CCF Parameter Estimations 2015

U.S. Nuclear Regulatory Commission, "CCF Parameter Estimations, 2015 Update"

This report documents the quantitative results of the common-cause failure (CCF) data collection effort and summarizes the results of the parameter estimation quantification process, performed on CCF data in the U.S. NRC CCF database.

10/26/2016

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This report documents the quantitative results of the common-cause failure (CCF) data collection effort and summarizes the results of the parameter estimation quantification process, performed on CCF data in the U.S. NRC CCF database.

These results are appropriate for use in Probabilistic Risk Assessment studies of commercial nuclear power plants in the U.S.

Included in these results are the applications to be used in the SPAR Version greater than 3.45 models. This is the 2015 update to NUREG/CR-5497, updating data and parameter estimations.

This release, CCF Parameter Estimation for 2015, reflects the CCF data contained within the CCF database, https://rads.inl.gov/(S(pfvmhhhjwqgwqdl05jlumdo0))/Pages/CCF.aspx, by executing the query rules in the folder of SPAR Rules 2015 on October 26, 2016. It contains data from 1/1/1997 to 12/31/2015.

The applications contained within were created with a starting date of 1/1/1997. This date was selected in order to use as much of the CCF data as possible, but to avoid using the large number of CCF events in the 1980 to 1996 period since the trend is decreasing significantly from 1980 to 1996.

The way to provide a reference for this update is:

U.S. Nuclear Regulatory Commission, "CCF Parameter Estimations, 2015 Update", http://nrcoe.inel.gov/resultsdb/ParamEstSpar/, October 2016.

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1 Introduction

1.1 General CCF Information

A general conclusion from probabilistic risk assessments (PRAs) of commercial nuclear power plants is that common cause failures (CCFs) are significant contributors to the unavailability of safety systems. A CCF event consists of component failures that meet the following four criteria: (1) two or more components fail or are degraded at the same plant and in the same system, (2) component failures occur within a selected period of time such that success of the PRA mission would be uncertain, (3) the component failures result from a single shared cause and are linked by a coupling mechanism such that other components in the group are susceptible to the same cause and failure mode and, (4) the equipment failures are not caused by the failure of equipment outside the established component boundary.

In response to these deficiencies, the Idaho National Laboratory (INL) staff and the Nuclear Regulatory Commission's (NRC) Office of Nuclear Regulatory Research have developed a CCF data collection and analysis system that includes a method for identifying CCF events, coding and classifying those events for use in CCF studies, and a computer system for storing and analyzing the data. The system is based, in part, on previous CCF methods and models and is designed to run on a personal computer (PC). The data collection effort has collected CCF events from 1980 through 2015 for use in CCF analyses. The current data collection effort has separated the data by system. The principal products of this CCF data collection and analysis system (CCF database) are the method for identifying and classifying CCF events, the CCF database containing both CCF events and independent failure counts, and the CCF parameter estimation software.

Three data sources are used to select equipment failure reports to be reviewed for CCF event identification: the Nuclear Plant Reliability Data System (NPRDS), which contained component failure information prior to 1997; the INPO Consolidated Events Database (ICES), formerly the Equipment Performance and Information Exchange (EPIX), which contains component failure information since 1997; and the Licensee Event Report Search (LERSearch), formerly the Sequence Coding and Search System (SCSS), which contains Licensee Event Reports (LERs). All events that meet the above criteria are identified as CCF events and included in the CCF database.

1.2 Industry Component CCF Parameter Estimations

This report contains CCF parameter estimations for components pooled at various levels. The first level presented is the industry-wide component specific pooled distribution. The pooled distribution represents the pooling of the more specific distributions shown under the pooled distribution. Typically, the pooling takes place across systems.

It is up to the user to decide the level of pooling that is appropriate to the intended use. If data exist at the system/component level most appropriate to the intended use, and are not sparse, it is recommended to use the more specific data. Otherwise, it is recommended to use the industry level pooled component data. If no pooled components are listed that are similar to the intended use, the use of the Generic Demand, Generic Rate, or the No Data (Prior Only) pooled distribution may be appropriate.

1.3 2015 Update

The 2015 Update reflects the CCF data contained within the CCF database, https://rads.inl.gov/(S(pfvmhhhjwqgwqdl05jlumdo0))/Pages/CCF.aspx, by executing the query rules included under the folder of *SPAR Rules 2015A* on October 26, 2016. It contains data from 1/1/1997 to

12/31/2015. This *2015 Report* and the rule folder of *SPAR Rules 2015A* (and *SPAR Rules 2015*) have mostly adopted the *2012 Report* and the *SPAR Rules 2012*, respectively, for program continuation purpose (the folder of *SPAR Rules 2015* has the same CCF rules as the *SPAR Rules 2012*, while the *SPAR Rules 2015A* include a few new CCF rules which were requested by the SPAR model developers). A few changes that were deemed necessary have been made. Appendix A includes a table that lists the differences between the *2012 Report* and *2015 Report*, with the highlights of the differences are presented below. Note that the table in Appendix A also includes the counts of CCF events and effective independent events from the *2012 report* and *2015 report* which can be used as a quick reference and comparison.

- The Date Range is changed from "1997 to 2012" to "1997 to 2015".
- For the CCF event type of those *SPAR Rules 2015*, "CCF Events Only" instead of "All Events" is selected to exclude those explicitly modeled events from the query results.
- The failure mode of UA is excluded from the CCF parameter estimation process. There was no equipment failure in the events with UA, in which the equipment was under maintenance or was out due to the state of another component.
- The section numbers are changed as the introduction section is separated from the CCF parameter estimations in the *2015 Report*.
- A few new rules were created and added to the CCF rule folder of *SPAR Rules 2015A* and this *2015 Report* due to one of the following reasons: (1) the SPAR model developers requested the additions (for example, added 2.3.1.5 ALL-MOV-LK for MOVs leakage failure; 2.4.1.4 ALL-AOV-SO for AOVs spurious operations; 2.13.2.4 ACP-CRB-4160-FTOC for 4160V circuit breakers fail to open/close, etc.); (2) the CCF failure data and parameter results support different levels of the pooled distributions (for example, added 2.1.1.5 ALL-MDP-NR-FR for normally running motor driven pump fail-to-run as the results are significantly different from those of the standby motor driven pump fail-to-run); and (3) other adjustment as needed (for example, the previous rule CCW-HTX-HT was actually for non-extreme environmental failure causes and should be named as CCW-HTX-HT-NE. As such, new rules 2.7.6.1 CCW-HTX-HT and 2.7.6.2 CCW-HTX-HT-EE were added in this update).
- The designations of various Service Water systems (normally running, standby, or both) in the *SPAR Rules 2012* are revised in the *SPAR Rules 2015(A)* in order to be consistent with the SPAR models and conventions.

