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Table F5.7-4. Localized Fire Initiating Event Frequencies

Localized Fires That Threatens Waste Form																
Contributions from Rooms Containing Waste Form																
Room of Origin (includes comments field as needed)	**Ignition Source (If Applicable)**	**Number in Room**	**Frequency per Unit (50 years)**	**Number at Target**	**Number Near Target**	**Propagation Probability to Target**	**Number Away from Target**	**Propagation Probability to Target**	**Target Exposure Time (Fraction)**	**Contribution to IE Frequency (50 years)**	**Target Exposure Time (Fraction)**	**Contribution to IE Frequency (50 years)**	**Target Exposure Time (Fraction)**	**Contribution to IE Frequency (50 years)**	**Target Exposure Time (Fraction)**	**Contribution to IE Frequency (50 years)**
Entry represents a vulnerability due to the WP Transfer Trolley									**TAD**		**HLW**		**HLW & DOE-SNF**			
1018, 2004 & 2007	Electrical	0	1.16E-03			0.211		0.061	9.6E-05	0.0E+00	1.3E-05	0.0E+00	9.8E-05	0.0E+00		
	HVAC	2	4.64E-03			0.211	2	0.061	9.6E-05	5.5E-08	1.3E-05	7.2E-09	9.8E-05	5.6E-08		
	Mechanical Equipment	21.4	7.57E-03	2.4		0.211	19	0.061	9.6E-05	2.6E-06	1.3E-05	3.4E-07	9.8E-05	2.6E-06		
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	9.6E-05	0.0E+00	1.3E-05	0.0E+00	9.8E-05	0.0E+00		
	Torches, welders, burners	956	5.87E-04	946		0.211	10	0.061	9.6E-05	5.3E-05	1.3E-05	7.0E-06	9.8E-05	5.4E-05		
	Internal combustion engines	0	3.89E-04			0.211		0.061	9.6E-05	0.0E+00	1.3E-05	0.0E+00	9.8E-05	0.0E+00		
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	9.6E-05	0.0E+00	1.3E-05	0.0E+00	9.8E-05	0.0E+00		
	Portable Equipment	4	6.29E-03	1		0.211	3	0.061	9.6E-05	7.2E-07	1.3E-05	9.4E-08	9.8E-05	7.3E-07		
	No equipment involved	4307	2.53E-05	213	120	0.211	3974	0.061	9.6E-05	1.2E-06	1.3E-05	1.5E-07	9.8E-05	1.2E-06		
Propagation from rooms in Fire Zone																
1016			8.46E-04			0.057			9.6E-05	4.7E-09	1.3E-05	6.1E-10	9.8E-05	4.8E-09		
1017			9.40E-04			0.057			9.6E-05	5.2E-09	1.3E-05	6.8E-10	9.8E-05	5.3E-09		
1019			2.98E-02			0.057			9.6E-05	1.6E-07	1.3E-05	2.2E-08	9.8E-05	1.7E-07		
1020			8.46E-04			0.057			9.6E-05	4.7E-09	1.3E-05	6.1E-10	9.8E-05	4.8E-09		
1021			7.75E-04			0.057			9.6E-05	4.3E-09	1.3E-05	5.6E-10	9.8E-05	4.4E-09		
2003			3.20E-02			0.057			9.6E-05	1.8E-07	1.3E-05	2.3E-08	9.8E-05	1.8E-07		
2003A			4.89E-04			0.057			9.6E-05	2.7E-09	1.3E-05	3.5E-10	9.8E-05	2.8E-09		
2007A			1.74E-02			0.057			9.6E-05	9.6E-08	1.3E-05	1.3E-08	9.8E-05	9.8E-08		
2007B			6.97E-03			0.057			9.6E-05	3.9E-08	1.3E-05	5.0E-09	9.8E-05	3.9E-08		
2011			3.23E-02			0.057			9.6E-05	1.8E-07	1.3E-05	2.3E-08	9.8E-05	1.8E-07		
2011A			4.79E-04			0.057			9.6E-05	2.6E-09	1.3E-05	3.5E-10	9.8E-05	2.7E-09		
Localized Fire Threatens Waste Form in WP in Positioning/Closure Room																
	Localized Fire Threatens TAD in WP in Positioning/Closure Room									**5.9E-05**						
	Localized Fire Threatens HLW in WP in Positioning/Closure Room											**7.7E-06**				
	Localized Fire Threatens HLW and DOE-SNF in WP in Positioning/Closure Room													**6.0E-05**		
Entry represents a vulnerability due to the Transportation Emplacement Vehicle									**TAD**		**HLW & DOE-SNF**					
1015 & 1014	Electrical	1	1.16E-03	1		0.211		0.061	1.2E-06	1.4E-09	1.2E-06	1.4E-09				
	HVAC	4	4.64E-03	2	2	0.211		0.061	1.2E-06	1.3E-08	1.2E-06	1.3E-08				
	Mechanical Equipment	11.2	7.57E-03	11.2		0.211		0.061	1.2E-06	1.0E-07	1.2E-06	1.0E-07				
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	1.2E-06	0.0E+00	1.2E-06	0.0E+00				
	Torches, welders, burners	0	5.87E-04			0.211		0.061	1.2E-06	0.0E+00	1.2E-06	0.0E+00				
	Internal combustion engines	0	3.89E-04			0.211		0.061	1.2E-06	0.0E+00	1.2E-06	0.0E+00				
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	1.2E-06	0.0E+00	1.2E-06	0.0E+00				
	Portable Equipment	3	6.29E-03	3		0.211		0.061	1.2E-06	2.2E-08	1.2E-06	2.2E-08				
	No equipment involved	1711	2.53E-05	880	300	0.211	531	0.061	1.2E-06	2.9E-08	1.2E-06	2.9E-08				
Localized Fire Threatens Waste Form in TEV in Loadout Room																
	Localized Fire Threatens TAD/WP in TEV in Loadout Room									**1.7E-07**						
	Localized Fire Threatens HLW and DOE-SNF in WP in TEV in Loadout Room											**1.7E-07**				

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Table F5.7-4. Localized Fire Initiating Event Frequencies (Continued)

Room of Origin (includes comments field as needed)	Ignition Source (If Applicable)	Number in Room	Frequency per Unit (50 years)	Number at Target	Number Near Target	Propagation Probability to Target	Number Away from Target	Propagation Probability to Target	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)
Entry represents a vulnerability due to the WP Transfer Trolley									**TAD**		**HLW & DOE-SNF**					
1015	Electrical	1	1.16E-03	1		0.211		0.061	7.1E-06	8.2E-09	7.1E-06	8.2E-09				
	HVAC	2	4.64E-03		2	0.211		0.061	7.1E-06	1.4E-08	7.1E-06	1.4E-08				
	Mechanical Equipment	9.2	7.57E-03	9.2		0.211		0.061	7.1E-06	4.9E-07	7.1E-06	4.9E-07				
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	7.1E-06	0.0E+00	7.1E-06	0.0E+00				
	Torches, welders, burners	0	5.87E-04			0.211		0.061	7.1E-06	0.0E+00	7.1E-06	0.0E+00				
	Internal combustion engines	0	3.89E-04			0.211		0.061	7.1E-06	0.0E+00	7.1E-06	0.0E+00				
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	7.1E-06	0.0E+00	7.1E-06	0.0E+00				
	Portable Equipment	2	6.29E-03	1	1	0.211	0	0.061	7.1E-06	5.4E-08	7.1E-06	5.4E-08				
	No equipment involved	1326	2.53E-05	430	250	0.211	646	0.061	7.1E-06	9.3E-08	7.1E-06	9.3E-08				
Localized Fire Threatens Waste Form in WP in Loadout Room																
	Localized Fire Threatens TAD in WP in Loadout Room									**6.6E-07**						
	Localized Fire Threatens HLW and DOE-SNF in WP in Loadout Room											**6.6E-07**				
Entry represents a vulnerability due to the Cask Transfer Trolley									**TAD**		**HLW**		**DOE-SNF**		**TC/DPC (VTC)**	
1023	Electrical	0	1.16E-03			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	HVAC	0	4.64E-03			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	Mechanical Equipment	1.05	7.57E-03	1.05		0.211		0.061	3.3E-06	2.7E-08	1.3E-05	1.1E-07	2.1E-05	1.7E-07	1.8E-06	1.4E-08
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	Torches, welders, burners	0	5.87E-04			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	Internal combustion engines	0	3.89E-04			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	3.3E-06	0.0E+00	1.3E-05	0.0E+00	2.1E-05	0.0E+00	1.8E-06	0.0E+00
	Portable Equipment	1	6.29E-03	1		0.211		0.061	3.3E-06	2.1E-08	1.3E-05	8.4E-08	2.1E-05	1.3E-07	1.8E-06	1.1E-08
	No equipment involved	78	2.53E-05	30	48	0.211	0	0.061	3.3E-06	3.4E-09	1.3E-05	1.4E-08	2.1E-05	2.1E-08	1.8E-06	1.8E-09
Propagation from rooms in Fire Zone																
1022			7.05E-04			0.057			3.3E-06	1.4E-10	1.3E-05	5.4E-10	2.1E-05	8.5E-10	1.8E-06	7.2E-11
1024			1.62E-02			0.057			3.3E-06	3.1E-09	1.3E-05	1.2E-08	2.1E-05	2.0E-08	1.8E-06	1.7E-09
1025			7.05E-04			0.057			3.3E-06	1.4E-10	1.3E-05	5.4E-10	2.1E-05	8.5E-10	1.8E-06	7.2E-11
1026			2.82E-01			0.057			3.3E-06	5.4E-08	1.3E-05	2.2E-07	2.1E-05	3.4E-07	1.8E-06	2.9E-08
Localized Fire Threatens Waste Form on CTT in Unloading Room																
	Localized Fire Threatens TC/TAD on CTT in Unloading Room									**1.1E-07**						
	Localized Fire Threatens TC/HLW on CTT in Unloading Room											**4.3E-07**				
	Localized Fire Threatens TC/DOE-SNF on CTT in Unloading Room													**6.8E-07**		
	Localized Fire Threatens TC/DPC (VTC) in Cask Unloading Room															**5.8E-08**

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Table F5.7-4. Localized Fire Initiating Event Frequencies (Continued)

Room of Origin (includes comments field as needed)	Ignition Source (If Applicable)	Number in Room	Frequency per Unit (50 years)	Number at Target	Number Near Target	Propagation Probability to Target	Number Away from Target	Propagation Probability to Target	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)
Entry represents a vulnerability due to the Site Transporter									**TAD**		**DPC (VTC)**					
1023	Electrical	0	1.16E-03			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	HVAC	0	4.64E-03			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	Mechanical Equipment	1.05	7.57E-03	1.05		0.211		0.061	3.5E-06	2.8E-08	3.3E-06	2.6E-08				
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	Torches, welders, burners	0	5.87E-04			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	Internal combustion engines	0	3.89E-04			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	3.5E-06	0.0E+00	3.3E-06	0.0E+00				
	Portable Equipment	1	6.29E-03	1		0.211		0.061	3.5E-06	2.2E-08	3.3E-06	2.1E-08				
	No equipment involved	78	2.53E-05	30	48	0.211	0	0.061	3.5E-06	3.6E-09	3.3E-06	3.4E-09				
Propagation from rooms in Fire Zone																
1022			7.05E-04			0.057			3.5E-06	1.4E-10	3.3E-06	1.3E-10				
1024			1.62E-02			0.057			3.5E-06	3.3E-09	3.3E-06	3.1E-09				
1025			7.05E-04			0.057			3.5E-06	1.4E-10	3.3E-06	1.3E-10				
1026			2.82E-01			0.057			3.5E-06	5.7E-08	3.3E-06	5.4E-08				
Localized Fire Threatens Waste Form in AO in Unloading Room (Diesel Present)																
	Localized Fire Threatens TAD in AO in Unloading Room (Diesel Present)									**1.1E-07**						
	Localized Fire Threatens DPC (VTC) in AO in Unloading Room (Diesel Present)											**1.1E-07**				
Entry represents a vulnerability due to the Site Prime Mover (Diesel Present)									**TAD**		**HLW**		**DOE-SNF**		**TC/DPC (VTC)**	
1026	Electrical	1	1.16E-03	1		0.211		0.061	2.1E-06	2.4E-09	2.1E-06	2.5E-09	2.1E-06	2.5E-09	2.1E-06	2.5E-09
1036	HVAC	4	4.64E-03	4		0.211		0.061	2.1E-06	3.8E-08	2.1E-06	4.0E-08	2.1E-06	4.0E-08	2.1E-06	4.0E-08
1036A	Mechanical Equipment	19.9	7.57E-03	4	15.9	0.211		0.061	2.1E-06	1.1E-07	2.1E-06	1.2E-07	2.1E-06	1.2E-07	2.1E-06	1.2E-07
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00
	Torches, welders, burners	0	5.87E-04			0.211		0.061	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00
	Internal combustion engines	190	3.89E-04	190		0.211		0.061	2.1E-06	1.5E-07	2.1E-06	1.6E-07	2.1E-06	1.6E-07	2.1E-06	1.6E-07
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00	2.1E-06	0.0E+00
	Portable Equipment	4	6.29E-03	2		0.211	2	0.061	2.1E-06	2.7E-08	2.1E-06	2.8E-08	2.1E-06	2.8E-08	2.1E-06	2.8E-08
	No equipment involved	2591	2.53E-05	1526	120	0.211	945	0.061	2.1E-06	8.4E-08	2.1E-06	8.7E-08	2.1E-06	8.7E-08	2.1E-06	8.7E-08
Propagation from rooms in Fire Zone					208											
1022			7.05E-04			0.057			2.1E-06	8.3E-11	2.1E-06	8.6E-11	2.1E-06	8.6E-11	2.1E-06	8.6E-11
1023			1.62E-02			0.057			2.1E-06	1.9E-09	2.1E-06	2.0E-09	2.1E-06	2.0E-09	2.1E-06	2.0E-09
1024			1.62E-02			0.057			2.1E-06	1.9E-09	2.1E-06	2.0E-09	2.1E-06	2.0E-09	2.1E-06	2.0E-09
1025			7.05E-04			0.057			2.1E-06	8.3E-11	2.1E-06	8.6E-11	2.1E-06	8.6E-11	2.1E-06	8.6E-11
Localized Fire Threatens Waste Form in Vestibule/Preparation Area w/SPM (Diesel Present)																
	Localized Fire Threatens TC/TAD in Vestibule/Preparation Area w/SPM (Diesel Present)									**4.2E-07**						
	Localized Fire Threatens TC/HLW in Vestibule/Preparation Area w/SPM (Diesel Present)											**4.4E-07**				
	Localized Fire Threatens TC/DOE-SNF in Vestibule/Preparation Area w/SPM (Diesel Present)													**4.4E-07**		
	Localized Fire Threatens TC/DPC (VTC) in Vestibule/Preparation Area (Diesel Present)															**4.4E-07**

