FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Plant:	Various	Date:	February 11, 2019 (Received by NRC 4/3/2019)
Contact:	Beth Meade	Phone:	(508) 532-7139
	Mark Schairer		(508) 532-7137
	Rob Cavedo		(301) 938-0397
		Email:	bah@epm-inc.com
			mvs@epm-inc.com
			robert.cavedo@exeloncorp.com

Distribution: *(NEI Internal Use)*

☒ FPRA TF ☐ BWROG ☐ PWROG

Purpose of FAQ:

This FAQ provides an update to the non-suppression probabilities (NSPs) based on Bayesian approach separating the data before Jan 1st, 2000 and after.

Relevant NRC document(s):

NUREG/CR-6850
NUREG/CR-6850 Supplement 1 (FAQ 08-0050)
NUREG 2169

Details:

NRC document needing interpretation (include document number and title, section, paragraph, and line numbers as applicable):

See list of relevant NRC documents

Circumstances requiring interpretation or new guidance:

The non-suppression probabilities (NSP) provided in NUREG 2169 Table 5-1 are considered overly conservative due to the equal treatment of fire data over a prolonged period. As a result, the risk associated with fires may not reflect the current NSP rates.

Detail contentious points if licensee and NRC have not reached consensus on the facts and circumstances:

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Although recent guidance has sought to provide a better estimate of non-suppression probability, in the case of fire events over a prolonged period, the probability of non-suppression is believed to be non-representative of the current NSPs.

Potentially relevant existing FAQ numbers:

FAQ 08-0050, "Manual Non-Suppression Probability"

Response Section:

Proposed resolution of FAQ and the basis for the proposal:

The fire NSPs are adjusted using a Gamma-Poisson Bayesian model using the data before Jan 1st, 2000 as a prior distribution. There have been numerous improvements to plant process controls that affect both the likelihood, control, and severity of fire scenarios. This includes smoking controls, foreign material exclusion, cutting and welding improvements, combustion controls, brigade training, etc. It is for these reasons among others, that the conclusion in NUREG 2169 is that data from 2000 and later is the most applicable in fire analysis.

It seems reasonable to assume that the data before 2000 would have some influence on the data 2000 and beyond but certainly not more influence. The prior distribution must have less influence than the posterior data. This is ensured by making the alpha factor of the prior distribution half that of the posterior data while maintaining the mean. This ensures that the data after 2000 has more influence that the data prior to 2000.

The NSP for HEAF is developed using the data from FAQ 17-0013.

The results for this process are presented for each suppression curve:

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

T/G Fires:

	Before 2000	After 2000		Combined
Alpha	23	7	Alpha	30
Beta	1057	110		1167
Mean	0.022	0.064		0.026
5th%	0.0149	0.0299		0.019
25th%	0.0186	0.0462		
50th%	0.0214	0.0606		0.025
75th%	0.0246	0.0778		
95th%	0.0297	0.1077		0.034

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	4	7	Alpha	11
Beta	184	110	Beta	294
Mean	0.022	0.064	Mean	0.037
5th%	0.007	0.030	5th%	0.021
25th%	0.014	0.046	25th%	0.029
50th%	0.020	0.061	50th%	0.036
75th%	0.028	0.078	75th%	0.044
95th%	0.042	0.108	95th%	0.058

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Control Room:

	Before 2000	After 2000		Combined
Alpha	7	4	Alpha	11
Beta	28	8		36
Mean	0.250	0.500		0.306
5th%	0.1173	0.1708		0.171
25th%	0.1815	0.3169		
50th%	0.2382	0.4590		0.296
75th%	0.3057	0.6387		
95th%	0.4229	0.9692		0.471

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	2	4	Alpha	6
Beta	8	8	Beta	16
Mean	0.250	0.500	Mean	0.375
5th%	0.044	0.171	5th%	0.163
25th%	0.120	0.317	25th%	0.264
50th%	0.210	0.459	50th%	0.354
75th%	0.337	0.639	75th%	0.464
95th%	0.593	0.969	95th%	0.657

Notes: The calculation sheet for NUREG-2169 uses one additional event: 537, 9/4/1986, 1 minute. This event is excluded as the event occurred during pre-operation testing and will no longer counted in the upcoming suppression rate as estimated for Chapter 8 of Rachelle Fire II.