Service Water System	**Old System Designation (2012 Rules)**	**New System Designation (2015 Rules)**	**2012 SPAR Rule**	**2015 SPAR Rule**
Normally Running Service Water	SWN	SWN	1.3.8 SWN-MDP-FS, -FR	2.1.8 SWN-MDP-FS, -FR
Standby Service Water	SWS	SSW	1.3.8 SWS-MDP-FS, -FR	2.1.8 SSW-MDP-FS, -FR
Normally Running + Standby	ESW	SWS	1.3.8 ESW-MDP-FS, -FR 1.8.2 ESW-TSA-FO, -PG 1.8.2 ESW-STR-PG 1.8.6 ESW-STR-EE-PG 1.8.6 ESW-TSA-EE-PG	2.1.8 SWS-MDP-FS, -FR 2.6.2 SWS-TSA-FO, -PG 2.6.2 SWS-STR-PG 2.6.2 SWS-STR-EE-PG 2.6.2 SWS-TSA-EE-PG

- The sections for the strainers and traveling screens are re-arranged to better present results for different systems (pooled systems, service water system, circulating water system). NE (designation for non-environmental failure causes) is added to the rule names as necessary. For

example, the 2012 rule ESW-STR-PG actually includes non-environmental failure causes in its rule selection criteria. The 2015 corresponding rule name is thus changed to SWS-STR-PG-EE (ESW is changed to SWS to represent both normally running and standby service water systems as described above).

- Previous updates (2010, 2012) to the parameter estimation report included the SPAR alpha factor basic event names (or called ZA template names) at the time to facilitate the cross reference of the CCF report to the SPAR models. These ZA template names have been changed along with the evolving of SPAR models. Appendix B provides a matrix between the current ZA template names and the CCF rules as in the *SPAR Rules 2015A.*

2 Industry Component CCF Distributions

2.1 Motor Driven Pumps

2.1.1 Pooled Motor Driven Pump Distributions

2.1.1.1 MOTOR DRIVEN PUMP FAIL TO START ALL SYSTEMS SPAR: MDP-FS

Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 679.0
Total Number of Common-Cause Failure Events: 21

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9725566	0.9833721	0.9840619	0.9918185	0.9839410	4.546E+02	7.687E+00
α_2	8.18E-03	1.66E-02	1.59E-02	2.74E-02	1.61E-02	7.687E+00	4.546E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741012	0.9828571	0.9833104	0.9900513	0.9837133	6.905E+02	1.204E+01
α_2	6.06E-03	1.19E-02	1.15E-02	1.93E-02	1.12E-02	8.371E+00	6.942E+02
α_3	1.68E-03	5.23E-03	4.77E-03	1.04E-02	5.07E-03	3.674E+00	6.989E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746143	0.9822380	0.9825763	0.9886924	0.9833634	9.223E+02	1.668E+01
α_2	6.19E-03	1.12E-02	1.08E-02	1.73E-02	1.04E-02	1.049E+01	9.285E+02
α_3	1.63E-03	4.55E-03	4.20E-03	8.65E-03	4.34E-03	4.268E+00	9.347E+02
α_4	3.43E-04	2.04E-03	1.70E-03	4.90E-03	1.90E-03	1.915E+00	9.370E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9774389	0.9838247	0.9840926	0.9892989	0.9855599	1.190E+03	1.956E+01
α_2	4.12E-03	7.75E-03	7.48E-03	1.23E-02	6.54E-03	9.375E+00	1.200E+03
α_3	2.25E-03	5.09E-03	4.82E-03	8.85E-03	4.67E-03	6.155E+00	1.203E+03
α_4	7.27E-04	2.58E-03	2.31E-03	5.34E-03	2.47E-03	3.116E+00	1.206E+03
α_5	3.10E-05	7.58E-04	5.07E-04	2.34E-03	7.61E-04	9.170E-01	1.208E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9796475	0.9852113	0.9854356	0.9900202	0.9870829	1.428E+03	2.144E+01
α_2	2.94E-03	5.78E-03	5.55E-03	9.39E-03	4.62E-03	8.379E+00	1.441E+03
α_3	1.98E-03	4.40E-03	4.17E-03	7.59E-03	3.94E-03	6.371E+00	1.443E+03
α_4	1.01E-03	2.88E-03	2.65E-03	5.51E-03	2.70E-03	4.173E+00	1.445E+03
α_5	2.48E-04	1.39E-03	1.16E-03	3.28E-03	1.34E-03	2.008E+00	1.447E+03
α_6	1.45E-06	3.49E-04	1.60E-04	1.33E-03	3.18E-04	5.053E-01	1.449E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.84E-01	9.84E-01	9.83E-01	9.86E-01	9.87E-01
α_2	1.61E-02	1.12E-02	1.04E-02	6.54E-03	4.62E-03
α_3		5.07E-03	4.34E-03	4.67E-03	3.94E-03
α_4			1.90E-03	2.47E-03	2.70E-03
α_5				7.61E-04	1.34E-03
α_6					3.18E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.84E-01	9.84E-01	9.83E-01	9.86E-01	9.87E-01
Beta	1.61E-02	1.63E-02	1.66E-02	1.44E-02	1.29E-02
Gamma		3.11E-01	3.75E-01	5.47E-01	6.42E-01
Delta			3.05E-01	4.09E-01	5.25E-01
Epsilon				2.36E-01	3.81E-01
Mu					1.91E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	432.09	648.14	864.18	1080.23	1296.27
N_1	12.2620	12.8561	11.9692	13.4597	14.7926
N_2	7.2523	7.5369	9.2664	7.2607	6.1395
N_3		3.4067	3.8636	5.1772	5.2289
N_4			1.6928	2.7417	3.5804
N_5				0.8447	1.7860
N_6					0.4220