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Table F5.7-4. Localized Fire Initiating Event Frequencies (Continued)

Room of Origin (includes comments field as needed)	Ignition Source (If Applicable)	Number in Room	Frequency per Unit (50 years)	Number at Target	Number Near Target	Propagation Probability to Target	Number Away from Target	Propagation Probability to Target	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)
Entry represents a vulnerability due to the Railcar (No Diesel Present)									**TAD**		**HLW**		**DOE-SNF**		**TC/DPC (VTC)**	
1026	Electrical	1	1.16E-03	1		0.211		0.061	1.5E-05	1.7E-08	1.8E-05	2.1E-08	1.5E-05	1.7E-08	1.3E-05	1.5E-08
1036	HVAC	4	4.64E-03	4		0.211		0.061	1.5E-05	2.8E-07	1.8E-05	3.3E-07	1.5E-05	2.8E-07	1.3E-05	2.4E-07
1036A	Mechanical Equipment	19.9	7.57E-03	4	15.9	0.211		0.061	1.5E-05	8.4E-07	1.8E-05	9.9E-07	1.5E-05	8.4E-07	1.3E-05	7.3E-07
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	1.5E-05	0.0E+00	1.8E-05	0.0E+00	1.5E-05	0.0E+00	1.3E-05	0.0E+00
	Torches, welders, burners	0	5.87E-04			0.211		0.061	1.5E-05	0.0E+00	1.8E-05	0.0E+00	1.5E-05	0.0E+00	1.3E-05	0.0E+00
	Internal combustion engines	0	3.89E-04			0.211		0.061	1.5E-05	0.0E+00	1.8E-05	0.0E+00	1.5E-05	0.0E+00	1.3E-05	0.0E+00
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	1.5E-05	0.0E+00	1.8E-05	0.0E+00	1.5E-05	0.0E+00	1.3E-05	0.0E+00
	Portable Equipment	4	6.29E-03	2		0.211	2	0.061	1.5E-05	2.0E-07	1.8E-05	2.4E-07	1.5E-05	2.0E-07	1.3E-05	1.8E-07
	No equipment involved	2591	2.53E-05	1526	120	0.211	945	0.061	1.5E-05	6.1E-07	1.8E-05	7.3E-07	1.5E-05	6.1E-07	1.3E-05	5.4E-07
Propagation from rooms in Fire Zone																
1022			7.05E-04			0.057			1.5E-05	6.1E-10	1.8E-05	7.2E-10	1.5E-05	6.1E-10	1.3E-05	5.3E-10
1023			1.62E-02			0.057			1.5E-05	1.4E-08	1.8E-05	1.7E-08	1.5E-05	1.4E-08	1.3E-05	1.2E-08
1024			1.62E-02			0.057			1.5E-05	1.4E-08	1.8E-05	1.7E-08	1.5E-05	1.4E-08	1.3E-05	1.2E-08
1025			7.05E-04			0.057			1.5E-05	6.1E-10	1.8E-05	7.2E-10	1.5E-05	6.1E-10	1.3E-05	5.3E-10
Localized Fire Threatens Waste Form in Preparation Area w/o SPM (No Diesel Present)																
	Localized Fire Threatens TC/TAD in Preparation Area w/o SPM (No Diesel Present)									**2.0E-06**						
	Localized Fire Threatens TC/HLW in Preparation Area w/o SPM (No Diesel Present)											**2.3E-06**				
	Localized Fire Threatens TC/DOE-SNF in Preparation Area w/o SPM (No Diesel Present)													**2.0E-06**		
	Localized Fire Threatens TC/DPC (VTC) in Preparation Area (No Diesel Present)															**1.7E-06**
Entry represents a vulnerability due to the Site Transporter									**TAD**		**DPC (VTC)**					
1026 & 1027	Electrical	1	1.16E-03	1		0.211		0.061	8.4E-06	9.7E-09	1.2E-05	1.4E-08				
	HVAC	2	4.64E-03	2		0.211		0.061	8.4E-06	7.8E-08	1.2E-05	1.1E-07				
	Mechanical Equipment	21.9	7.57E-03	21.9		0.211		0.061	8.4E-06	1.4E-06	1.2E-05	2.0E-06				
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	8.4E-06	0.0E+00	1.2E-05	0.0E+00				
	Torches, welders, burners	5	5.87E-04			0.211	5	0.061	8.4E-06	1.5E-09	1.2E-05	2.2E-09				
	Internal combustion engines	140	3.89E-04	140		0.211		0.061	8.4E-06	4.6E-07	1.2E-05	6.6E-07				
	Office/kitchen equipment	0	2.37E-02			0.211		0.061	8.4E-06	0.0E+00	1.2E-05	0.0E+00				
	Portable Equipment	4	6.29E-03	4		0.211		0.061	8.4E-06	2.1E-07	1.2E-05	3.0E-07				
	No equipment involved	2485	2.53E-05	2143		0.211	342	0.061	8.4E-06	4.6E-07	1.2E-05	6.6E-07				
Propagation from rooms in Fire Zone																
1022			7.05E-04			0.057			8.4E-06	3.4E-10	1.2E-05	4.9E-10				
1023			1.62E-02			0.057			8.4E-06	7.8E-09	1.2E-05	1.1E-08				
1024			1.62E-02			0.057			8.4E-06	7.8E-09	1.2E-05	1.1E-08				
1025			7.05E-04			0.057			8.4E-06	3.4E-10	1.2E-05	4.9E-10				
Localized Fire Threatens Waste Form in AO in Vestibule/Preparation Area (Diesel Present)																
	Localized Fire Threatens TAD in AO in Vestibule/Preparation Area (Diesel Present)									**2.6E-06**						
	Localized Fire Threatens DPC (VTC) in AO in Vestibule/Preparation Area (Diesel Present)											**3.8E-06**				

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Table F5.7-4. Localized Fire Initiating Event Frequencies (Continued)

Room of Origin (includes comments field as needed)	Ignition Source (If Applicable)	Number in Room	Frequency per Unit (50 years)	Number at Target	Number Near Target	Propagation Probability to Target	Number Away from Target	Propagation Probability to Target	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)	Target Exposure Time (Fraction)	Contribution to IE Frequency (50 years)
Entry represents a vulnerability due to the Cask Transfer Trolley									**TAD**		**HLW**		**DOE-SNF**		**TC/DPC (VTC)**	
1026	Electrical	1	1.16E-03	1		0.211		0.061	1.6E-05	1.8E-08	1.4E-05	1.6E-08	1.5E-05	1.7E-08	1.5E-05	1.7E-08
	HVAC	0	4.63E-03			0.211		0.061	1.6E-05	0.0E+00	1.4E-05	0.0E+00	1.5E-05	0.0E+00	1.5E-05	0.0E+00
	Mechanical Equipment	19.9	7.55E-03	4	15.9	0.211		0.061	1.6E-05	8.7E-07	1.4E-05	7.7E-07	1.5E-05	8.2E-07	1.5E-05	8.2E-07
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	1.6E-05	0.0E+00	1.4E-05	0.0E+00	1.5E-05	0.0E+00	1.5E-05	0.0E+00
	Torches, welders, burners	0	5.86E-04			0.211		0.061	1.6E-05	0.0E+00	1.4E-05	0.0E+00	1.5E-05	0.0E+00	1.5E-05	0.0E+00
	Internal combustion engines	130	3.88E-04	130		0.211		0.061	1.6E-05	7.9E-07	1.4E-05	7.0E-07	1.5E-05	7.4E-07	1.5E-05	7.4E-07
	Office/kitchen equipment	0	2.36E-02			0.211		0.061	1.6E-05	0.0E+00	1.4E-05	0.0E+00	1.5E-05	0.0E+00	1.5E-05	0.0E+00
	Portable Equipment	4	6.28E-03	2		0.211	2	0.061	1.6E-05	2.1E-07	1.4E-05	1.9E-07	1.5E-05	2.0E-07	1.5E-05	2.0E-07
	No equipment involved	2143	2.53E-05	1070	120	0.211	953	0.061	1.6E-05	4.6E-07	1.4E-05	4.1E-07	1.5E-05	4.3E-07	1.5E-05	4.3E-07
Propagation from rooms in Fire Zone																
1022			7.05E-04			0.057			1.6E-05	6.3E-10	1.4E-05	5.6E-10	1.5E-05	5.9E-10	1.5E-05	6.0E-10
1023			1.62E-02			0.057			1.6E-05	1.5E-08	1.4E-05	1.3E-08	1.5E-05	1.4E-08	1.5E-05	1.4E-08
1024			1.62E-02			0.057			1.6E-05	1.5E-08	1.4E-05	1.3E-08	1.5E-05	1.4E-08	1.5E-05	1.4E-08
1025			7.05E-04			0.057			1.6E-05	6.3E-10	1.4E-05	5.6E-10	1.5E-05	5.9E-10	1.5E-05	6.0E-10
Localized Fire Threatens Waste Form on CTT in Preparation Area																
	Localized Fire Threatens TC/TAD on CTT in Preparation Area									**2.4E-06**						
	Localized Fire Threatens TC/HLW on CTT in Preparation Area											**2.1E-06**				
	Localized Fire Threatens TC/DOE-SNF on CTT in Preparation Area													**2.2E-06**		
	Localized Fire Threatens TC/DPC (VTC) in Preparation Area															**2.2E-06**
Entry represents a vulnerability due to the Canister Transfer Machine									**TAD**		**HLW**		**DOE-SNF**		**TC/DPC (VTC)**	
2004	Electrical	0	1.16E-03			0.211		0.061	1.1E-06	0.0E+00	1.3E-06	0.0E+00	1.1E-06	0.0E+00	1.2E-06	0.0E+00
	HVAC	2	4.63E-03			0.211	2	0.061	1.1E-06	6.3E-10	1.3E-06	7.3E-10	1.1E-06	6.3E-10	1.2E-06	6.9E-10
	Mechanical Equipment	14	7.55E-03	10	0	0.211	4	0.061	1.1E-06	8.5E-08	1.3E-06	1.0E-07	1.1E-06	8.5E-08	1.2E-06	9.4E-08
	Heat Generating Equipment	0	0.00E+00			0.211		0.061	1.1E-06	0.0E+00	1.3E-06	0.0E+00	1.1E-06	0.0E+00	1.2E-06	0.0E+00
	Torches, welders, burners	10	5.86E-04			0.211	10	0.061	1.1E-06	4.0E-10	1.3E-06	4.6E-10	1.1E-06	4.0E-10	1.2E-06	4.4E-10
	Internal combustion engines	0	3.88E-04			0.211		0.061	1.1E-06	0.0E+00	1.3E-06	0.0E+00	1.1E-06	0.0E+00	1.2E-06	0.0E+00
	Office/kitchen equipment	0	2.36E-02			0.211		0.061	1.1E-06	0.0E+00	1.3E-06	0.0E+00	1.1E-06	0.0E+00	1.2E-06	0.0E+00
	Portable Equipment	1	6.28E-03	1		0.211		0.061	1.1E-06	6.9E-09	1.3E-06	8.1E-09	1.1E-06	6.9E-09	1.2E-06	7.6E-09
	No equipment involved	3846	2.53E-05	60	240	0.211	3546	0.061	1.1E-06	9.1E-09	1.3E-06	1.1E-08	1.1E-06	9.1E-09	1.2E-06	1.0E-08
Localized Fire Threatens Waste Form in CTM in Transfer Room																
	Localized Fire Threatens TAD in CTM in Transfer Room									**1.0E-07**						
	Localized Fire Threatens HLW in CTM in Transfer Room (per individual canister)											**1.2E-07**				
	Localized Fire Threatens DOE-SNF in CTM in Transfer Room (per individual canister)													**1.0E-07**		
	Localized Fire Threatens DPC (VTC) in CTM in Transfer Room															**1.1E-07**

NOTE: Blank cells in this table are intentional and have been verified.

AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; DOE = U.S. Department of Energy; HLW = high-level radioactive waste; HVAC = heating, ventilation, and air conditioning; IE = initiating event; SNF = spent nuclear fuel; TAD = transportation, aging, and disposal; TC = transportation cask; TEV = transport and emplacement vehicle; VTC = a transportation cask that is upended on a railcar; WP = waste package.

Source: Original

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Table F5.7-5. Localized Fire Initiating Events with Multiple Rooms of Origin

Rooms	Vulnerability	Justification
1018	WP Transfer Trolley	Room 1018 is open to 2004 (port slide gate) and 2007 (robot arms/welding)
2004		
2007		
1015	Transportation Emplacement Vehicle	Rooms open to each other due to open doors as the TEV moves from 1014 into 1015
1014		
1026	Site Prime Mover (Diesel Present)	Rooms open to each other due to open doors as the Site Prime Mover moves from 1036A to 1036 to 1026
1036		
1036A		
1026	Railcar (No Diesel Present)	Rooms open to each other due to open doors as the Railcar moves from 1036A to 1036 to 1026
1036		
1036A		
1026	Site Transporter	Rooms open to each other due to open doors as the Site Transporter moves from 1027 to 1026
1027		

NOTE: TEV = transport and emplacement vehicle; WP = waste package.

Source: Original

Table F5.7-6. Large Fire Initiating Event Frequencies

Large Fire Threatens Waste Form In Fire Zones Containing Vulnerable Waste Forms									
Large fires are those that spread beyond the boundaries of a fire area, up through those that breach the building boundary.									
			Total Ignition Frequency			Propagation Probability Beyond Fire -rated Area			Target Exposure Time (Fraction)	Contribution to IE Frequency
Large Fire Threatens TC/TAD (Diesel Present)			3.13E+00			0.169			2.1E-06	1.1E-06
Large Fire Threatens TC/TAD (No Diesel)			3.13E+00			0.169			3.3E-05	1.7E-05
Large Fire Threatens TAD in AO (Diesel Present)			3.13E+00			0.169			1.1E-05	5.9E-06
Large Fire Threatens TAD in CTM			3.13E+00			0.169			1.5E-06	7.8E-07
Large Fire Threatens TAD in WP in WPTT			3.13E+00			0.169			1.0E-04	5.4E-05
Large Fire Threatens TAD in WP in TEV			3.13E+00			0.169			1.8E-06	9.2E-07
Large Fire Threatens TC/HLW (Diesel Present)			3.13E+00			0.169			2.1E-06	1.1E-06
Large Fire Threatens TC/HLW (No Diesel)			3.13E+00			0.169			3.4E-05	1.8E-05
Large Fire Threatens HLW in CTM (per indiv canister)			3.13E+00			0.169			1.5E-06	7.8E-07
Large Fire Threatens HLW in WP			3.13E+00			0.169			1.3E-05	6.6E-06
Large Fire Threatens HLW and DOE-SNF in WP			3.13E+00			0.169			1.1E-04	5.6E-05
Large Fire Threatens TC/DOE-SNF (Diesel Present)			3.13E+00			0.169			2.1E-06	1.1E-06
Large Fire Threatens TC/DOE-SNF (No Diesel)			3.13E+00			0.169			3.2E-05	1.7E-05
Large Fire Threatens DOE-SNF in CTM (per canister)			3.13E+00			0.169			1.1E-06	5.8E-07
Large Fire Threatens DOE-SNF in Staging Area			3.13E+00			0.169			1.0E+00	5.3E-01
Large Fire Threatens TC/DPC (VTC) (Diesel)			3.13E+00			0.169			2.1E-06	1.1E-06
Large Fire Threatens TC/DPC (VTC) (No Diesel)			3.13E+00			0.169			3.0E-05	1.6E-05
Large Fire Threatens DPC (VTC) in CTM			3.13E+00			0.169			1.2E-06	6.4E-07
Large Fire Threatens DPC (VTC) in AO (Diesel)			3.13E+00			0.169			1.5E-05	7.7E-06

NOTE: AO = aging overpack; CTM = canister transfer machine; DOE = U.S. Department of Energy; HLW = high-level radioactive waste; SNF = spent nuclear fuel; TAD = transportation, aging, and disposal; TC = transportation cask; TEV = transport and emplacement vehicle; VTC = a transportation cask that is upended on a railcar; WP = waste package; WPTT = waste package transfer trolley.

Blank cells in this table are intentional and have been verified.

Source: Original

F5.8 MONTE CARLO SIMULATION/UNCERTAINTY DISTRIBUTIONS

F5.8.1 Uncertainty Distributions

Uncertainty distributions are utilized in the contribution to initiating event frequency calculations to account for the potential of variance in the data. For example, the ignition frequency presented in Table F5.2-1, Section F5.1 is the result of a calculation based on room area. The equation utilized to perform this calculation was derived from data collected on building fires. While the data collected and the equation developed to fit the data have a good R-squared (percentage of variability accounted for in the equation) value (90), an uncertainty distribution is necessary to account for the natural variability of the frequency of ignition.

The uncertainty distributions used for this analysis are primarily normal, with the exception of the ignition frequency distribution, which is lognormal (skewed bell curve shape, with the median value at the top of the curve). Lognormal distributions can be accurately represented by a median (50%) and a 97.5% value. The 97.5% value is a figure that represents a point at which only 2.5% of all possible outcomes will vary from the mean more significantly.

Three uncertainty distributions were developed for this analysis: ignition frequency, category fraction, and conditional probability. The distribution for ignition frequency is discussed in detail in Appendix F.III. The distributions for category fraction and conditional probability are discussed in Appendix F.II.

F5.8.2 Monte Carlo Simulation

Monte Carlo simulations are performed to determine the mean, standard deviation, variance, minimum, and maximum values of each of the initiating event frequencies based on the variance of the contributing data. To accomplish this, the Microsoft Excel add-on package Crystal Ball was used. This software requires input of the necessary uncertainty distribution figures (in this case, median (50%) and 97.5% values), and the figures that the simulation will produce results for (IE frequencies). Crystal Ball software uses the mean and 97.5% value to calculate the equation which represents the distribution. The software then randomly selects a value from the possibilities defined by the distribution. This is set within the software to be done 10,000 times to ensure accurate results.

F5.9 RESULTS

The results of the analysis are the fire initiating event frequencies and their associated distributions. The initiating event frequencies represent the probability, over the length of the pre-closure period, that a fire will threaten the stated waste form during the stated vulnerability. Because data used to obtain these results are based on existing fire data, it was necessary to determine the uncertainty distribution for each initiating event. Figure F5.7-1 displays the Crystal Ball results for a localized fire threatening a TAD canister in the canister transfer machine in the Canister Transfer Room.

These results provide a statistical reference for the variance of each initiating event frequency. As seen in Section F5.7.2, Table F5.7-4, the baseline initiating event frequency for this case is 1.0E-07. The Crystal Ball results give insight into this, showing that given the variability of the

inputs, the true result could lie anywhere between 1.2E-08 and 5.6E-07, with a mean of 1.1E-7, a standard deviation of 5.4E-8, and a lognormal shape. Crystal Ball was run for all of the initiating events, and a summary of the results, giving the distribution parameters of each distribution, is shown in Table F5.7-7. The 97.5 percentile values in Table F5.7-7 are not provided in the Crystal Ball full report. Instead, these values were obtained by utilizing the Extract Data option, which allows the analyst to specify the percentile values necessary. Also not included in the Crystal Ball report is the error factors, these figures were calculated from the mean and median as discussed in Appendix F.V. It was determined via methods described in Appendix F.IV that all of the resultant distributions are lognormal. The complete output from Crystal Ball and the 97.5 percentile values are provided in Appendix F.VI. In addition to showing the initiating event frequency distribution, it also shows the input distribution for the parameters that were varied, which match the distributions developed and documented in Appendices F.II and F.III.

Table F5.7-7. Fire Initiating Events Results Summary

Initiating Event	Equipment	Mean	Median	97.5% Value	EF	Type
Localized Fire Threatens Waste Form in WP in Positioning/Closure Room	**WP Transfer Trolley**					
Localized Fire Threatens TAD in WP in Positioning/Closure Room		6.5E-05	5.8E-05	1.42E-4	2.2E+00	Lognormal
Localized Fire Threatens HLW in WP in Positioning/Closure Room		8.5E-06	7.6E-06	1.9E-05	2.2E+00	Lognormal
Localized Fire Threatens HLW and DOE SNF in WP in Positioning/Closure Room		6.6E-05	5.9E-05	1.4E-04	2.2E+00	Lognormal
Localized Fire Threatens Waste Form in TEV in Loadout Room	**Transportation Emplacement Vehicle**					
Localized Fire Threatens TAD/WP in TEV in Loadout Room		1.9E-07	1.7E-07	4.1E-07	2.1E+00	Lognormal
Localized Fire Threatens HLW and DOE SNF in WP in TEV in Loadout Room		1.9E-07	1.7E-07	4.1E-07	2.1E+00	Lognormal
Localized Fire Threatens Waste Form in WP in Loadout Room	**WP Transfer Trolley**					
Localized Fire Threatens TAD in WP in Loadout Room		7.3E-07	6.6E-07	1.6E-06	2.0E+00	Lognormal
Localized Fire Threatens HLW and DOE SNF in WP in Loadout Room		7.3E-07	6.6E-07	1.6E-06	2.0E+00	Lognormal
Localized Fire Threatens Waste Form on CTT in Unloading Room	**Cask Transfer Trolley**					
Localized Fire Threatens TC/TAD on CTT in Unloading Room		1.2E-07	1.1E-07	2.8E-07	2.3E+00	Lognormal
Localized Fire Threatens TC/HLW on CTT in Unloading Room		4.7E-07	4.2E-07	1.1E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DOE SNF on CTT in Unloading Room		7.5E-07	6.7E-07	1.7E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DPC (VTC) in Cask Unloading Room		6.4E-08	5.6E-08	1.5E-07	2.3E+00	Lognormal
Localized Fire Threatens Waste Form in AO in Unloading Room (Diesel Present)	**Site Transporter**					
Localized Fire Threatens TAD in AO in Unloading Room (Diesel Present)		1.3E-07	1.1E-07	2.9E-07	2.5E+00	Lognormal
Localized Fire Threatens DPC (VTC) in AO in Unloading Room (Diesel Present)		1.2E-07	1.0E-07	2.7E-07	2.4E+00	Lognormal
Localized Fire Threatens Waste Form in Vestibule/Preparation Area w/SPM (Diesel Present)	**Site Prime Mover**					
Localized Fire Threatens TC/TAD in Vestibule/Preparation Area w/SPM (Diesel Present)		4.7E-07	4.2E-07	1.1E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/HLW in Vestibule/Preparation Area w/SPM (Diesel Present)		4.9E-07	4.3E-07	1.1E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DOE SNF in Vestibule/Preparation Area w/SPM (Diesel Present)		4.9E-07	4.3E-07	1.1E-06	2.2E+00	Lognormal
Localized Fire Threatens TC/DPC (VTC) in Vestibule/Preparation Area (Diesel Present)		4.9E-07	4.3E-07	1.1E-06	2.2E+00	Lognormal
Localized Fire Threatens Waste Form in Preparation Area w/o SPM (No Diesel Present)	**Railcar**					
Localized Fire Threatens TC/TAD in Preparation Area 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 Preparation Area 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 Preparation Area 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 Preparation Area (No Diesel Present)		1.9E-06	1.7E-06	4.1E-06	2.1E+00	Lognormal

Table F5.7-7. Fire Initiating Events Results Summary (Continued)

Initiating Event	Equipment	Mean	Median	97.5% Value	EF	Type
Localized Fire Threatens Waste Form in AO in Vestibule/Preparation Area (Diesel Present)	**Site Transporter**					
Localized Fire Threatens TAD in AO in Vestibule/Preparation Area (Diesel Present)		2.9E-06	2.6E-06	6.3E-06	2.2E+00	Lognormal
Localized Fire Threatens DPC (VTC) in AO in Vestibule/Preparation Area (Diesel Present)		4.2E-06	3.8E-06	9.2E-06	2.1E+00	Lognormal
Localized Fire Threatens Waste Form on CTT in Preparation Area	**Cask Transfer Trolley**					
Localized Fire Threatens TC/TAD on CTT in Preparation Area		2.6E-06	2.4E-06	6.0E-06	2.1E+00	Lognormal
Localized Fire Threatens TC/HLW on CTT in Preparation Area		2.3E-06	2.1E-06	5.3E-06	2.0E+00	Lognormal
Localized Fire Threatens TC/DOE SNF on CTT in Preparation Area		2.5E-06	2.2E-06	5.6E-06	2.3E+00	Lognormal
Localized Fire Threatens TC/DPC (VTC) in Preparation Area		2.5E-06	2.2E-06	5.6E-06	2.2E+00	Lognormal
Localized Fire Threatens Waste Form in CTM in Transfer Room	**Canister Transfer Machine**					
Localized Fire Threatens TAD in CTM in Transfer Room		1.1E-07	1.0E-07	2.5E-07	2.0E+00	Lognormal
Localized Fire Threatens HLW in CTM in 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 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 Transfer Room		1.2E-07	1.1E-07	2.7E-07	1.9E+00	Lognormal
Large Fire Threatens TC/TAD (Diesel Present)	-	1.2E-06	1.1E-06	2.8E-06	2.3E+00	Lognormal
Large Fire Threatens TC/TAD (No Diesel)	-	1.9E-05	1.7E-05	4.4E-05	2.2E+00	Lognormal
Large Fire Threatens TAD in AO (Diesel Present)	-	6.5E-06	5.8E-06	1.5E-05	2.2E+00	Lognormal
Large Fire Threatens TAD in CTM	-	8.6E-07	7.7E-07	2.0E-06	2.2E+00	Lognormal
Large Fire Threatens TAD in WP in WPTT	-	5.9E-05	5.3E-05	1.4E-04	2.1E+00	Lognormal
Large Fire Threatens TAD 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 indiv 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
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

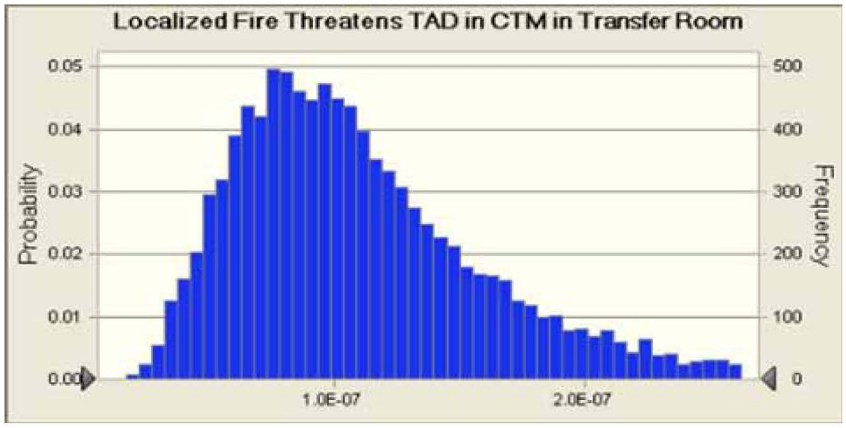
NOTE: Blank cells in this table are intentional and have been verified.