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

PWR Containment (AP):

	Before 2000	After 2000		Combined
Alpha	3	0	Alpha	3
Beta	36	0		36
Mean	0.083	N/A		0.083
5th%	0.0227	N/A		0.023
25th%	0.0480	N/A		
50th%	0.0743	N/A		0.074
75th%	0.1089	N/A		
95th%	0.1749	N/A		0.175

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	1	0	Alpha	1
Beta	12	0	Beta	12
Mean	0.083	N/A	Mean	0.083
5th%	0.004	N/A	5th%	0.004
25th%	0.024	N/A	25th%	0.024
50th%	0.058	N/A	50th%	0.058
75th%	0.116	N/A	75th%	0.116
95th%	0.250	N/A	95th%	0.250

Note: The calculations utilized to develop the NSP values in NUREG-2169 Table 5-3 included an error. Fire Event 66 was associated with a suppression duration of 14 minutes, but the actual duration is 10 minutes. Therefore, the combined duration is 36 minutes versus the 40 minutes reported in NUREG-2169.

Containment (LPSD):

	Before 2000	After 2000		Combined
Alpha	10	21	Alpha	31
Beta	141	158		299
Mean	0.071	0.133		0.104
5th%	0.0385	0.0891		0.075
25th%	0.0548	0.1124		
50th%	0.0686	0.1308		0.103
75th%	0.0845	0.1512		
95th%	0.1114	0.1839		0.136

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	10	21	Alpha	31
Beta	141	158	Beta	299
Mean	0.071	0.133	Mean	0.104
5th%	0.038	0.089	5th%	0.075
25th%	0.055	0.112	25th%	0.091
50th%	0.069	0.131	50th%	0.103
75th%	0.084	0.151	75th%	0.116
95th%	0.111	0.184	95th%	0.136

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Outdoor Transformers:

	Before 2000	After 2000		Combined
Alpha	18	6	Alpha	24
Beta	635	293		928
Mean	0.028	0.020		0.026
5th%	0.0183	0.0089		0.018
25th%	0.0236	0.0144		
50th%	0.0278	0.0194		0.026
75th%	0.0325	0.0253		
95th%	0.0402	0.0359		0.035

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	3	6	Alpha	9
Beta	106	293	Beta	399
Mean	0.028	0.020	Mean	0.023
5th%	0.008	0.009	5th%	0.012
25th%	0.016	0.014	25th%	0.017
50th%	0.025	0.019	50th%	0.022
75th%	0.037	0.025	75th%	0.027
95th%	0.059	0.036	95th%	0.036

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Flammable Gas:

	Before 2000	After 2000		Combined
Alpha	5	3	Alpha	8
Beta	199	35		234
Mean	0.025	0.086		0.034
5th%	0.0099	0.0234		0.017
25th%	0.0169	0.0494		
50th%	0.0235	0.0764		0.033
75th%	0.0315	0.1120		
95th%	0.0460	0.1799		0.056

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	2	3	Alpha	5
Beta	80	35	Beta	115
Mean	0.025	0.086	Mean	0.044
5th%	0.004	0.023	5th%	0.017
25th%	0.012	0.049	25th%	0.029
50th%	0.021	0.076	50th%	0.041
75th%	0.034	0.112	75th%	0.055
95th%	0.060	0.180	95th%	0.080

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Oil Fires:

	Before 2000	After 2000		Combined
Alpha	32	18	Alpha	50
Beta	464	98		562
Mean	0.069	0.184		0.089
5th%	0.0502	0.1187		0.069
25th%	0.0604	0.1529		
50th%	0.0682	0.1803		0.088
75th%	0.0768	0.2107		
95th%	0.0902	0.2602		0.111

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	9	18	Alpha	27
Beta	131	98	Beta	229
Mean	0.069	0.184	Mean	0.118
5th%	0.036	0.119	5th%	0.083
25th%	0.052	0.153	25th%	0.102
50th%	0.066	0.180	50th%	0.117
75th%	0.083	0.211	75th%	0.133
95th%	0.111	0.260	95th%	0.158

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Cable Fires:

	Before 2000	After 2000		Combined
Alpha	4	0	Alpha	4
Beta	29	0		29
Mean	0.138	N/A		0.138
5th%	0.0471	N/A		0.047
25th%	0.0874	N/A		
50th%	0.1266	N/A		0.127
75th%	0.1762	N/A		
95th%	0.2674	N/A		0.267
Prior Development Rule:				
The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)				
	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	1	0	Alpha	1
Beta	7	0	Beta	7
Mean	0.138	N/A	Mean	0.138
5th%	0.007	N/A	5th%	0.007
25th%	0.040	N/A	25th%	0.040
50th%	0.096	N/A	50th%	0.096
75th%	0.191	N/A	75th%	0.191
95th%	0.413	N/A	95th%	0.413
				0.0%

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Electrical NSP (relocated two events to HEAF per FAQ 17-013):

	Before 2000	After 2000		Combined
Alpha	110	64	Alpha	174
Beta	1177	628		1805
Mean	0.093	0.102		0.096
5th%	0.0793	0.0819		0.085
25th%	0.0873	0.0931		
50th%	0.0932	0.1014		0.096
75th%	0.0993	0.1102		
95th%	0.1086	0.1237		0.109

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	32	64	Alpha	96
Beta	342	628	Beta	970
Mean	0.093	0.102	Mean	0.099
5th%	0.068	0.082	5th%	0.083
25th%	0.082	0.093	25th%	0.092
50th%	0.092	0.101	50th%	0.099
75th%	0.104	0.110	75th%	0.106
95th%	0.122	0.124	95th%	0.116

Note: FAQ 17-0013 revised the event count by removing fire events #792 and #922 with a duration of 5 and 3 minutes respectively. Even without the HEAF FAQ adjustments, the totals obtained from the fire event data differ slightly from those reported in NREG-2169. When the data from NUREG 2169 is totaled there are 177 events with a duration of 1816 minutes, versus the total of 1815 minutes reported in NUREG-2169 Table 5-3. This one-minute increase from the original data results in a minor decrease to the lambda mean (from 0.098 to 0.097) that is not expected to result in statistically significant changes to the overall risk calculations.

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Welding Fires:

	Before 2000	After 2000		Combined
Alpha	26	26	Alpha	52
Beta	248	236		484
Mean	0.105	0.110		0.107
5th%	0.0735	0.0772		0.084
25th%	0.0903	0.0949		
50th%	0.1035	0.1088		0.107
75th%	0.1179	0.1239		
95th%	0.1408	0.1479		0.133

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	13	26	Alpha	39
Beta	124	236	Beta	360
Mean	0.105	0.110	Mean	0.108
5th%	0.062	0.077	5th%	0.081
25th%	0.084	0.095	25th%	0.096
50th%	0.102	0.109	50th%	0.107
75th%	0.123	0.124	75th%	0.119
95th%	0.157	0.148	95th%	0.138

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Transient fires:

	Before 2000	After 2000		Combined
Alpha	27	16	Alpha	43
Beta	252	136		388
Mean	0.107	0.118		0.111
5th%	0.0756	0.0738		0.085
25th%	0.0926	0.0967		
50th%	0.1058	0.1152		0.110
75th%	0.1202	0.1359		
95th%	0.1432	0.1698		0.140

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	8	16	Alpha	24
Beta	75	136	Beta	211
Mean	0.107	0.118	Mean	0.114
5th%	0.053	0.074	5th%	0.079
25th%	0.080	0.097	25th%	0.097
50th%	0.103	0.115	50th%	0.112
75th%	0.130	0.136	75th%	0.129
95th%	0.176	0.170	95th%	0.155

Note: The transient fire total duration is slightly larger than the NUREG-2169 total of 386. This two-minute difference over 388 minutes is conservative, but not significantly conservative.