2.1.1.2 MOTOR DRIVEN PUMP FTR LESS THAN 1H ALL SYSTEMS

Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 56.8
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9161027	0.9648330	0.9705025	0.9941436	0.9662215	5.125E+01	1.868E+00
α_2	5.86E-03	3.52E-02	2.95E-02	8.39E-02	3.38E-02	1.868E+00	5.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9273613	0.9637112	0.9669862	0.9888623	0.9635258	8.978E+01	3.381E+00
α_2	6.78E-03	2.79E-02	2.46E-02	6.04E-02	2.83E-02	2.604E+00	9.056E+01
α_3	2.10E-04	8.34E-03	5.19E-03	2.72E-02	8.16E-03	7.772E-01	9.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9266443	0.9586821	0.9610111	0.9827522	0.9571267	1.248E+02	5.378E+00
α_2	1.05E-02	3.05E-02	2.81E-02	5.85E-02	3.33E-02	3.964E+00	1.262E+02
α_3	3.19E-04	7.22E-03	4.91E-03	2.20E-02	6.52E-03	9.403E-01	1.292E+02
α_4	1.07E-05	3.64E-03	1.58E-03	1.42E-02	3.05E-03	4.737E-01	1.297E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9395205	0.9635024	0.9650301	0.9822763	0.9625144	1.941E+02	7.353E+00
α_2	7.73E-03	2.14E-02	1.98E-02	4.03E-02	2.15E-02	4.302E+00	1.972E+02
α_3	1.98E-03	1.04E-02	8.85E-03	2.42E-02	1.10E-02	2.100E+00	1.994E+02
α_4	8.47E-05	3.74E-03	2.28E-03	1.24E-02	3.73E-03	7.539E-01	2.007E+02
α_5	8.30E-10	9.80E-04	9.84E-05	5.07E-03	1.23E-03	1.974E-01	2.013E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9440410	0.9652736	0.9665435	0.9821646	0.9658438	2.341E+02	8.421E+00
α_2	6.10E-03	1.72E-02	1.59E-02	3.28E-02	1.60E-02	4.175E+00	2.383E+02
α_3	2.24E-03	1.00E-02	8.69E-03	2.23E-02	1.06E-02	2.426E+00	2.401E+02
α_4	3.87E-04	4.95E-03	3.68E-03	1.39E-02	5.02E-03	1.202E+00	2.413E+02
α_5	5.67E-06	1.95E-03	8.45E-04	7.63E-03	2.07E-03	4.727E-01	2.420E+02
α_6	3.07E-12	6.01E-04	2.24E-05	3.33E-03	5.15E-04	1.457E-01	2.424E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.66E-01	9.64E-01	9.57E-01	9.63E-01	9.66E-01
α_2	3.38E-02	2.83E-02	3.33E-02	2.15E-02	1.60E-02
α_3		8.16E-03	6.52E-03	1.10E-02	1.06E-02
α_4			3.05E-03	3.73E-03	5.02E-03
α_5				1.23E-03	2.07E-03
α_6					5.15E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.66E-01	9.64E-01	9.57E-01	9.63E-01	9.66E-01
Beta	3.38E-02	3.65E-02	4.29E-02	3.75E-02	3.42E-02
Gamma		2.24E-01	2.23E-01	4.27E-01	5.33E-01
Delta			3.19E-01	3.10E-01	4.18E-01
Epsilon				2.48E-01	3.39E-01
Mu					2.00E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	37.87	56.80	75.73	94.67	113.60
N_1	3.1333	3.4300	2.9160	3.2805	3.5429
N_2	1.4333	1.7700	2.7360	2.1873	1.9355
N_3		0.5100	0.5360	1.1227	1.2847
N_4			0.2510	0.3795	0.6094
N_5				0.1251	0.2505
N_6					0.0625

2.1.1.3 MOTOR DRIVEN PUMP FAIL TO RUN (STANDBY)

Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run >1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 217.3
Total Number of Common-Cause Failure Events: 15

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432187	0.9699125	0.9721024	0.9891280	0.9707771	1.373E+02	4.259E+00
α_2	1.09E-02	3.01E-02	2.79E-02	5.68E-02	2.92E-02	4.259E+00	1.373E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9430349	0.9652268	0.9666087	0.9827130	0.9654075	2.159E+02	7.777E+00
α_2	1.21E-02	2.73E-02	2.59E-02	4.73E-02	2.73E-02	6.110E+00	2.175E+02
α_3	1.04E-03	7.45E-03	6.04E-03	1.87E-02	7.25E-03	1.666E+00	2.220E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9423892	0.9620233	0.9630366	0.9781847	0.9621514	2.906E+02	1.147E+01
α_2	1.28E-02	2.57E-02	2.47E-02	4.23E-02	2.58E-02	7.778E+00	2.943E+02
α_3	2.56E-03	9.62E-03	8.56E-03	2.03E-02	9.85E-03	2.906E+00	2.992E+02
α_4	6.82E-05	2.61E-03	1.63E-03	8.50E-03	2.22E-03	7.880E-01	3.013E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9501449	0.9659456	0.9666949	0.9791935	0.9663997	4.006E+02	1.412E+01
α_2	8.93E-03	1.83E-02	1.75E-02	3.02E-02	1.73E-02	7.574E+00	4.071E+02
α_3	3.56E-03	1.01E-02	9.30E-03	1.92E-02	1.02E-02	4.177E+00	4.105E+02
α_4	8.76E-04	4.86E-03	4.09E-03	1.15E-02	5.21E-03	2.016E+00	4.127E+02
α_5	3.67E-07	8.53E-04	2.66E-04	3.70E-03	8.94E-04	3.539E-01	4.143E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9542171	0.9681430	0.9687718	0.9799316	0.9692530	4.811E+02	1.583E+01
α_2	6.87E-03	1.44E-02	1.38E-02	2.42E-02	1.31E-02	7.160E+00	4.897E+02
α_3	3.40E-03	9.12E-03	8.47E-03	1.71E-02	9.02E-03	4.531E+00	4.924E+02
α_4	1.28E-03	5.30E-03	4.65E-03	1.15E-02	5.43E-03	2.633E+00	4.943E+02
α_5	2.29E-04	2.58E-03	1.95E-03	7.08E-03	2.82E-03	1.281E+00	4.956E+02
α_6	2.07E-09	4.51E-04	6.20E-05	2.25E-03	3.74E-04	2.239E-01	4.967E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.71E-01	9.65E-01	9.62E-01	9.66E-01	9.69E-01
α_2	2.92E-02	2.73E-02	2.58E-02	1.73E-02	1.31E-02
α_3		7.25E-03	9.85E-03	1.02E-02	9.02E-03
α_4			2.22E-03	5.21E-03	5.43E-03
α_5				8.94E-04	2.82E-03
α_6					3.74E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.71E-01	9.65E-01	9.62E-01	9.66E-01	9.69E-01
Beta	2.92E-02	3.46E-02	3.78E-02	3.36E-02	3.07E-02
Gamma		2.10E-01	3.19E-01	4.84E-01	5.74E-01
Delta			1.84E-01	3.75E-01	4.89E-01
Epsilon				1.46E-01	3.70E-01
Mu					1.17E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	118.53	177.79	237.05	296.32	355.58
N_1	8.5273	8.5145	7.4303	8.0803	8.5358
N_2	3.8247	5.2766	6.5501	5.4598	4.9205
N_3		1.3992	2.5020	3.2001	3.3893
N_4			0.5653	1.6420	2.0413
N_5				0.2816	1.0590
N_6					0.1407

2.1.1.4 MOTOR DRIVEN PUMP FAIL TO RUN >1H ALL SYSTEMS

Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run >1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 160.5
Total Number of Common-Cause Failure Events: 11