AO = aging overpack; CTM = canister transfer machine; CTT = cask transfer trolley; DOE = U.S. Department of Energy; HLW = high-level radioactive waste; SNF = spent nuclear fuel; TAD = transportation, aging, and disposal canister; TC = transportation cask; TEV = transport and emplacement vehicle; VTC = a transportation cask that is upended on a railcar; WP = waste package; WPTT = waste package transfer trolley.

Source: Original

Forecast: Localized Fire Threatens TAD in CTM in Transfer Room **Cell: K194**

Summary:
Entire range is from 1.2E-08 to 5.6E-07
Base case is 1.0E-07
After 10,000 trials, the std. error of the mean is 5.4E-10



Statistics:	Forecast values
Trials	10,000
Mean	1.1E-07
Median	1.0E-07
Mode	---
Standard Deviation	5.4E-08
Variance	2.9E-15
Skewness	1.33
Kurtosis	5.85
Coeff. of Variability	0.4813
Minimum	1.2E-08
Maximum	5.6E-07
Range Width	5.5E-07
Mean Std. Error	5.4E-10

Forecast: Localized Fire Threatens TAD in CTM in Transfer Room (cont'd) **Cell: K194**

Percentiles:	Forecast values
0%	1.2E-08
10%	5.5E-08
20%	6.8E-08
30%	7.9E-08
40%	9.0E-08
50%	1.0E-07
60%	1.1E-07
70%	1.3E-07
80%	1.5E-07
90%	1.8E-07
100%	5.6E-07

NOTE: CTM = canister transfer machine; TAD = transportation, aging, and disposal canister.

Source: Crystal Ball software output

Figure F5.7-1. Example of Crystal Ball Output for a Fire Initiating Event

APPENDIX F.I
DEFINITION OF IGNITION SOURCE CATEGORY

Table F.I-1. Definition of Ignition Source Category

Ignition Source Category	NFPA Equipment Categories Included
Electrical Equipment	**Fixed wiring**; **transformer, associated over current or disconnect equipment**; **meter, meter box**; power switchgear, over current protection devices; switch, receptacle, outlet; lighting fixture, lamp holder, ballast, sign; cord, plug; lamp, light bulb; unclassified or **unknown-type electrical distribution equipment**; electronic equipment; rectifier, charger
Mechanical and Electrical HVAC Equipment	**Central heating unit**; water heater; **fixed, stationary local heating unit**; central air conditioning, refrigeration equipment; water cooling device, tower; **fixed, stationary local refrigeration unit**; fixed, stationary local air conditioning unit; chimney, gas vent flue; chimney connector, vent connector; **heat transfer system**; unclassified heating systems; **other HVAC equipment**; unclassified air conditioning, refrigeration systems
Mechanical Equipment	Chemical process equipment; **waste recovery equipment**; **working, shaping machine**; coating machine; painting machine; unclassified process equipment; **separate motor or generator**; separate pump or compressor; conveyor, **unknown mechanical equipment**
Fixed Heat-Generating Process Equipment	**Casting, molding, or forging equipment**; heat-treating equipment; **dryers; furnaces; incinerators**
Torches/Welders	**Torches, welders, burners**
Internal Combustion Engines	**Internal combustion engines**
Office and Kitchen Equipment	**Television, radio, stereo; fixed food-warming appliance; fixed or stationary oven;** all other categories
Portable and Special Equipment	**Portable local heating unit**; **hand tools**; portable appliance designed to produce controlled heat; **portable appliance designed not to produce heat; unclassified special equipment; unclassified service or maintenance equipment; biomedical equipment or device**
No Equipment Involved	**No equipment**

NOTE: The entries shown in bold in the table were those that had caused fires in the data set. The other entries were included in the data set retrieval, but no fires were attributed to them. Given that there were only a total of 188 fires in the entire data set, the fact that certain items had not been associated with an observed fire cannot be taken to mean that they can be eliminated as potential ignition sources.

HVAC = heating, ventilation, and air conditioning.

Source: Ref. F2.2.76

APPENDIX F.II
DERIVATION OF IGNITION SOURCE DISTRIBUTION AND FIRE PROPAGATION PROBABILITIES

Three independent data sets concerning fires in radioactive material working facilities (Tables F.II-1 through F.II-3) have been analyzed for statistical confidence. The data sets are in the format of a tally; each sample (fire) is placed in the appropriate category (equipment type, extent of flame damage, etc.), and the reported figure for each category is the number of fires that pertained to the category. All of these data sets reflect the operating history of nuclear facilities of non-combustible construction as defined by the NFPA. The NFPA data is taken from NFPA, 2007.[3]

The first data set provides a distribution of fire ignition as a function of the ignition source category, as defined in Appendix F.I. Table F.II.1 provides a summary of that data.

Table F.II-1. Fires in Radioactive Material Working Facilities by Originating Equipment

Ignition Source Category	Fires	
Electrical	16	9%
Mechanical/Electrical HVAC	15	8%
Mechanical	26	14%
Heat Generating	29	16%
Torches/Welders	41	22%
Internal Combustion	4	2%
Offices/Kitchen Equipment	12	6%
Portable Equipment	19	10%
No Equipment	25	13%
Total	187	100%

NOTE: HVAC = heating, ventilation, and air conditioning.

Blank cells in this table are intentional and have been verified.

Source: Ref. F2.2.76

[3] NFPA, "Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction," 1980-1998, National Fire Protection Association, April 2007. (Ref. F2.2.77)

Table F.II-2. Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which No Automatic Suppression System Was Present or the Automatic Suppression System Failed to Operate

Extent of Flame Damage	Fires	
Confined to object of origin	54	63%
Confined to part of room/area of origin	13	15%
Confined to room of origin	0	0
Confined to fire-rated compartment of origin	5	6%
Confined to floor of origin	0	0
Confined to structure of origin	14	16%
Extended beyond structure of origin	0	0
Total	86	100%

NOTE: Blank cells in this table are intentional and have been verified.

Source: Ref. F2.2.76

Table F.II-3. Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which the Fire Was Too Small to Activate the Automatic Suppression System or the Automatic System Operated Properly

Extent of Flame Damage	Fires	
Confined to object of origin	40	56%
Confined to part of room/area of origin	23	32%
Confined to room of origin	2	3%
Confined to fire-rated compartment of origin	0	0%
Confined to floor of origin	5	7%
Confined to structure of origin	2	3%
Extended beyond structure of origin	0	0
Total	72	100%

NOTE: Blank cells in this table are intentional and have been verified.

Source: Ref. F2.2.76

The method chosen for calculating the confidence interval of the data is the margin of error calculation as follows in Equation F.II-1:

$$ME = \sqrt{\frac{p(1-p)}{n}} \; x \; t \qquad \text{(Eq. F.II-1)}$$

where

ME	=	Margin of error
p	=	Event probability
n	=	Number of samples
t	=	t-distribution value (see Table F.II-4)

The event probabilities are in the second "Fire" column of Tables F.II-1 through F.II-3, and are converted to decimal format (divided by 100) for the calculations. Values for t are obtained from a standard t-distribution table, the necessary excerpt from which is provided in Table F.II-4.

Table F.II-4. t-Distribution Value

		α	
		0.025	0.005
v	60	2.000	2.660
	120	1.980	2.617
Source: Ref. F2.2.79			

where

α	=	One minus the confidence interval divided by two (e.g., a 95% confidence interval corresponds to an α of 0.025)
v	=	Degrees of freedom (number of samples minus one)

For the data sets analyzed, confidence intervals of 95% and 99% were analyzed. This is done because while 95% is an accepted and commonly used confidence interval, 99% is an extremely conservative confidence interval.

Completed calculations and the ranges based on the margins of error are provided in Tables F.II-5 through F.II-10 below. To demonstrate the calculations performed in Tables F.II-5 through F.II-10, an example is completed from Table F.II-5, row 1. The event probability (p) is determined by dividing the number of occurrences (16) for that event by the total number of fires (187). Thus, 0.0856 is the event probability for an electrically originated fire. The margin of error (ME) is then calculated utilizing Equation 1 above, obtaining t from Table F.II-4. For this example, t is 1.98 because the degrees of freedom (v = n-1 = 186) is greater than 120, and the confidence interval is 95 %, making α=0.025. The ME obtained, ±0.0405, when subtracted from and added to the event probability provides a percentile range (Probability range column). It can be said with 95% confidence that the true event probability lies within this range. The final column is an occurrences range, which is calculated by converting the percentages of the preceding row to decimal format (dividing by 100), and multiplying them by the total number of fires (187). It can be said with 95% confidence that the true number of occurrences for any set of 187 fires is within this range. The calculations throughout Tables F.-II-5 through F.II-10 are performed in the same manner, with the value of t depending on the number of samples (fires) and the confidence interval.

Table F.II-5. Margin of Error Results at 95% Confidence Interval for Fires in Radioactive Material Working Facilities by Originating Equipment

Equipment Type	Occurances	Probability		Margin of Error (95% confidence)		Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Electrical	16	8.56E-02	±	4.05E-02		4.51	≤ p ≤	12.61		8.43	≤ O ≤	23.58
Mechanical/Electrical HVAC	15	8.02E-02	±	3.93E-02		4.09	≤ p ≤	11.95		7.65	≤ O ≤	22.35
Mechanical	26	1.39E-01	±	5.01E-02		8.89	≤ p ≤	18.91		16.62	≤ O ≤	35.36
Heat Generating	29	1.55E-01	±	5.24E-02		10.27	≤ p ≤	20.75		19.20	≤ O ≤	38.80
Torches/Welders	41	2.19E-01	±	5.99E-02		15.93	≤ p ≤	27.92		29.79	≤ O ≤	52.21
Internal Combustion	4	2.14E-02	±	2.09E-02		0.04	≤ p ≤	4.23		0.07	≤ O ≤	7.91
Offices/Kitchen Equipment	12	6.42E-02	±	3.55E-02		2.87	≤ p ≤	9.97		5.37	≤ O ≤	18.64
Portable Equipment	19	1.02E-01	±	4.37E-02		5.79	≤ p ≤	14.53		10.83	≤ O ≤	27.17
No Equipment	25	1.34E-01	±	4.93E-02		8.44	≤ p ≤	18.3		15.78	≤ O ≤	34.22
Total	187	1										

NOTE: HVAC = heating, ventilation, and air conditioning.

Blank cells in this table are intentional and have been verified.

Source: Original

Table F.II-6. Margin of Error Results at 99% Confidence Interval for Fires in Radioactive Material Working Facilities by Originating Equipment

Equipment Type	Occurances	Probability		Margin of Error (99% confidence)		Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Electrical	16	8.56E-02	±	5.35E-02		3.2	≤ p ≤	13.91		5.98	≤ O ≤	26.01
Mechanical/Electrical HVAC	15	8.02E-02	±	5.20E-02		2.82	≤ p ≤	13.22		5.27	≤ O ≤	24.72
Mechanical	26	1.39E-01	±	6.62E-02		7.28	≤ p ≤	20.53		13.61	≤ O ≤	38.39
Heat Generating	29	1.55E-01	±	6.93E-02		8.58	≤ p ≤	22.44		16.04	≤ O ≤	41.96
Torches/Welders	41	2.19E-01	±	7.92E-02		14.01	≤ p ≤	29.84		26.20	≤ O ≤	55.80
Internal Combustion	4	2.14E-02	±	2.77E-02		-0.63	≤ p ≤	4.91		0.00	≤ O ≤	9.18
Offices/Kitchen Equipment	12	6.42E-02	±	4.69E-02		1.73	≤ p ≤	11.11		3.24	≤ O ≤	20.78
Portable Equipment	19	1.02E-01	±	5.78E-02		4.38	≤ p ≤	15.94		8.19	≤ O ≤	29.81
No Equipment	25	1.34E-01	±	6.51E-02		6.86	≤ p ≤	19.88		12.83	≤ O ≤	37.18
Total	187	1										

NOTE: HVAC = heating, ventilation, and air conditioning.
Blank cells in this table are intentional and have been verified.

