiating event does not require further analysis[c]	Table 6.0-2
		Cask port slide gates (060-HTC0-HTCH-00001, 2)	Protect against[a] dropping a canister due to a spurious closure of the slide gate	13. The mean probability of a canister drop resulting from a spurious closure of the slide gate shall be less than or equal to 2E-6 per transfer.	CRCF-ESD09-HLW (Seq. 3-3)	GATE-36-109 OF CTM-DROP---ALL-HEIGHTS
			Protect against[a] direct exposure to personnel	14. The mean probability of occurrence of an inadvertent opening of a slide gate shall be less than or equal to 4E-9 per transfer.	CRCF-ESD18-TAD (Seq. 2)	060-18-SLIDE-GATE-DIR-EX
			Preclude canister breach	15. Closure of the slide gate shall be incapable of breaching a canister.	Initiating event does not require further analysis[c]	Table 6.0-2
		TAD canister slide gates (060-HTC0-HTCH-00010, 11)	Protect against[a] dropping a canister due to a spurious closure of the slide gate	16. The mean probability of a canister drop resulting from a spurious closure of the slide gate shall be less than or equal to 2E-6 per transfer.	CRCF-ESD09-TAD (Seq. 3-3)	GATE-36-109 OF CTM-DROP---ALL-HEIGHTS
			Protect against[a] direct exposure to personnel	17. The mean probability of occurrence of an inadvertent opening of a slide gate shall be less than or equal to 4E-9 per transfer.	CRCF-ESD18-TAD (Seq. 2)	060-18-SLIDE-GATE-DIR-EX
			Preclude canister breach	18. Closure of the slide gate shall be incapable of breaching a canister.	Initiating event does not require further analysis[c]	Table 6.0-2

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
Canister Receipt and Closure Facility (CR) (Continued)	Canister Receipt and Closure Facility (CRCF) (Continued)	Waste package port slide gates (060-HTC0-HTCH-00003, 4)	Protect against[a] dropping a canister due to a spurious closure of the slide gate	19. The mean probability of a canister drop resulting from a spurious closure of the slide gate shall be less than or equal to 2E-6 per transfer.	CRCF-ESD09-HLW (Seq. 3-3)	GATE-36-109 OF CTM-DROP---ALL-HEIGHTS
			Protect against[a] direct exposure to personnel	20. The mean probability of occurrence of an inadvertent opening of a slide gate shall be less than or equal to 4E-9 per transfer.	CRCF-ESD18-TAD (Seq. 2)	060-18-SLIDE-GATE-DIR-EX
			Preclude canister breach	21. Closure of the slide gate shall be incapable of breaching a canister.	Initiating event does not require further analysis[c]	Table 6.0-2
			Preclude canister drop onto floor	22. The waste package port slide gate shall be incapable of opening without a waste package transfer trolley with waste package in position to receive a canister.	Initiating event does not require further analysis[c]	Table 6.0-2
DOE and commercial waste package system (DS)	DOE and commercial waste package	Entire	Provide containment	23. The mean conditional probability of breach of a sealed waste package resulting from a side impact shall be less than or equal to 1E-08 per impact.	CRCF-ESD13-WP-TAD (Seq. 2-4)	13-WP_FAIL_COLLISION
				24. The mean conditional probability of breach of a sealed waste package resulting from a drop of a load onto the waste package shall be less than or equal to 1E-05 per drop.	CRCF-ESD15-WP-TAD (Seq. 3-4)	15-WP_FAIL_DROPON

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	**Controlling Parameters and Values**		
DOE and commercial waste package system (DS) (Continued)	DOE and commercial waste package (Continued)	Entire (Continued)	Provide containment (Continued)	25. The mean conditional probability of breach of a sealed waste package resulting from an end-on impact or collision shall be less than or equal to 1E-05 per impact.	CRCF-ESD15-WP-TAD (Seq. 3-4)	15-WP_FAIL_ DROPON
	Defense high-level waste/DOE SNF codisposal	DOE Standardized canister	Provide containment	26. The mean conditional probability of breach of a DOE standardized canister resulting from a drop of the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DSTD (Seq. 3-3)	09-DSTD-FAIL-DROP
				27. The mean conditional probability of breach of a DOE standardized canister resulting from a drop of a load onto the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DSTD (Seq. 6-3)	09-DSTD-FAIL-DROPON
				28. The mean conditional probability of breach of a DOE standardized canister resulting from a side impact or collision shall be less than or equal to 1E-8 per impact.	CRCF-ESD10-WP-H&D (Seq. 3-3)	10-H&D-FAIL-WPTT-COLLIDE
				29. The mean conditional probability of breach of a DOE standardized canister contained within a waste package resulting from the spectrum of fires shall be less than or equal to 3E-4 per fire event.	CRCF-ESD20-WP-H&D (Seq. 3-3)	060-H&D-WP-CAN-FAIL-LOR