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9406737	0.9719050	0.9749780	0.9926332	0.9734006	9.776E+01	2.826E+00
α_2	7.37E-03	2.81E-02	2.50E-02	5.93E-02	2.66E-02	2.826E+00	9.776E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9404120	0.9663428	0.9682332	0.9858261	0.9668636	1.578E+02	5.497E+00
α_2	9.70E-03	2.66E-02	2.47E-02	5.00E-02	2.64E-02	4.340E+00	1.590E+02
α_3	5.12E-04	7.08E-03	5.20E-03	2.01E-02	6.70E-03	1.156E+00	1.622E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9418397	0.9643252	0.9657092	0.9820962	0.9651432	2.149E+02	7.949E+00
α_2	9.04E-03	2.26E-02	2.12E-02	4.10E-02	2.18E-02	5.042E+00	2.178E+02
α_3	2.32E-03	1.06E-02	9.21E-03	2.38E-02	1.12E-02	2.370E+00	2.205E+02
α_4	1.37E-05	2.41E-03	1.17E-03	9.01E-03	1.80E-03	5.370E-01	2.223E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9495524	0.9674400	0.9684224	0.9819843	0.9687867	3.063E+02	1.031E+01
α_2	7.04E-03	1.70E-02	1.60E-02	3.04E-02	1.51E-02	5.387E+00	3.112E+02
α_3	2.69E-03	9.65E-03	8.64E-03	2.01E-02	9.58E-03	3.055E+00	3.135E+02
α_4	6.99E-04	5.17E-03	4.17E-03	1.31E-02	5.82E-03	1.637E+00	3.149E+02
α_5	4.34E-09	7.23E-04	1.05E-04	3.59E-03	7.22E-04	2.288E-01	3.163E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9534270	0.9692431	0.9700650	0.9822637	0.9713700	3.683E+02	1.169E+01
α_2	5.59E-03	1.37E-02	1.29E-02	2.48E-02	1.15E-02	5.224E+00	3.747E+02
α_3	2.50E-03	8.54E-03	7.70E-03	1.75E-02	8.13E-03	3.246E+00	3.767E+02
α_4	9.64E-04	5.33E-03	4.49E-03	1.26E-02	5.53E-03	2.024E+00	3.779E+02
α_5	1.50E-04	2.71E-03	1.91E-03	8.03E-03	3.12E-03	1.031E+00	3.789E+02
α_6	1.46E-11	4.25E-04	2.30E-05	2.30E-03	3.02E-04	1.614E-01	3.798E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.73E-01	9.67E-01	9.65E-01	9.69E-01	9.71E-01
α_2	2.66E-02	2.64E-02	2.18E-02	1.51E-02	1.15E-02
α_3		6.70E-03	1.12E-02	9.58E-03	8.13E-03
α_4			1.80E-03	5.82E-03	5.53E-03
α_5				7.22E-04	3.12E-03
α_6					3.02E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.73E-01	9.67E-01	9.65E-01	9.69E-01	9.71E-01
Beta	2.66E-02	3.31E-02	3.49E-02	3.12E-02	2.86E-02
Gamma		2.02E-01	3.74E-01	5.17E-01	5.97E-01
Delta			1.38E-01	4.06E-01	5.24E-01
Epsilon				1.10E-01	3.82E-01
Mu					8.82E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	82.12	123.17	164.23	205.29	246.35
N_1	5.3940	5.0845	4.5143	4.7998	4.9928
N_2	2.3913	3.5066	3.8141	3.2724	2.9849
N_3		0.8892	1.9660	2.0774	2.1046
N_4			0.3143	1.2625	1.4319
N_5				0.1565	0.8084
N_6					0.0782

2.1.1.5 MOTOR DRIVEN PUMP FAIL TO RUN (NORMALLY RUNNING)

Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 354.2
Total Number of Common-Cause Failure Events: 9

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9726838	0.9861473	0.9873495	0.9955075	0.9872698	2.623E+02	3.685E+00
α_2	4.49E-03	1.39E-02	1.27E-02	2.73E-02	1.27E-02	3.685E+00	2.623E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9685824	0.9808622	0.9816363	0.9904962	0.9822169	4.024E+02	7.851E+00
α_2	6.54E-03	1.48E-02	1.40E-02	2.58E-02	1.38E-02	6.084E+00	4.041E+02
α_3	6.51E-04	4.31E-03	3.53E-03	1.06E-02	3.95E-03	1.767E+00	4.085E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9710143	0.9813676	0.9819443	0.9897399	0.9832768	5.410E+02	1.027E+01
α_2	4.73E-03	1.08E-02	1.03E-02	1.90E-02	9.44E-03	5.978E+00	5.453E+02
α_3	1.79E-03	6.02E-03	5.44E-03	1.23E-02	5.80E-03	3.321E+00	5.480E+02
α_4	8.45E-05	1.76E-03	1.21E-03	5.33E-03	1.49E-03	9.727E-01	5.503E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728780	0.9817317	0.9821695	0.9890773	0.9844714	7.131E+02	1.327E+01
α_2	3.94E-03	8.76E-03	8.32E-03	1.51E-02	6.79E-03	6.367E+00	7.200E+02
α_3	2.16E-03	5.97E-03	5.53E-03	1.13E-02	5.36E-03	4.338E+00	7.220E+02
α_4	5.57E-04	2.92E-03	2.47E-03	6.78E-03	2.78E-03	2.117E+00	7.243E+02
α_5	1.30E-06	6.16E-04	2.52E-04	2.46E-03	5.98E-04	4.473E-01	7.259E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748349	0.9826784	0.9830434	0.9892611	0.9855842	8.560E+02	1.509E+01
α_2	3.07E-03	6.98E-03	6.60E-03	1.22E-02	5.12E-03	6.078E+00	8.650E+02
α_3	1.92E-03	5.18E-03	4.81E-03	9.72E-03	4.50E-03	4.514E+00	8.666E+02
α_4	9.23E-04	3.41E-03	3.04E-03	7.17E-03	3.17E-03	2.970E+00	8.681E+02
α_5	1.23E-04	1.44E-03	1.08E-03	3.99E-03	1.38E-03	1.256E+00	8.698E+02
α_6	1.23E-08	3.11E-04	6.34E-05	1.47E-03	2.50E-04	2.707E-01	8.708E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.87E-01	9.82E-01	9.83E-01	9.84E-01	9.86E-01
α_2	1.27E-02	1.38E-02	9.44E-03	6.79E-03	5.12E-03
α_3		3.95E-03	5.80E-03	5.36E-03	4.50E-03
α_4			1.49E-03	2.78E-03	3.17E-03
α_5				5.98E-04	1.38E-03
α_6					2.50E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.87E-01	9.82E-01	9.83E-01	9.84E-01	9.86E-01
Beta	1.27E-02	1.78E-02	1.67E-02	1.55E-02	1.44E-02
Gamma		2.22E-01	4.36E-01	5.63E-01	6.45E-01
Delta			2.05E-01	3.87E-01	5.16E-01
Epsilon				1.77E-01	3.39E-01
Mu					1.53E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	245.22	367.82	490.43	613.04	735.65
N_1	6.8333	5.0000	4.4444	3.9120	3.4005
N_2	3.2500	5.2500	4.7500	4.2523	3.8385
N_3		1.5000	2.9167	3.3611	3.3717
N_4			0.7500	1.7431	2.3779
N_5				0.3750	1.0341
N_6					0.1875

2.1.1.6 MOTOR DRIVEN PUMP FAIL TO START (STANDBY)

Systems/Clean Water/Auxiliary feedwater
Systems/Clean Water/Containment spray recirculation
Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/High pressure core spray
Systems/Clean Water/High pressure injection
Systems/Clean Water/Isolation condenser
Systems/Clean Water/Low pressure core spray
Systems/Clean Water/Reactor core isolation
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Systems/Clean Water/Standby liquid control
Systems/Electrical/Emergency power supply
Systems/Electrical/Fuel Oil Transfer
Systems/Other
Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start (Normally standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 428.2
Total Number of Common-Cause Failure Events: 21