Source: Original

Table F.II-7. Margin of Error Results at 95% Confidence Interval for Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which No Automatic Suppression System Was Present or the Automatic Suppression System Failed to Operate

Extent of Flame Damage	Occurances	Probability		Margin of Error (95% confidence)			Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Confined to object of origin	54	6.21E-01		±	1.04E-01		51.67	≤ p ≤	72.48		44.78	≤ O ≤	62.81
Confined to part of room/ area of origin	13	1.49E-01		±	7.65E-02		7.3	≤ p ≤	22.59		6.33	≤ O ≤	19.58
Confined to room of origin	0.33	3.79E-03		±	1.32E-02		0	≤ p ≤	1.7		0	≤ O ≤	1.47
Confined to fire-rated compartment of origin	5	5.75E-02		±	4.99E-02		0.76	≤ p ≤	10.74		0.66	≤ O ≤	9.31
Confined to floor of origin	0.33	3.79E-03		±	1.32E-02		0	≤ p ≤	1.7		0	≤ O ≤	1.47
Confined to structure of origin	14	1.61E-01		±	7.88E-02		8.21	≤ p ≤	23.97		7.11	≤ O ≤	20.77
Extended beyond structure of origin	0.33	3.79E-03		±	1.32E-02		0	≤ p ≤	1.7		0	≤ O ≤	1.47
Total	86.99	1											

NOTE: Blank cells in this table are intentional and have been verified.

Source: Original

Table F.II-8. Margin of Error Results at 99% Confidence Interval for Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which No Automatic Suppression System Was Present or the Automatic Suppression System Failed to Operate

Extent of Flame Damage	Occurances	Probability		Margin of Error (99% confidence)			Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Confined to object of origin	54	6.21E-01		±	1.38E-01		48.24	≤ p ≤	75.91		41.8	≤ O ≤	65.78
Confined to part of room/ area of origin	13	1.49E-01		±	1.02E-01		4.78	≤ p ≤	25.11		4.14	≤ O ≤	21.76
Confined to room of origin	0.33	3.79E-03		±	1.75E-02		0	≤ p ≤	2.13		0	≤ O ≤	1.85
Confined to fire-rated compartment of origin	5	5.75E-02		±	6.64E-02		0	≤ p ≤	12.39		0	≤ O ≤	10.74
Confined to floor of origin	0.33	3.79E-03		±	1.75E-02		0	≤ p ≤	2.13		0	≤ O ≤	1.85
Confined to structure of origin	14	1.61E-01		±	1.05E-01		5.61	≤ p ≤	26.57		4.86	≤ O ≤	23.03
Extended beyond structure of origin	0.33	3.79E-03		±	1.75E-02		0	≤ p ≤	2.13		0	≤ O ≤	1.85
Total	86.99	1											

NOTE: Blank cells in this table are intentional and have been verified.

Source: Original

Table F.II-9. Margin of Error Results at 95% Confidence Interval for Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which the Fire Was Too Small to Activate the Automatic Suppression System or the Automatic System Operated Properly

Extent of Flame Damage	Occurances	Probability		Margin of Error (95% confidence)			Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Confined to object of origin	40	5.51E-01		±	1.17E-01		43.38	≤ p ≤	66.72		31.52	≤ O ≤	48.48
Confined to part of room/ area of origin	23	3.17E-01		±	1.09E-01		20.74	≤ p ≤	42.57		15.07	≤ O ≤	30.93
Confined to room of origin	2	2.75E-02		±	3.84E-02		0	≤ p ≤	6.59		0	≤ O ≤	4.79
Confined to fire-rated compartment of origin	0.33	4.54E-03		±	1.58E-02		0	≤ p ≤	2.03		0	≤ O ≤	1.47
Confined to floor of origin	5	6.88E-02		±	5.94E-02		0.94	≤ p ≤	12.82		0.68	≤ O ≤	9.32
Confined to structure of origin	2	2.75E-02		±	3.84E-02		0	≤ p ≤	6.59		0	≤ O ≤	4.79
Extended beyond structure of origin	0.33	4.54E-03		±	1.58E-02		0	≤ p ≤	2.03		0	≤ O ≤	1.47
Total	72.66	1											

NOTE: Blank cells in this table are intentional and have been verified.

Source: Original

Table F.II-10. Margin of Error Results at 99% Confidence Interval for Structure Fires in Radioactive Material Working Facilities and Nuclear Energy Plants of Non-Combustible Construction and in which the Fire Was Too Small to Activate the Automatic Suppression System or the Automatic System Operated Properly

Extent of Flame Damage	Occurances	Probability		Margin of Error (99% confidence)			Probability range based on Margin of Error (%)				Occurances range based on Margin of Error		
Confined to object of origin	40	5.51E-01		±	1.55E-01		39.53	≤ p ≤	70.57		28.72	≤ O ≤	51.28
Confined to part of room/ area of origin	23	3.17E-01		±	1.45E-01		17.14	≤ p ≤	46.17		12.45	≤ O ≤	33.55
Confined to room of origin	2	2.75E-02		±	5.11E-02		0	≤ p ≤	7.86		0	≤ O ≤	5.71
Confined to fire-rated compartment of origin	0.33	4.54E-03		±	2.10E-02		0	≤ p ≤	2.55		0	≤ O ≤	1.85
Confined to floor of origin	5	6.88E-02		±	7.90E-02		0	≤ p ≤	14.78		0	≤ O ≤	10.74
Confined to structure of origin	2	2.75E-02		±	5.11E-02		0	≤ p ≤	7.86		0	≤ O ≤	5.71
Extended beyond structure of origin	0.33	4.54E-03		±	2.10E-02		0	≤ p ≤	2.55		0	≤ O ≤	1.85
Total	72.66	1											

NOTE: Blank cells in this table are intentional and have been verified.

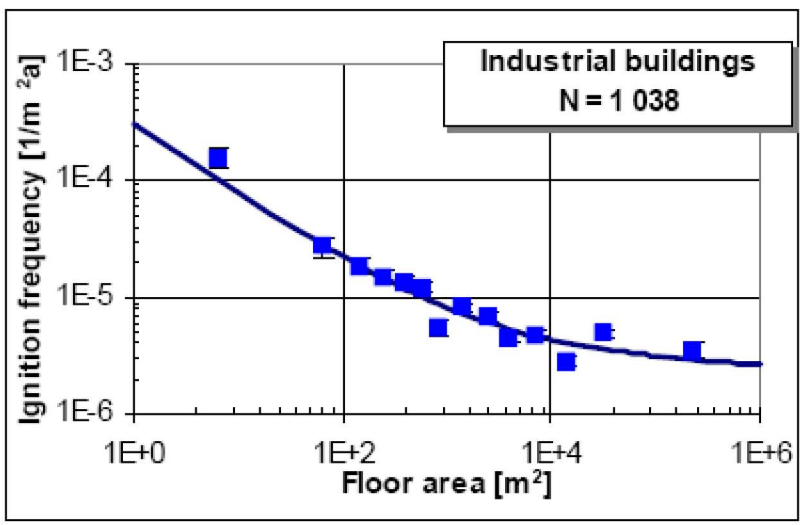
Source: Original

APPENDIX F.III
DERIVATION OF IGNITION FREQUENCY DISTRIBUTION

For proper consideration of the fire frequency analysis of the CRCF, Wet Handling Facility, Initial Handling Facility, and Receipt Facility (RF), it was necessary to develop an uncertainty distribution for the industrial building fire frequency. The *Utilisation of Statistics to Assess Fire Risks in Buildings* study (Ref. F2.2.78) used to develop these frequencies presents an equation with floor area as an input to determine frequency. Equation F.III-1 is developed based on sample data collected:

$$f''_m(A) = c_1 A^r + c_2 A^s \qquad \text{(Eq. F.III-1)}$$

where f''_m is the annual fire frequency per square meter of floor area, A is the floor area, and the values c_1, c_2, r, and s are constants determined by the line of best fit derived from the data. For industrial buildings, the values for the constants are as follows: $c_1 = 3 \times 10^{-4}$, $c_2 = 5 \times 10^{-6}$, r = -0.61. and s = -0.05. The data for industrial buildings and the resulting line of best fit are presented in Figure F.III-1.



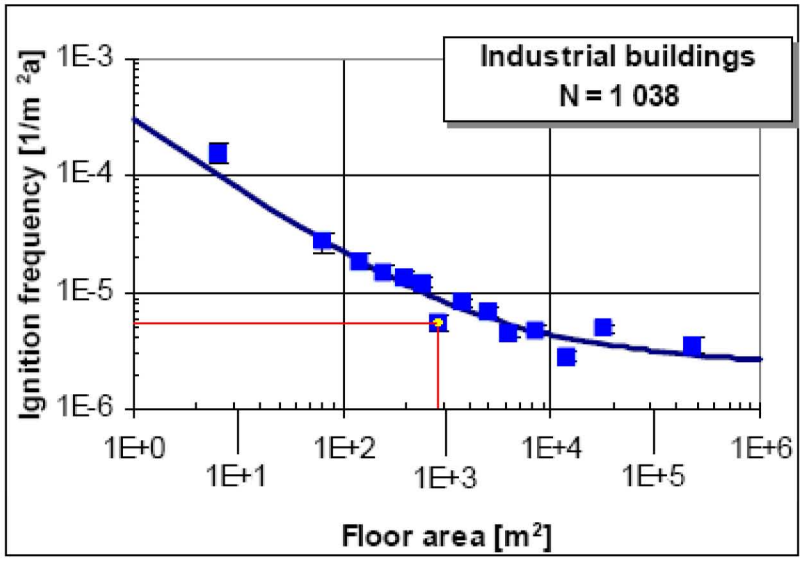
NOTE: m = meter.

Source: Ref. F2.2.78

Figure F.III-1. Ignition Frequency Observations

Each data point in the graph represents the average of many data points. The individual data points and the average values were not provided in the reference. Because the data were only presented graphically, it was necessary to estimate the data for the purposes of this analysis. To accomplish this, the center of each data point was found, and x axis values were added such that the powers increase by a unit of one. Horizontal and vertical lines were drawn from each data point to the x and y axes. The ignition frequency and floor area were then estimated based on the relative distances between these lines and the major axis values. For the example shown in Figure F.III-2 below, the distance from the 1E+2 label to the red vertical line is divided by the

distance from the 1E+2 to 1E+3 labels. In this case, the result is 0.925. Thus, the floor area for the data point is $10^{2.925}$. The ignition frequency is determined in an identical manner. The ignition frequency and floor area obtained in this manner are displayed in Table F.III-1. The ignition frequency predicted based on Equation F.III-1 is also provided in the table.



NOTE: m = meter.

Source: Ref. F2.2.78

Figure F.III-2. Data Point Determination

Table F.III-1. Ignition Frequency Data from Figure F.III-1 and Equation F.III-1

Graphically Determined Data Points		From Equation 1
Floor Area (m^2)	Ignition Frequency (1/yr m^2)	Predicted Frequency (1/yr m^2)
7	1.6×10^{-4}	9.6×10^{-5}
65	2.8×10^{-5}	2.8×10^{-5}
150	1.9×10^{-5}	1.8×10^{-5}
240	1.5×10^{-5}	1.4×10^{-5}
380	1.4×10^{-5}	1.2×10^{-5}
570	1.2×10^{-5}	9.9×10^{-6}
840	5.6×10^{-6}	8.5×10^{-6}
1,400	8.9×10^{-6}	7.1×10^{-6}
2,500	7.0×10^{-6}	5.9×10^{-6}
4,100	4.6×10^{-6}	5.2×10^{-6}
7,100	4.8×10^{-6}	4.5×10^{-6}
14,000	2.9×10^{-6}	4.0×10^{-6}
33,000	5.1×10^{-6}	3.5×10^{-6}
230,000	3.6×10^{-6}	2.9×10^{-6}

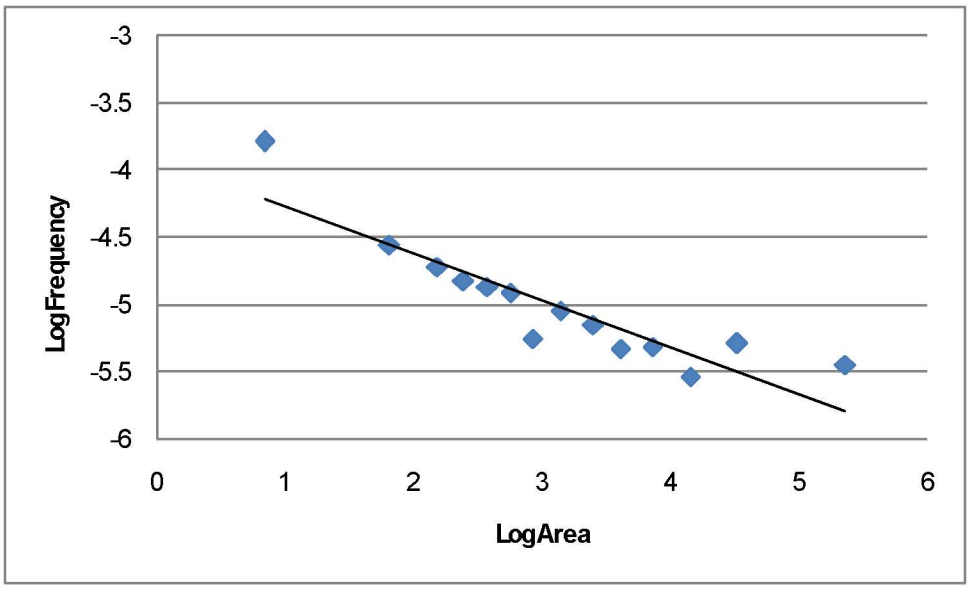
NOTE: m = meter; yr = year.