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

HEAFs (updated per FAQ 17-0013):

	Before 2000	After 2000		Combined
Alpha	6	5	Alpha	11
Beta	146	239		385
Mean	0.041	0.021		0.029
5th%	0.0179	0.0082		0.016
25th%	0.0289	0.0141		
50th%	0.0388	0.0195		0.028
75th%	0.0508	0.0263		
95th%	0.0720	0.0383		0.044

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	3	5	Alpha	8
Beta	73	239	Beta	312
Mean	0.041	0.021	Mean	0.026
5th%	0.011	0.008	5th%	0.013
25th%	0.024	0.014	25th%	0.019
50th%	0.037	0.020	50th%	0.025
75th%	0.054	0.026	75th%	0.031
95th%	0.086	0.038	95th%	0.042

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

All Fires (adjusted per FAQ 17-013):

	Before 2000	After 2000		Combined
Alpha	271	170	Alpha	441
Beta	4412	1941		6353
Mean	0.061	0.088		0.069
5th%	0.0554	0.0768		0.064
25th%	0.0589	0.0830		
50th%	0.0613	0.0874		0.069
75th%	0.0639	0.0920		
95th%	0.0677	0.0989		0.075

Prior Development Rule:

The prior Alpha factor from the before 2000 data is considered to be half that of the distribution that would be developed without a prior (i.e. the data after 2000 is more signficant than the data prior to 2000)

	Weak Prior Before 2000	After 2000		Gamma/Poisson Bayesian Model Combined
Alpha	85	170	Alpha	255
Beta	1384	1941	Beta	3325
Mean	0.061	0.088	Mean	0.077
5th%	0.051	0.077	5th%	0.069
25th%	0.057	0.083	25th%	0.073
50th%	0.061	0.087	50th%	0.077
75th%	0.066	0.092	75th%	0.080
95th%	0.073	0.099	95th%	0.085

Notes: The calculation sheet for NUREG-2169 uses one additional event: 537, 9/4/1986, 1 minute. This event is excluded as the event occurred during pre-operation testing and will no longer counted in the upcoming suppression rate as estimated for Chapter 8 of Rachelle Fire II. As Part of FAQ 17-0013, Event 162 was added to HEAF. As discussed under the EC NSP, there is one event missing. Therefore, the total for this FAQ is one event lower than NUREG-2169.

FAQ Number	18-0018	FAQ Revision	0 (Draft G)
FAQ Title	Updated Non-Suppression Probability (NSP)		

Summary Results:

	Base	Adjusted		
Suppression Curve	Mean	Mean	Change	
T/G Fires	0.026	0.037	44.0%	
Control Room	0.324	0.375	15.7%	
PWR Containmnt AP	0.075	0.083	11.1%	
Containment LPSD	0.104	0.104	0.0%	No Post 2000 Data
Outdoor transformers	0.026	0.023	-13.2%	
Flammable gas	0.034	0.044	28.3%	
Oil Fires	0.089	0.118	32.8%	
Cable fires	0.138	0.138	0.0%	No Post 2000 Data
Electrical fires - adusted per FAQ 17-013	0.096	0.099	2.6%	
Welding fires	0.107	0.108	1.2%	
Transient fires	0.111	0.114	2.6%	
HEAFs - from FAQ-17-013	0.029	0.026	-10.3%	
All fires	0.067	0.077	14.5%	

If appropriate, provide proposed rewording of guidance for inclusion in the next Revision:

The following are proposed revisions to NUREG 2169:

Table 5-1
Probability distribution for rate of fires suppressed per unit time, λ (Originally, Table P-2 from NUREG/CR-6850)

Suppression Curve	Number of Events in Curve	Total Duration (minutes)	Rate of Fire Suppressed (λ)			
			Mean	5th Percent	50th Percent	95th Percent
T/G Fires.	30	1167	0.037	0.021	0.036	0.058
Control Room	11	36	0.375	0.163	0.354	0.657
PWR Containment (AP)	3	36	0.083	0.004	0.058	0.250
Containment (LPSD)	31	299	0.104	0.075	0.103	0.136
Outdoor transformers	24	928	0.023	0.012	0.022	0.036
Flammable gas	8	234	0.044	0.017	0.041	0.080
Oil fires	50	562	0.118	0.083	0.117	0.158
Cable fire	4	29	0.138	0.007	0.096	0.413
Electrical fires	174	1805	0.099	0.083	0.099	0.116
Weld fires	52	484	0.108	0.081	0.107	0.138
Transient fire	43	388	0.114	0.079	0.112	0.155
HEAFs	11	385	0.026	0.013	0.025	0.031
All fires	441	6353	0.077	0.069	0.077	0.085