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9581918	0.9746046	0.9756455	0.9874754	0.9751637	2.950E+02	7.687E+00
α_2	1.25E-02	2.54E-02	2.44E-02	4.18E-02	2.48E-02	7.687E+00	2.950E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9607983	0.9739968	0.9746746	0.9848755	0.9746990	4.511E+02	1.204E+01
α_2	9.21E-03	1.81E-02	1.74E-02	2.93E-02	1.74E-02	8.371E+00	4.548E+02
α_3	2.56E-03	7.93E-03	7.24E-03	1.57E-02	7.88E-03	3.674E+00	4.595E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9616112	0.9730900	0.9735995	0.9828364	0.9740757	6.031E+02	1.668E+01
α_2	9.39E-03	1.69E-02	1.64E-02	2.62E-02	1.62E-02	1.049E+01	6.093E+02
α_3	2.47E-03	6.89E-03	6.36E-03	1.31E-02	6.76E-03	4.268E+00	6.155E+02
α_4	5.21E-04	3.09E-03	2.58E-03	7.42E-03	2.96E-03	1.915E+00	6.178E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9663836	0.9758610	0.9762542	0.9840108	0.9774532	7.908E+02	1.956E+01
α_2	6.15E-03	1.16E-02	1.12E-02	1.83E-02	1.02E-02	9.375E+00	8.010E+02
α_3	3.36E-03	7.59E-03	7.19E-03	1.32E-02	7.28E-03	6.155E+00	8.043E+02
α_4	1.09E-03	3.85E-03	3.45E-03	7.97E-03	3.86E-03	3.116E+00	8.073E+02
α_5	4.63E-05	1.13E-03	7.57E-04	3.49E-03	1.19E-03	9.170E-01	8.095E+02

CCCG = 6

MOTOR DRIVEN PUMP FAIL TO START (STANDBY)

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696447	0.9779162	0.9782459	0.9850700	0.9798019	9.492E+02	2.144E+01
α_2	4.39E-03	8.63E-03	8.30E-03	1.40E-02	7.23E-03	8.379E+00	9.623E+02
α_3	2.95E-03	6.56E-03	6.23E-03	1.13E-02	6.16E-03	6.371E+00	9.643E+02
α_4	1.51E-03	4.30E-03	3.96E-03	8.23E-03	4.22E-03	4.173E+00	9.665E+02
α_5	3.70E-04	2.07E-03	1.74E-03	4.90E-03	2.10E-03	2.008E+00	9.686E+02
α_6	2.16E-06	5.21E-04	2.39E-04	1.99E-03	4.97E-04	5.053E-01	9.701E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.75E-01	9.75E-01	9.74E-01	9.77E-01	9.80E-01
α_2	2.48E-02	1.74E-02	1.62E-02	1.02E-02	7.23E-03
α_3		7.88E-03	6.76E-03	7.28E-03	6.16E-03
α_4			2.96E-03	3.86E-03	4.22E-03
α_5				1.19E-03	2.10E-03
α_6					4.97E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.75E-01	9.75E-01	9.74E-01	9.77E-01	9.80E-01
Beta	2.48E-02	2.53E-02	2.59E-02	2.25E-02	2.02E-02
Gamma		3.11E-01	3.75E-01	5.47E-01	6.42E-01
Delta			3.05E-01	4.09E-01	5.25E-01
Epsilon				2.36E-01	3.81E-01
Mu					1.91E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	272.49	408.74	544.98	681.23	817.47
N_1	12.2620	12.8561	11.9692	13.4597	14.7926
N_2	7.2523	7.5369	9.2664	7.2607	6.1395
N_3		3.4067	3.8636	5.1772	5.2289
N_4			1.6928	2.7417	3.5804
N_5				0.8447	1.7860
N_6					0.4220

2.1.1.7 MOTOR DRIVEN PUMP FAIL TO START (NORMALLY RUNNING)

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/Component cooling water
Systems/Clean Water/Condensate system
Systems/Clean Water/Condensate transfer system
Systems/Clean Water/Main feedwater
Systems/Clean Water/Reactor coolant
Systems/Raw Water/Circulating water system
Systems/Raw Water/Firewater
Systems/Raw Water/Generic dirty water system for relief valves
Systems/Raw Water/Normally operating service water
Systems/Reactor/Control rod drive
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 247.8
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9932197	0.9983189	0.9993323	0.9999937	1.0000000	2.580E+02	4.345E-01
α_2	2.98E-06	1.68E-03	6.70E-04	6.78E-03	0.00E+00	4.345E-01	2.580E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9885702	0.9960465	0.9971553	0.9997424	1.0000000	2.774E+02	1.101E+00
α_2	9.34E-05	2.99E-03	1.92E-03	9.55E-03	0.00E+00	8.337E-01	2.776E+02
α_3	3.32E-08	9.60E-04	1.91E-04	4.55E-03	0.00E+00	2.672E-01	2.782E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9848040	0.9937284	0.9948039	0.9989836	1.0000000	2.939E+02	1.855E+00
α_2	3.39E-04	4.15E-03	3.10E-03	1.16E-02	0.00E+00	1.228E+00	2.946E+02
α_3	1.53E-06	1.37E-03	5.03E-04	5.66E-03	0.00E+00	4.043E-01	2.954E+02
α_4	3.22E-09	7.53E-04	1.02E-04	3.77E-03	0.00E+00	2.227E-01	2.956E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9796774	0.9898180	0.9907395	0.9968024	1.0000000	3.440E+02	3.538E+00
α_2	1.16E-03	6.08E-03	5.17E-03	1.41E-02	0.00E+00	2.114E+00	3.454E+02
α_3	1.37E-04	2.81E-03	1.94E-03	8.48E-03	0.00E+00	9.774E-01	3.465E+02
α_4	7.05E-07	1.08E-03	3.62E-04	4.58E-03	0.00E+00	3.744E-01	3.471E+02
α_5	1.71E-21	2.08E-04	1.17E-07	1.20E-03	0.00E+00	7.228E-02	3.474E+02

MOTOR DRIVEN PUMP FAIL TO START (NORMALLY RUNNING)
CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9780064	0.9884053	0.9892735	0.9958348	1.0000000	3.647E+02	4.279E+00
α_2	1.24E-03	6.07E-03	5.20E-03	1.39E-02	0.00E+00	2.239E+00	3.668E+02
α_3	2.17E-04	3.09E-03	2.26E-03	8.83E-03	0.00E+00	1.142E+00	3.679E+02
α_4	1.43E-05	1.60E-03	8.38E-04	5.80E-03	0.00E+00	5.922E-01	3.684E+02
α_5	2.51E-09	6.02E-04	8.14E-05	3.02E-03	0.00E+00	2.222E-01	3.688E+02
α_6	3.81E-19	2.26E-04	3.94E-07	1.31E-03	0.00E+00	8.324E-02	3.689E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	247.80	247.80	247.80	247.80	247.80
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.1.2 Pooled Pump Volutes