Source: Original

Because the ignition frequency is determined based on the line of best fit, the uncertainty distribution for the calculated ignition frequency can be determined by estimating the uncertainty in the ability of the best fit equation to predict the ignition frequency of any industrial building not included in the database. This is accomplished using the methodology presented below.

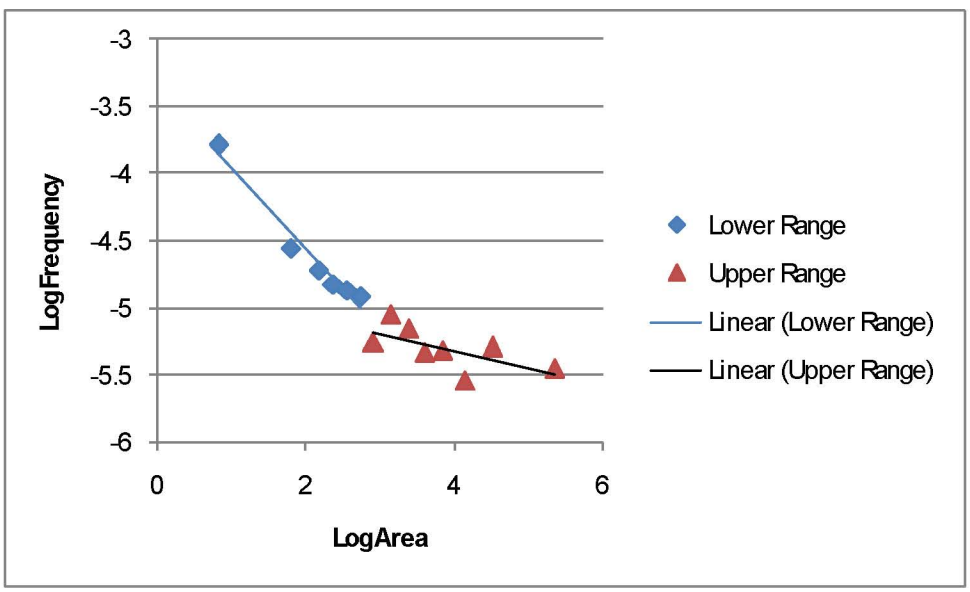
Statistics: Probability, Inference, and Decision (Ref. F2.2.79) outline a procedure to determine the confidence limits for a value predicted based on a linear regression equation. Though the ignition frequency and floor area are not linearly related, as illustrated by the figure and by equation F.III-1, the relationship between the log of the ignition frequency and the log of the floor area is approximately linear. This is illustrated in Figure F.III-3.

As shown in Figures F.III-1 and F.III-3, the portion of the curve for buildings less than 1,000m^2 has a steeper slope than the portion of the curve for buildings larger than 1,000m^2. For that reason, the data were divided into two ranges as shown in Figure F.III-4. Because all of the YMP facilities have floor areas larger than 1,000m^2, the remaining analysis focused on the upper end of the floor area range.



Source: Original

Figure F.III-3. Plot of Log(Ignition Frequency) as a Function of Log(Floor Area)



Source: Original

Figure F.III-4. Plot of Log(Ignition Frequency) as a Function of Log(Floor Area) Divided into Two Floor Area Ranges

To arrive at the confidence interval for the log of the ignition frequency, Equations F.III-2, F.III-3, and F.III-4 are used:

$$\hat{y} \pm a \frac{s_{xy}}{\sqrt{n-2}} \sqrt{n+1+\frac{(x-m_x)^2}{s_x^2}} \qquad \text{(Eq. F.III-2)}$$

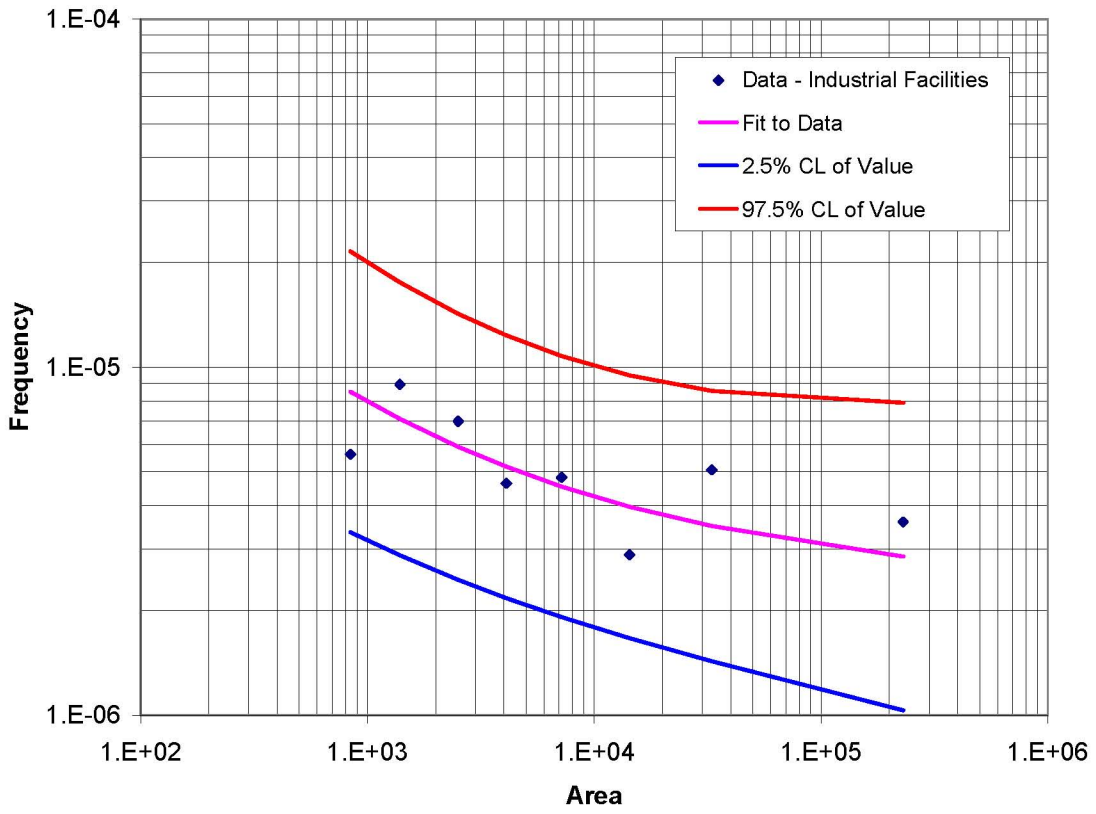
$$s_{xy} = \sqrt{s_y^2 (1 - r_{xy}^2)} \qquad \text{(Eq. F.III-3)}$$

$$r_{xy} = \frac{\sum_{i=0}^{i=n} (x_i - m_x)(y - m_y)}{n\, s_x\, s_y} \qquad \text{(Eq. F.III-4)}$$

where

$\hat{y}$	=	the predicted value for the log of the ignition frequency using Equation F-III.1
x	=	the log of the corresponding floor area value
n	=	number of data points used in the linear regression analysis (8 for the upper floor area range)
a	=	the 1-(α/2) fractile of the t-distribution with n-2 degrees of freedom (for a 95% confidence interval, α is 5% and the value for a is 2.447)
x_i	=	the x data values (log of floor area)
y_i	=	the y data values (log of ignition frequency)
m_x	=	the mean of the x data values
m_y	=	the mean of the y data values
s_x	=	the standard deviation of the x data values
s_y	=	the standard deviation of the y data values

The upper and lower confidence limits (i.e., the 97.5% and 2.5% values) for any predicted value of the ignition frequency can be determined from Equations F.III-2 through F.III-4 using the x-y data for the upper end of the floor area range. The upper and lower confidence limits for the ignition frequency were then determined by taking the anti-log of the predicted y values. Figure F.III-5 is a plot showing the original data, the predicted values using Equation F.III-1, and the upper and lower confidence limits for the predicted values. The same approach can be used to determine the upper and lower confidence limits for the ignition frequency calculated for each of the YMP facilities. Those results are provided in Table F.III-2.



NOTE: CL = confidence limit.

Source: Original

Figure F.III-5. Plot of the Ignition Frequency Data, the Predicted Ignition Frequency, and Confidence Limits for the Predicted Value

Table F.III-2. Calculated Mean and Confidence Limits for the YMP Facility Ignition Frequency

Facility	Ignition Frequency (Ignitions per sq-m per year)		
	Median	2.5% LCL	97.5% UCL
CRCF	3.78×10^{-6}	1.58×10^{-6}	9.08×10^{-6}
IHF	4.79×10^{-6}	2.02×10^{-6}	1.14×10^{-5}
RF	4.05×10^{-6}	1.70×10^{-6}	9.64×10^{-6}
WHF	3.93×10^{-6}	1.65×10^{-6}	9.39×10^{-6}

NOTE: CRCF = Canister Receipt and Closure Facility; IHF = Initial Handling Facility; LCL = lower confidence limit; RF = Receipt Facility; ULC = upper confidence limit; WHF = Wet Handling Facility.

Source: Original

APPENDIX F.IV
PROOF OF LOGNORMAL DISTRIBUTION

The fire initiating event frequencies presented throughout this document are the result of a series of calculations performed using inputs in the form of three different probability distributions. Two of the input distributions (see Appendix II) are normally distributed, and the third (see Appendix III) is lognormally distributed. After the calculations were performed, it was necessary to determine what type of distribution best represented the results. The Crystal Ball output (see Appendix VI) shows the calculated distributions at ten percentile intervals. Crystal Ball also provides the mean and the median of the distributions.

Microsoft Excel has a function, LOGNORMDIST, which can be utilized to calculate the corresponding intervals for a lognormal distribution. The Excel function requires that the log mean (μ) and log standard deviation (σ) be provided. To perform this analysis, it was necessary to calculate μ and σ using Equations F.IV-1 and F.IV-2, where the mean and median in these equations are provided in the Crystal Ball results.

$$\mu = \ln(median) \qquad \text{(Eq. F.IV-1)}$$

$$\sigma = \sqrt{2\ln\left(\frac{mean}{median}\right)} \qquad \text{(Eq. F.IV-2)}$$

A comparison between the Crystal Ball and Excel percentile intervals reveals whether the data is a satisfactory fit to a lognormal distribution. Table F.IV-1 shows the result of this analysis. The table shows that the difference between the Excel calculated values and the Crystal Ball percentile values never exceeds 1.4 percent. Thus, it is concluded that the fire initiating events are lognormally distributed.

Table F.IV-1. Comparison Between Crystal Ball and Excel Percentile Intervals

Forecast Values	Excel Calculated Percentiles	Crystal Ball Percentiles	Difference
1.18E-08	0.003	0	0.00
5.49E-08	8.682	10	1.32
6.8E-08	18.84	20	1.16
7.9E-08	29.08	30	0.92
9.0E-08	39.81	40	0.19
1.0E-07	49.98	50	0.02
1.1E-07	59.86	60	0.14
1.3E-07	70.27	70	0.27
1.5E-07	80.58	80	0.58
1.8E-07	90.82	90	0.82
5.6E-07	99.99	100	0.01
Mu	-16.1067	Mean	1.12E-07
Sigma	0.4496	Median	1.01E-07

Source: Original

APPENDIX F.V
DERIVATION OF ERROR FACTORS

It was necessary to provide an error factor for each initiating event frequency, which was calculated using data provided by Crystal Ball. The software output in Appendix F.VI provides the mean and median necessary to determine the error factor. Equation F.V-1 is utilized to calculate the log standard deviation (σ), and Equation F.V-2 provides a method for calculating the error factor from the log standard deviation.

$$\sigma = \sqrt{2\ln\left(\frac{mean}{median}\right)} \qquad \text{(Eq. F.V-1)}$$

$$\text{EF} = e^{\sigma \times 1.645} \qquad \text{(Eq. F.V-2)}$$

The resultant error factors for each initiating event frequency are displayed in Table F5.7-5, as well as the mean and median utilized to calculate the error factor.

Several of the initiating event frequencies were not utilized as originally anticipated, many were summed for the purpose of developing split fractions. It was necessary to develop error factors for these summed figures as well. This was accomplished by directly summing the figures, then defining the summation as a Crystal Ball forecast value. The Crystal Ball results (Table F.5.7-7) provided a mean and median by which the error factors can be calculated using equations F.V-1 and F.V-2.