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
DOE and commercial waste package system (DS) (Continued)	Defense high-level waste/DOE SNF codisposal (Continued)	DOE Standardized canister (Continued)	Provide containment (Continued)	30. The mean conditional probability of breach of a DOE standardized canister contained within a transportation cask or staging area resulting from the spectrum of fires shall be less than or equal to 2E-6 per fire event.	CRCF-ESD20-DSTD (Seq. 5-5)	060-DSTD-FAIL-TC-DIESEL; 060-DSTD-FAIL-TC-NODIES; 060-DSTD-FAILURE-SA
				31. The mean conditional probability of breach of a DOE standardized canister located within the CTM Shield Bell resulting from the spectrum of fires shall be less than or equal to 1E-4 per fire event.	CRCF-ESD20-DSTD (Seq. 5-5)	060-DSTD-FAIL-CTM
				32. The mean conditional probability of breach of a DOE standardized canister, given the drop of an HLW canister onto the DOE standardized canister, shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DSTD (Seq. 6-3)	09-DSTD-FAIL-DROPON
				33. The mean conditional probability of breach of a DOE standardized canister, given the drop of another DOE standardized canister onto the first canister, shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DSTD (Seq. 6-3)	09-DSTD-FAIL-DROPON
		HLW canister	Provide containment	34. The mean conditional probability of breach of a HLW canister resulting from a drop of the canister shall be less than or equal to 3E-2 per drop.	CRCF-ESD09-HLW (Seq. 3-3)	09-HLW-FAIL-DROP

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
DOE and commercial waste package system (DS) (Continued)	Defense high-level waste/DOE SNF codisposal (Continued)	HLW canister (Continued)	Provide containment (Continued)	35. The mean conditional probability of breach of a HLW canister resulting from a drop of a load onto the canister shall be less than or equal to 3E-2 per drop	CRCF-ESD09-HLW (Seq. 6-3)	09-HLW-FAIL-DROPON
				36. The mean conditional probability of breach of a HLW canister resulting from a side impact or collision shall be less than or equal to 1E-8 per impact.	CRCF-ESD10-WP-H&D (Seq. 3-3)	10-H&D-FAIL-WPTT-COLLIDE
				37. The mean conditional probability of breach of a HLW canister contained within a waste package resulting from the spectrum of fires shall be less than or equal to 3E-4 per fire event.	CRCF-ESD20-WP-H&D (Seq. 3-3)	060-H&D-WP-CAN-FAIL-LOR
				38. The mean conditional probability of breach of a HLW canister contained within a transportation cask resulting from the spectrum of fires shall be less than or equal to 2E-6 per fire event.	CRCF-ESD20-HLW (Seq. 5-5)	060-HLW-CAN-FAIL-WD; 060-HLW-CAN-FAIL-WOD
				39. The mean conditional probability of breach of a HLW canister located within the CTM Shield Bell resulting from the spectrum of fires shall be less than or equal to 1E-4 per fire event.	CRCF-ESD20-HLW (Seq. 5-5)	060-HLW-CTM-FAIL

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
DOE and commercial waste package system (DS) (Continued)	Defense high-level waste/DOE SNF codisposal (Continued)	HLW canister (Continued)	Provide containment (Continued)	40. The mean conditional probability of breach of an HLW canister, given the drop of a DOE standardized canister onto the HLW canister, shall be less than or equal to 3E-2 per drop.	CRCF-ESD09-HLW (Seq. 6-3)	09-HLW-FAIL-DROPON
				41. The mean conditional probability of breach of an HLW canister, given the drop of another HLW canister onto the first canister, shall be less than or equal to 3E-2 per drop.	CRCF-ESD09-HLW (Seq. 6-3)	09-HLW-FAIL-DROPON
	Canistered spent nuclear fuel	Dual-purpose canister (analyzed as a representative canister)	Provide containment	42. The mean conditional probability of breach of a canister resulting from a drop of the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DPC (Seq. 3-3)	09-CAN-FAIL-DROP
				43. The mean conditional probability of breach of a canister resulting from a drop of a load onto the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-DPC (Seq. 6-3)	09-CAN-FAIL-DROPON
				44. The mean conditional probability of breach of a canister resulting from a side impact or collision shall be less than or equal to 1E-8 per impact	CRCF-ESD14-DPC (Seq. 2-3)	14-DPC_ST-COLLISION

Table 6.9-1. Preclosure Nuclear Safety Design Bases for the CRCF ITS SSCs (Continued)

System or Facility (System Code)	Subsystem (As Applicable)	Component	Nuclear Safety Design Bases		Representative Affiliated Event Sequence (Sequence Number)	Source
			Safety Function	Controlling Parameters and Values		
DOE and commercial waste package system (DS) (Continued)	Canistered spent nuclear fuel (Continued)	Dual-purpose canister (analyzed as a representative canister) (Continued)	Provide containment (Continued)	45. The mean conditional probability of breach of a canister contained within a cask resulting from the spectrum of fires shall be less than or equal to 2E-6 per fire event.	CRCF-ESD20-DPC (Seq. 5-5)	060-DPC-TC-FAIL-DIES; 060-DPC-TC-FAIL-NODIES
				46. The mean conditional probability of breach of a canister contained within an aging overpack resulting from the spectrum of fires shall be less than or equal to 1E-6 per fire event.	CRCF-ESD20-DPC (Seq. 5-5)	060-DPC-AO-FAIL-DIES
				47. The mean conditional probability of breach of a canister located within the CTM Shield Bell resulting from the spectrum of fires shall be less than or equal to 1E-4 per fire event.	CRCF-ESD20-DPC (Seq. 4-3)	060-DPC-CTM-CAN-FAIL
		TAD canister (analyzed as a representative canister)	Provide containment	48. The mean conditional probability of breach of a canister resulting from a drop of the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD09-TAD (Seq. 3-3)	09-CAN-FAIL-DROP
				49. The mean conditional probability of breach of a canister resulting from a drop of a load onto the canister shall be less than or equal to 1E-5 per drop.	CRCF-ESD11-WP-TAD (Seq. 3-3)	11-CAN-FAIL-WP-DROPON