2.1.2.1 CLEAN SYSTEM PUMP VOLUTES FAIL TO RUN SPAR: PMP-FR

Systems/Clean Water/Auxiliary feedwater
Systems/Clean Water/Chemical and volume control
Systems/Clean Water/Component cooling water
Systems/Clean Water/Containment spray recirculation
Systems/Clean Water/Low pressure core spray
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Systems/Clean Water/Standby liquid control
Components/Pump/Engine Driven Pump/Centrifugal/Pump
Components/Pump/Motor Driven Pump/Centrifugal/Pump
Components/Pump/Turbine Driven Pump/Centrifugal/Pump
Failure Modes/Fail to Run (Normally running equipment)
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 92.1
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9627206	0.9854796	0.9884084	0.9982105	0.9884211	1.041E+02	1.535E+00
α_2	1.79E-03	1.45E-02	1.16E-02	3.73E-02	1.16E-02	1.535E+00	1.041E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9691642	0.9861991	0.9880317	0.9969738	0.9909770	1.701E+02	2.381E+00
α_2	1.22E-03	9.30E-03	7.48E-03	2.36E-02	5.43E-03	1.604E+00	1.709E+02
α_3	1.13E-04	4.51E-03	2.79E-03	1.47E-02	3.60E-03	7.772E-01	1.717E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9711786	0.9857242	0.9870719	0.9956727	0.9919264	2.333E+02	3.378E+00
α_2	1.45E-03	8.30E-03	6.96E-03	1.97E-02	3.90E-03	1.964E+00	2.347E+02
α_3	1.75E-04	3.97E-03	2.69E-03	1.21E-02	2.84E-03	9.403E-01	2.357E+02
α_4	5.88E-06	2.00E-03	8.69E-04	7.83E-03	1.33E-03	4.737E-01	2.362E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.88E-01	9.91E-01	9.92E-01
α_2	1.16E-02	5.43E-03	3.90E-03
α_3		3.60E-03	2.84E-03
α_4			1.33E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.88E-01	9.91E-01	9.92E-01
Beta	1.16E-02	9.02E-03	8.07E-03
Gamma		3.98E-01	5.17E-01
Delta			3.19E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	92.10	138.15	184.20
N_1	1.8000	2.4300	2.9160
N_2	1.1000	0.7700	0.7360
N_3		0.5100	0.5360
N_4			0.2510

2.1.3 Pooled Clean System Motor Driven Pump Distributions

2.1.3.1 CLEAN SYSTEM MOTOR DRIVEN PUMPS FAIL TO START

Systems/Clean Water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 464.6
Total Number of Common-Cause Failure Events: 13

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700612	0.9824078	0.9832476	0.9918778	0.9830777	3.722E+02	6.665E+00
α_2	8.12E-03	1.76E-02	1.68E-02	2.99E-02	1.69E-02	6.665E+00	3.722E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746613	0.9840581	0.9846097	0.9915668	0.9851748	5.696E+02	9.228E+00
α_2	4.17E-03	9.81E-03	9.25E-03	1.74E-02	8.84E-03	5.679E+00	5.731E+02
α_3	1.92E-03	6.13E-03	5.57E-03	1.22E-02	5.99E-03	3.549E+00	5.753E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9760296	0.9840607	0.9844721	0.9906779	0.9855594	7.630E+02	1.236E+01
α_2	4.24E-03	9.01E-03	8.60E-03	1.52E-02	7.92E-03	6.989E+00	7.684E+02
α_3	1.41E-03	4.54E-03	4.12E-03	9.09E-03	4.28E-03	3.517E+00	7.719E+02
α_4	3.85E-04	2.39E-03	1.98E-03	5.80E-03	2.24E-03	1.853E+00	7.735E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9784672	0.9852224	0.9855397	0.9908807	0.9875005	9.912E+02	1.487E+01
α_2	3.06E-03	6.64E-03	6.32E-03	1.13E-02	5.04E-03	6.684E+00	9.994E+02
α_3	1.71E-03	4.56E-03	4.24E-03	8.52E-03	3.98E-03	4.588E+00	1.002E+03
α_4	6.70E-04	2.69E-03	2.37E-03	5.82E-03	2.58E-03	2.710E+00	1.003E+03
α_5	3.27E-05	8.80E-04	5.80E-04	2.75E-03	8.97E-04	8.857E-01	1.005E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9805171	0.9864185	0.9866841	0.9914051	0.9888441	1.190E+03	1.639E+01
α_2	2.26E-03	5.11E-03	4.83E-03	8.88E-03	3.61E-03	6.160E+00	1.200E+03
α_3	1.44E-03	3.83E-03	3.56E-03	7.14E-03	3.20E-03	4.620E+00	1.202E+03
α_4	8.21E-04	2.76E-03	2.49E-03	5.61E-03	2.52E-03	3.327E+00	1.203E+03
α_5	2.28E-04	1.48E-03	1.22E-03	3.64E-03	1.44E-03	1.789E+00	1.205E+03
α_6	1.43E-06	4.06E-04	1.81E-04	1.57E-03	3.74E-04	4.897E-01	1.206E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.83E-01	9.85E-01	9.86E-01	9.88E-01	9.89E-01
α_2	1.69E-02	8.84E-03	7.92E-03	5.04E-03	3.61E-03
α_3		5.99E-03	4.28E-03	3.98E-03	3.20E-03
α_4			2.24E-03	2.58E-03	2.52E-03
α_5				8.97E-04	1.44E-03
α_6					3.74E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.83E-01	9.85E-01	9.86E-01	9.88E-01	9.89E-01
Beta	1.69E-02	1.48E-02	1.44E-02	1.25E-02	1.12E-02
Gamma		4.04E-01	4.52E-01	5.97E-01	6.76E-01
Delta			3.44E-01	4.66E-01	5.75E-01
Epsilon				2.58E-01	4.19E-01
Mu					2.06E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	355.28	532.92	710.56	888.21	1065.85
N_1	6.6400	7.1150	6.3171	6.8643	7.3041
N_2	6.2300	4.8450	5.7613	4.5697	3.9206
N_3		3.2817	3.1124	3.6110	3.4781
N_4			1.6303	2.3355	2.7347
N_5				0.8134	1.5673
N_6					0.4064