APPENDIX F.VI
RESULTS FROM MONTE CARLO SIMULATION

Initiating Event	97.5% Percentile
Large Fire Theatens TAD in WP in WPTT	1.4E-04
Large Fire Theatens TAD in WP in TEV	2.3E-06
Large Fire Threatens DOE-SNF in CTM (per canister)	1.5E-06
Large Fire Threatens DOE-SNF in Staging Area	1.4E+00
Large Fire Threatens DPC (VTC) in AO (Diesel)	2.0E-05
Large Fire Threatens DPC (VTC) in CTM	1.6E-06
Large Fire Threatens HLW and DOE-SNF in WP	1.4E-04
Large Fire Threatens HLW in CTM (per indiv canister)	2.0E-06
Large Fire Threatens HLW in WP	1.7E-05
Large Fire Threatens TAD in AO (Diesel Present)	1.5E-05
Large Fire Threatens TAD in CTM	2.0E-06
Large Fire Threatens TC/DOE-SNF (Diesel Present)	2.8E-06
Large Fire Threatens TC/DOE-SNF (No Diesel)	4.2E-05
Large Fire Threatens TC/DPC (VTC) (Diesel)	2.9E-06
Large Fire Threatens TC/DPC (VTC) (No Diesel)	4.0E-05
Large Fire Threatens TC/HLW (Diesel Present)	2.8E-06
Large Fire Threatens TC/HLW (No Diesel)	4.6E-05
Large Fire Threatens TC/TAD (Diesel Present)	2.8E-06
Large Fire Threatens TC/TAD (No Diesel)	4.4E-05
Localized Fire Threatens DOE-SNF in CTM in Transfer Room (per individual canister)	2.5E-07
Localized Fire Threatens DPC (VTC) in AO in Unloading Room (Diesel Present)	2.7E-07
Localized Fire Threatens DPC (VTC) in AO in Vestibule/Preparation Area (Diesel Present)	9.2E-06
Localized Fire Threatens DPC (VTC) in CTM in Transfer Room	2.7E-07
Localized Fire Threatens HLW and DOE-SNF in WP in Loadout Room	1.6E-06
Localized Fire Threatens HLW and DOE-SNF in WP in Positioning/Closure Room	1.4E-04
Localized Fire Threatens HLW and DOE-SNF in WP in TEV in Loadout Room	4.1E-07
Localized Fire Threatens HLW in CTM in Transfer Room (per individual canister)	2.9E-07
Localized Fire Threatens HLW in WP in Positioning/Closure Room	1.9E-05
Localized Fire Threatens TAD in AO in Unloading Room (Diesel Present)	2.9E-07
Localized Fire Threatens TAD in AO in Vestibule/Preparation Area (Diesel Present)	6.3E-06
Localized Fire Threatens TAD in CTM in Transfer Room	2.5E-07
Localized Fire Threatens TAD in WP in Loadout Room	1.6E-06
Localized Fire Threatens TAD in WP in Positioning/Closure Room	1.4E-04
Localized Fire Threatens TAD/WP in TEV in Loadout Room	4.1E-07
Localized Fire Threatens TC/DOE-SNF in Preparation Area w/o SPM (No Diesel Present)	4.7E-06

Localized Fire Threatens TC/DOE-SNF in Vestibule/Preparation Area w/SPM (Diesel Present)	1.1E-06
Localized Fire Threatens TC/DOE-SNF on CTT in Preparation Area	5.6E-06
Localized Fire Threatens TC/DOE-SNF on CTT in Unloading Room	1.7E-06
Localized Fire Threatens TC/DPC (VTC) in Cask Unloading Room	1.5E-07
Localized Fire Threatens TC/DPC (VTC) in Preparation Area	5.6E-06
Localized Fire Threatens TC/DPC (VTC) in Preparation Area (No Diesel Present)	4.1E-06
Localized Fire Threatens TC/DPC (VTC) in Vestibule/Preparation Area (Diesel Present)	1.1E-06
Localized Fire Threatens TC/HLW in Preparation Area w/o SPM (No Diesel Present)	5.6E-06
Localized Fire Threatens TC/HLW in Vestibule/Preparation Area w/SPM (Diesel Present)	1.1E-06
Localized Fire Threatens TC/HLW on CTT in Preparation Area	5.3E-06
Localized Fire Threatens TC/HLW on CTT in Unloading Room	1.1E-06
Localized Fire Threatens TC/TAD in Preparation Area w/o SPM (No Diesel Present)	4.7E-06
Localized Fire Threatens TC/TAD in Vestibule/Preparation Area w/SPM (Diesel Present)	1.1E-06
Localized Fire Threatens TC/TAD on CTT in Preparation Area	6.0E-06
Localized Fire Threatens TC/TAD on CTT in Unloading Room	2.8E-07

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

Source: Crystal Ball 'extract data' output

The Crystal Ball report, forecast worksheets, and "assumptions" follow. The term "assumptions" is used by Crystal Ball to denote the probability distributions of the inputs, and does not refer to assumptions as defined by the calculations and analysis procedure.

Crystal Ball Report - Full
Simulation started on 11/7/2007 at 17:30:59
Simulation stopped on 11/7/2007 at 17:32:39

Run preferences:	
Number of trials run	10,000
Monte Carlo	
Random seed	
Run statistics:	
Total running time (sec)	100.05
Trials/second (average)	100
Random numbers per sec	1,699
Crystal Ball data:	
Assumptions	17
Correlations	0
Correlated groups	0
Decision variables	0
Forecasts	49

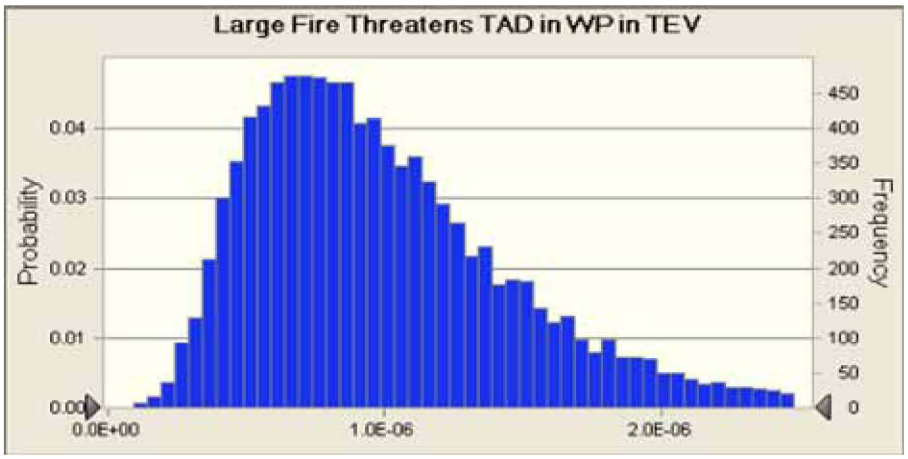
Forecasts

Worksheet: [CRCF Fire Frequency - No Suppression.xls]Initiating Event Frequency

Forecast: Large Fire Threatens TAD in WP in TEV **Cell: K210**

Summary:

Entire range is from 4.5E-08 to 5.2E-06
Base case is 9.2E-07
After 10,000 trials, the std. error of the mean is 5.2E-09



Statistics:	Forecast values
Trials	10,000
Mean	1.0E-06
Median	9.1E-07
Mode	1.4E-06
Standard Deviation	5.2E-07
Variance	2.7E-13
Skewness	1.43
Kurtosis	6.53
Coeff. of Variability	0.5124
Minimum	4.5E-08
Maximum	5.2E-06
Range Width	5.2E-06
Mean Std. Error	5.2E-09

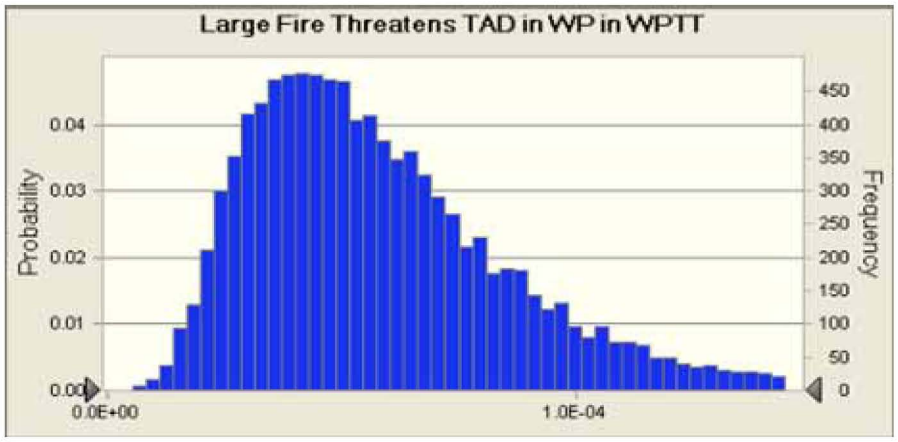
Forecast: Large Fire Threatens TAD in WP in TEV (cont'd) **Cell: K210**

Percentiles:	Forecast values
0%	4.5E-08
10%	4.7E-07
20%	5.9E-07
30%	7.0E-07
40%	8.0E-07
50%	9.1E-07
60%	1.0E-06
70%	1.2E-06
80%	1.4E-06
90%	1.7E-06
100%	5.2E-06

Forecast: Large Fire Threatens TAD in WP in WPTT **Cell: K209**

Summary:

Entire range is from 2.6E-06 to 3.0E-04
Base case is 5.4E-05
After 10,000 trials, the std. error of the mean is 3.0E-07



Statistics:	Forecast values
Trials	10,000
Mean	5.9E-05
Median	5.3E-05
Mode	8.1E-05
Standard Deviation	3.0E-05
Variance	9.2E-10
Skewness	1.43
Kurtosis	6.53
Coeff. of Variability	0.5124
Minimum	2.6E-06
Maximum	3.0E-04
Range Width	3.0E-04
Mean Std. Error	3.0E-07

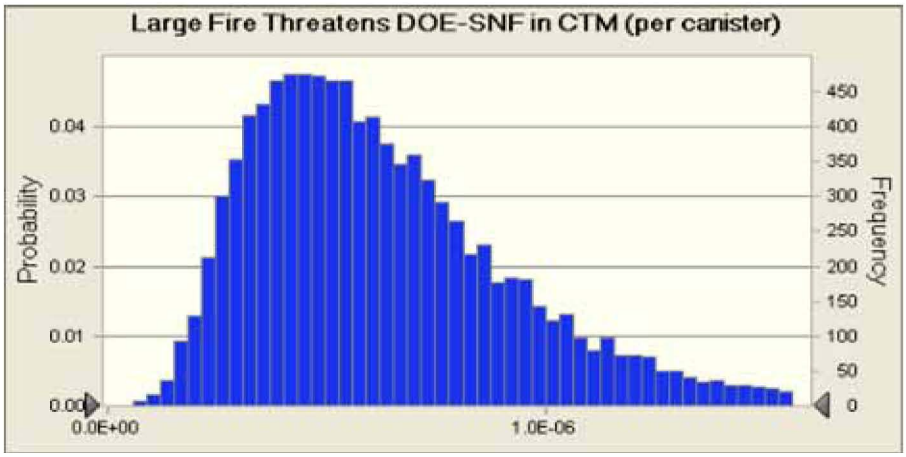
Forecast: Large Fire Threatens TAD in WP in WPTT (cont'd) **Cell: K209**

Percentiles:	Forecast values
0%	2.6E-06
10%	2.8E-05
20%	3.4E-05
30%	4.1E-05
40%	4.7E-05
50%	5.3E-05
60%	6.0E-05
70%	6.9E-05
80%	8.0E-05
90%	9.9E-05
100%	3.0E-04

Forecast: Large Fire Threatens DOE-SNF in CTM (per canister) **Cell: K217**

Summary:

Entire range is from 2.8E-08 to 3.3E-06
Base case is 5.8E-07
After 10,000 trials, the std. error of the mean is 3.3E-09



Statistics:	Forecast values
Trials	10,000
Mean	6.4E-07
Median	5.8E-07
Mode	8.8E-07
Standard Deviation	3.3E-07
Variance	1.1E-13
Skewness	1.43
Kurtosis	6.53
Coeff. of Variability	0.5124
Minimum	2.8E-08
Maximum	3.3E-06
Range Width	3.3E-06
Mean Std. Error	3.3E-09

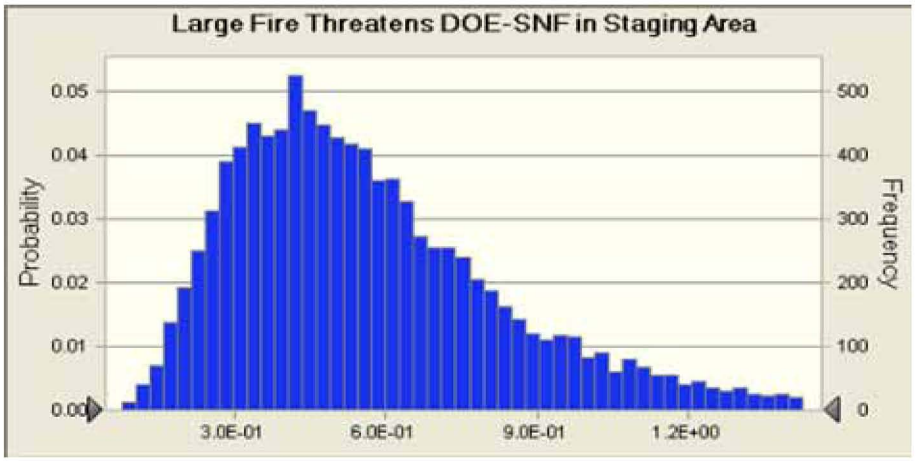
Forecast: Large Fire Threatens DOE-SNF in CTM (per canister) (cont'd) **Cell: K217**