2.1.3.2 CLEAN SYSTEM MDP-FTR LESS THAN 1 HOUR

Systems/Clean Water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.1
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8918323	0.9558005	0.9634717	0.9934850	0.9544501	3.679E+01	1.701E+00
α_2	6.51E-03	4.42E-02	3.65E-02	1.08E-01	4.55E-02	1.701E+00	3.679E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9157818	0.9596958	0.9639137	0.9891668	0.9563966	6.860E+01	2.881E+00
α_2	5.67E-03	2.94E-02	2.52E-02	6.78E-02	3.11E-02	2.104E+00	6.937E+01
α_3	2.75E-04	1.09E-02	6.77E-03	3.54E-02	1.25E-02	7.772E-01	7.070E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9195882	0.9569002	0.9598743	0.9840543	0.9529194	9.720E+01	4.378E+00
α_2	7.99E-03	2.92E-02	2.61E-02	6.08E-02	3.24E-02	2.964E+00	9.862E+01
α_3	4.09E-04	9.26E-03	6.30E-03	2.82E-02	1.00E-02	9.403E-01	1.006E+02
α_4	1.38E-05	4.66E-03	2.03E-03	1.82E-02	4.68E-03	4.737E-01	1.011E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9345462	0.9617257	0.9635660	0.9826113	0.9575364	1.596E+02	6.353E+00
α_2	7.05E-03	2.19E-02	2.00E-02	4.32E-02	2.29E-02	3.635E+00	1.623E+02
α_3	1.62E-03	1.06E-02	8.75E-03	2.61E-02	1.19E-02	1.767E+00	1.642E+02
α_4	1.03E-04	4.54E-03	2.77E-03	1.50E-02	5.73E-03	7.539E-01	1.652E+02
α_5	1.01E-09	1.19E-03	1.19E-04	6.15E-03	1.89E-03	1.974E-01	1.658E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9386827	0.9629174	0.9644477	0.9819110	0.9601745	1.927E+02	7.421E+00
α_2	6.11E-03	1.86E-02	1.71E-02	3.66E-02	1.89E-02	3.730E+00	1.964E+02
α_3	1.75E-03	9.90E-03	8.32E-03	2.35E-02	1.06E-02	1.982E+00	1.981E+02
α_4	3.45E-04	5.45E-03	3.92E-03	1.58E-02	6.31E-03	1.090E+00	1.990E+02
α_5	6.87E-06	2.36E-03	1.02E-03	9.25E-03	3.17E-03	4.727E-01	1.997E+02
α_6	3.73E-12	7.28E-04	2.72E-05	4.03E-03	7.92E-04	1.457E-01	2.000E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.54E-01	9.56E-01	9.53E-01	9.58E-01	9.60E-01
α_2	4.55E-02	3.11E-02	3.24E-02	2.29E-02	1.89E-02
α_3		1.25E-02	1.00E-02	1.19E-02	1.06E-02
α_4			4.68E-03	5.73E-03	6.31E-03
α_5				1.89E-03	3.17E-03
α_6					7.92E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.54E-01	9.56E-01	9.53E-01	9.58E-01	9.60E-01
Beta	4.55E-02	4.36E-02	4.71E-02	4.25E-02	3.98E-02
Gamma		2.87E-01	3.12E-01	4.60E-01	5.26E-01
Delta			3.19E-01	3.90E-01	4.91E-01
Epsilon				2.48E-01	3.86E-01
Mu					2.00E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	24.07	36.11	48.15	60.19	72.22
N_1	2.4667	2.9300	2.9160	3.2805	3.5429
N_2	1.2667	1.2700	1.7360	1.5207	1.4911
N_3		0.5100	0.5360	0.7893	0.8402
N_4			0.2510	0.3795	0.4983
N_5				0.1251	0.2505
N_6					0.0625

2.1.3.3 CLEAN SYSTEM MDP-FTR LESS THAN AND > 1 HOUR

Systems/Clean Water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 89.6
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9264791	0.9640841	0.9675921	0.9896820	0.9647528	8.370E+01	3.118E+00
α_2	1.03E-02	3.59E-02	3.24E-02	7.35E-02	3.52E-02	3.118E+00	8.370E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9378053	0.9658546	0.9680087	0.9865447	0.9663364	1.381E+02	4.882E+00
α_2	7.59E-03	2.43E-02	2.22E-02	4.86E-02	2.36E-02	3.480E+00	1.395E+02
α_3	1.03E-03	9.81E-03	7.63E-03	2.60E-02	1.01E-02	1.402E+00	1.416E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9419694	0.9656629	0.9672387	0.9839844	0.9670617	1.894E+02	6.734E+00
α_2	7.31E-03	2.09E-02	1.93E-02	3.99E-02	1.93E-02	4.091E+00	1.920E+02
α_3	1.54E-03	9.47E-03	7.86E-03	2.29E-02	9.81E-03	1.857E+00	1.943E+02
α_4	1.04E-04	4.01E-03	2.50E-03	1.31E-02	3.80E-03	7.862E-01	1.953E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9495613	0.9683123	0.9694111	0.9833258	0.9703744	2.745E+02	8.983E+00
α_2	6.03E-03	1.61E-02	1.50E-02	3.00E-02	1.33E-02	4.557E+00	2.789E+02
α_3	2.42E-03	9.64E-03	8.51E-03	2.07E-02	9.55E-03	2.732E+00	2.808E+02
α_4	4.58E-04	4.73E-03	3.63E-03	1.28E-02	5.26E-03	1.341E+00	2.822E+02
α_5	5.34E-07	1.25E-03	3.89E-04	5.40E-03	1.53E-03	3.536E-01	2.831E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9532765	0.9698896	0.9708080	0.9833799	0.9727557	3.303E+02	1.026E+01
α_2	4.87E-03	1.31E-02	1.22E-02	2.46E-02	1.02E-02	4.477E+00	3.361E+02
α_3	2.25E-03	8.49E-03	7.54E-03	1.79E-02	7.97E-03	2.890E+00	3.377E+02
α_4	8.52E-04	5.37E-03	4.44E-03	1.31E-02	5.64E-03	1.829E+00	3.388E+02
α_5	7.68E-05	2.45E-03	1.57E-03	7.82E-03	2.79E-03	8.350E-01	3.397E+02
α_6	3.01E-09	6.57E-04	9.05E-05	3.29E-03	6.41E-04	2.239E-01	3.404E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.65E-01	9.66E-01	9.67E-01	9.70E-01	9.73E-01
α_2	3.52E-02	2.36E-02	1.93E-02	1.33E-02	1.02E-02
α_3		1.01E-02	9.81E-03	9.55E-03	7.97E-03
α_4			3.80E-03	5.26E-03	5.64E-03
α_5				1.53E-03	2.79E-03
α_6					6.41E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.65E-01	9.66E-01	9.67E-01	9.70E-01	9.73E-01
Beta	3.52E-02	3.37E-02	3.29E-02	2.96E-02	2.72E-02
Gamma		3.00E-01	4.13E-01	5.51E-01	6.26E-01
Delta			2.79E-01	4.16E-01	5.32E-01
Epsilon				2.26E-01	3.78E-01
Mu					1.87E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	69.69	104.53	139.38	174.22	209.07
N_1	3.7660	4.0030	3.8731	4.1338	4.3231
N_2	2.6837	2.6460	2.8630	2.4429	2.2373
N_3		1.1350	1.4527	1.7546	1.7485
N_4			0.5635	0.9663	1.2373
N_5				0.2814	0.6128
N_6					0.1406