Percentiles:	Forecast values
0%	2.8E-08
10%	3.0E-07
20%	3.7E-07
30%	4.4E-07
40%	5.0E-07
50%	5.8E-07
60%	6.5E-07
70%	7.5E-07
80%	8.7E-07
90%	1.1E-06
100%	3.3E-06

Forecast: Large Fire Threatens DOE-SNF in Staging Area **Cell: K218**

Summary:

Entire range is from 7.5E-02 to 3.9E+00
Base case is 5.2E-01
After 10,000 trials, the std. error of the mean is 3.0E-03



Statistics:	Forecast values
Trials	10,000
Mean	5.8E-01
Median	5.2E-01
Mode	---
Standard Deviation	3.0E-01
Variance	9.2E-02
Skewness	1.52
Kurtosis	7.35
Coeff. of Variability	0.5220
Minimum	7.5E-02
Maximum	3.9E+00
Range Width	3.8E+00
Mean Std. Error	3.0E-03

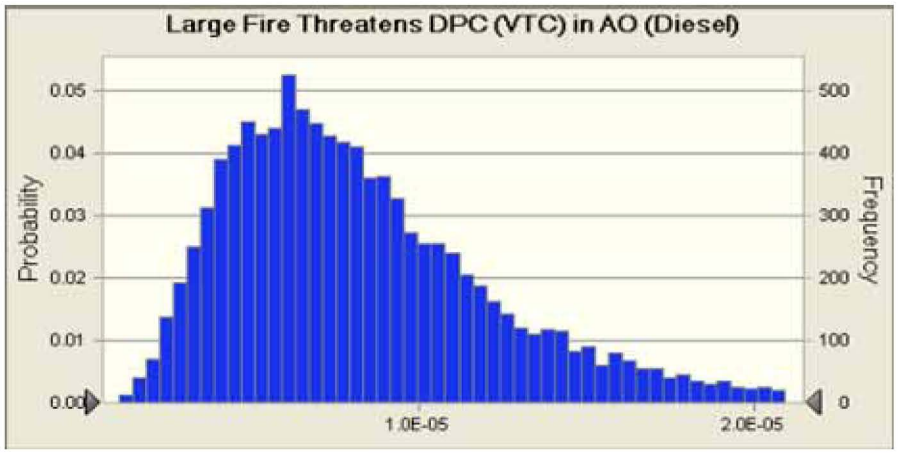
Forecast: Large Fire Threatens DOE-SNF in Staging Area (cont'd) **Cell: K218**

Percentiles:	Forecast values
0%	7.5E-02
10%	2.7E-01
20%	3.3E-01
30%	4.0E-01
40%	4.5E-01
50%	5.2E-01
60%	5.9E-01
70%	6.7E-01
80%	7.8E-01
90%	9.8E-01
100%	3.9E+00

Forecast: Large Fire Threatens DPC (VTC) in AO (Diesel) **Cell: K222**

Summary:

Entire range is from 1.1E-06 to 5.7E-05
Base case is 7.6E-06
After 10,000 trials, the std. error of the mean is 4.4E-08



Statistics:	Forecast values
Trials	10,000
Mean	8.5E-06
Median	7.6E-06
Mode	---
Standard Deviation	4.4E-06
Variance	2.0E-11
Skewness	1.52
Kurtosis	7.35
Coeff. of Variability	0.5220
Minimum	1.1E-06
Maximum	5.7E-05
Range Width	5.6E-05
Mean Std. Error	4.4E-08

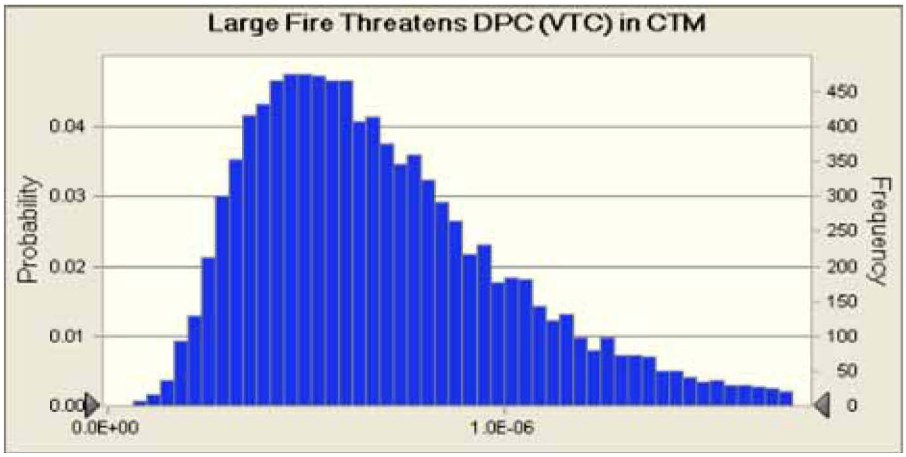
Forecast: Large Fire Threatens DPC (VTC) in AO (Diesel) (cont'd) **Cell: K222**

Percentiles:	Forecast values
0%	1.1E-06
10%	3.9E-06
20%	4.9E-06
30%	5.8E-06
40%	6.7E-06
50%	7.6E-06
60%	8.6E-06
70%	9.8E-06
80%	1.1E-05
90%	1.4E-05
100%	5.7E-05

Forecast: Large Fire Threatens DPC (VTC) in CTM **Cell: K221**

Summary:

Entire range is from 3.1E-08 to 3.6E-06
Base case is 6.4E-07
After 10,000 trials, the std. error of the mean is 3.6E-09



Statistics:	Forecast values
Trials	10,000
Mean	7.1E-07
Median	6.4E-07
Mode	9.7E-07
Standard Deviation	3.6E-07
Variance	1.3E-13
Skewness	1.43
Kurtosis	6.53
Coeff. of Variability	0.5124
Minimum	3.1E-08
Maximum	3.6E-06
Range Width	3.6E-06
Mean Std. Error	3.6E-09

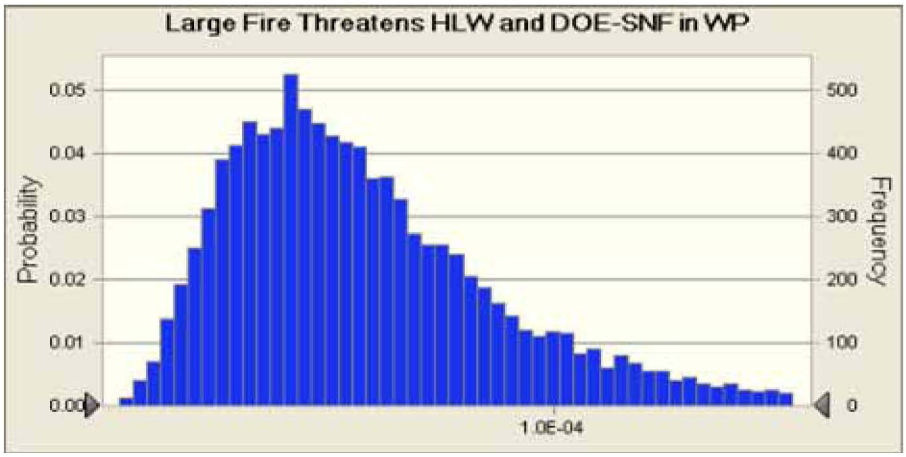
Forecast: Large Fire Threatens DPC (VTC) in CTM (cont'd) **Cell: K221**

Percentiles:	Forecast values
0%	3.1E-08
10%	3.3E-07
20%	4.1E-07
30%	4.9E-07
40%	5.6E-07
50%	6.3E-07
60%	7.2E-07
70%	8.2E-07
80%	9.6E-07
90%	1.2E-06
100%	3.6E-06

Forecast: Large Fire Threatens HLW and DOE-SNF in WP **Cell: K214**

Summary:

Entire range is from 7.9E-06 to 4.1E-04
Base case is 5.5E-05
After 10,000 trials, the std. error of the mean is 3.2E-07



Statistics:	Forecast values
Trials	10,000
Mean	6.1E-05
Median	5.5E-05
Mode	---
Standard Deviation	3.2E-05
Variance	1.0E-09
Skewness	1.52
Kurtosis	7.35
Coeff. of Variability	0.5220
Minimum	7.9E-06
Maximum	4.1E-04
Range Width	4.0E-04
Mean Std. Error	3.2E-07

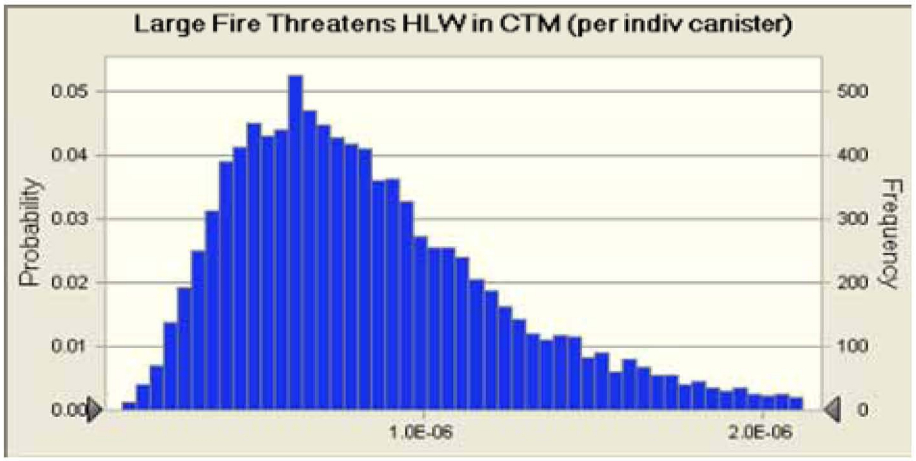
Forecast: Large Fire Threatens HLW and DOE-SNF in WP (cont'd) **Cell: K214**

Percentiles:	Forecast values
0%	7.9E-06
10%	2.8E-05
20%	3.5E-05
30%	4.2E-05
40%	4.8E-05
50%	5.5E-05
60%	6.2E-05
70%	7.0E-05
80%	8.2E-05
90%	1.0E-04
100%	4.1E-04

Forecast: Large Fire Threatens HLW in CTM (per indiv canister) **Cell: K212**

Summary:

Entire range is from 1.1E-07 to 5.8E-06
Base case is 7.7E-07
After 10,000 trials, the std. error of the mean is 4.5E-09



Statistics:	Forecast values
Trials	10,000
Mean	8.6E-07
Median	7.7E-07
Mode	---
Standard Deviation	4.5E-07
Variance	2.0E-13
Skewness	1.52
Kurtosis	7.35
Coeff. of Variability	0.5220
Minimum	1.1E-07
Maximum	5.8E-06
Range Width	5.7E-06
Mean Std. Error	4.5E-09

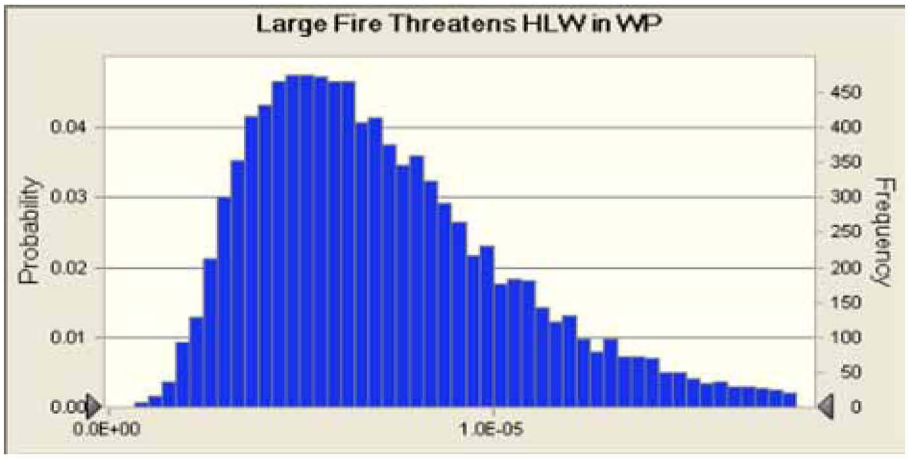
Forecast: Large Fire Threatens HLW in CTM (per indiv canister) (cont'd) **Cell: K212**

Percentiles:	Forecast values
0%	1.1E-07
10%	4.0E-07
20%	5.0E-07
30%	5.9E-07
40%	6.7E-07
50%	7.7E-07
60%	8.7E-07
70%	9.9E-07
80%	1.2E-06
90%	1.4E-06
100%	5.8E-06

Forecast: Large Fire Threatens HLW in WP **Cell: K213**

Summary:

Entire range is from 3.2E-07 to 3.7E-05
Base case is 6.6E-06
After 10,000 trials, the std. error of the mean is 3.8E-08



Statistics:	Forecast values
Trials	10,000
Mean	7.3E-06
Median	6.6E-06
Mode	1.0E-05
Standard Deviation	3.8E-06
Variance	1.4E-11
Skewness	1.43
Kurtosis	6.53
Coeff. of Variability	0.5124
Minimum	3.2E-07
Maximum	3.7E-05
Range Width	3.7E-05
Mean Std. Error	3.8E-08

Forecast: Large Fire Threatens HLW in WP (cont'd) **Cell: K213**

Percentiles:	Forecast values
0%	3.2E-07
10%	3.4E-06
20%	4.3E-06
30%	5.0E-06
40%	5.8E-06
50%	6.6E-06
60%	7.5E-06
70%	8.5E-06
80%	9.9E-06
90%	1.2E-05
100%	3.7E-05