2.1.3.4 CLEAN SYSTEM MDP-FTR > 1 HOUR

Systems/Clean Water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 57.5
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9252868	0.9688280	0.9739374	0.9948793	0.9709132	5.755E+01	1.852E+00
α_2	5.12E-03	3.12E-02	2.61E-02	7.47E-02	2.91E-02	1.852E+00	5.755E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379571	0.9698055	0.9728072	0.9913953	0.9722369	9.963E+01	3.102E+00
α_2	4.37E-03	2.15E-02	1.85E-02	4.90E-02	1.91E-02	2.210E+00	1.005E+02
α_3	3.32E-04	8.69E-03	5.77E-03	2.70E-02	8.67E-03	8.922E-01	1.018E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9443666	0.9706133	0.9727795	0.9894636	0.9752799	1.391E+02	4.211E+00
α_2	3.57E-03	1.64E-02	1.42E-02	3.68E-02	1.18E-02	2.355E+00	1.409E+02
α_3	8.71E-04	9.22E-03	7.06E-03	2.50E-02	9.62E-03	1.321E+00	1.420E+02
α_4	2.09E-05	3.73E-03	1.81E-03	1.40E-02	3.28E-03	5.352E-01	1.428E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9511853	0.9717262	0.9731584	0.9873863	0.9777977	2.120E+02	6.169E+00
α_2	3.86E-03	1.39E-02	1.25E-02	2.90E-02	7.78E-03	3.036E+00	2.151E+02
α_3	1.53E-03	8.90E-03	7.45E-03	2.12E-02	8.15E-03	1.943E+00	2.162E+02
α_4	2.05E-04	4.41E-03	3.01E-03	1.34E-02	4.95E-03	9.612E-01	2.172E+02
α_5	6.20E-09	1.05E-03	1.51E-04	5.21E-03	1.32E-03	2.285E-01	2.180E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9547210	0.9729391	0.9741325	0.9870923	0.9799890	2.557E+02	7.112E+00
α_2	3.10E-03	1.14E-02	1.01E-02	2.38E-02	5.27E-03	2.985E+00	2.598E+02
α_3	1.44E-03	7.80E-03	6.59E-03	1.83E-02	6.41E-03	2.050E+00	2.608E+02
α_4	4.84E-04	5.06E-03	3.88E-03	1.37E-02	5.22E-03	1.331E+00	2.615E+02
α_5	1.87E-05	2.22E-03	1.15E-03	8.07E-03	2.56E-03	5.845E-01	2.622E+02
α_6	2.10E-11	6.14E-04	3.33E-05	3.33E-03	5.52E-04	1.614E-01	2.627E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.71E-01	9.72E-01	9.75E-01	9.78E-01	9.80E-01
α_2	2.91E-02	1.91E-02	1.18E-02	7.78E-03	5.27E-03
α_3		8.67E-03	9.62E-03	8.15E-03	6.41E-03
α_4			3.28E-03	4.95E-03	5.22E-03
α_5				1.32E-03	2.56E-03
α_6					5.52E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.71E-01	9.72E-01	9.75E-01	9.78E-01	9.80E-01
Beta	2.91E-02	2.78E-02	2.47E-02	2.22E-02	2.00E-02
Gamma		3.12E-01	5.22E-01	6.49E-01	7.37E-01
Delta			2.54E-01	4.35E-01	5.65E-01
Epsilon				2.10E-01	3.73E-01
Mu					1.77E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	46.00	69.00	92.00	115.00	138.00
N_1	1.2993	1.0730	0.9571	0.8533	0.7801
N_2	1.4170	1.3760	1.1270	0.9223	0.7462
N_3		0.6250	0.9167	0.9653	0.9082
N_4			0.3125	0.5868	0.7390
N_5				0.1563	0.3623
N_6					0.0781

2.1.4 PWR Containment Spray Pumps

2.1.4.1 CONTAINMENT SPRAY MDP FAIL TO START

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 37.0
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α1	0.8953872	0.9518788	0.9576183	0.9887297	0.9499389	4.915E+01	2.485E+00
α2	1.13E-02	4.81E-02	4.24E-02	1.05E-01	5.01E-02	2.485E+00	4.915E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	9.50E-01
α_2	5.01E-02

MGL	CCCG=2
1-Beta	9.50E-01
Beta	5.01E-02

Avg. Impact Vector	CCCG=2
Adj. IEs	37.00
N_1	1.9000
N_2	2.0500

2.1.4.2 CONTAINMENT SPRAY MDP FTR LESS THAN 1H

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9069843	0.9767394	0.9904343	0.9999537	1.0000000	1.825E+01	4.345E-01
α_2	4.27E-05	2.33E-02	9.56E-03	9.30E-02	0.00E+00	4.345E-01	1.825E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	8.00
N_1	0.0000
N_2	0.0000

2.1.4.3 CONTAINMENT SPRAY MDP-FTR LESS THAN AND > 1 HOUR

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 14.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9297049	0.9824653	0.9928546	0.9999652	1.0000000	2.435E+01	4.345E-01
α_2	3.19E-05	1.75E-02	7.15E-03	7.03E-02	0.00E+00	4.345E-01	2.435E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	14.10
N_1	0.0000
N_2	0.0000

2.1.4.4 CONTAINMENT SPRAY MDP FTR >1H

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8965817	0.9741057	0.9893092	0.9999484	1.0000000	1.635E+01	4.345E-01
α_2	4.78E-05	2.59E-02	1.07E-02	1.03E-01	0.00E+00	4.345E-01	1.635E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	6.10
N_1	0.0000
N_2	0.0000

2.1.5 BWR Residual Heat Removal Pumps

2.1.5.1 BWR RHR MDP FAIL TO START

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 39.0
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9216087	0.9758894	0.9849067	0.9994029	0.9842520	3.108E+01	7.679E-01
α_2	5.94E-04	2.41E-02	1.51E-02	7.84E-02	1.57E-02	7.679E-01	3.108E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9219129	0.9660633	0.9709572	0.9934474	0.9680000	5.981E+01	2.101E+00
α_2	4.80E-03	2.96E-02	2.47E-02	7.13E-02	3.20E-02	1.834E+00	6.007E+01
α_3	1.51E-07	4.32E-03	8.68E-04	2.05E-02	0.00E+00	2.672E-01	6.164E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9164947	0.9566802	0.9600629	0.9852850	0.9512195	8.514E+01	3.855E+00
α_2	1.07E-02	3.63E-02	3.29E-02	7.35E-02	4.88E-02	3.228E+00	8.576E+01
α_3	5.10E-06	4.54E-03	1.68E-03	1.88E-02	0.00E+00	4.043E-01	8.859E+01
α_4	1.08E-08	2.50E-03	3.42E-04	1.25E-02	0.00E+00	2.227E-01	8.877E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.84E-01	9.68E-01	9.51E-01
α_2	1.57E-02	3.20E-02	4.88E-02
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.84E-01	9.68E-01	9.51E-01
Beta	1.57E-02	3.20E-02	4.88E-02
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	19.50	29.25	39.00
N_1	1.3333	1.0000	0.0000
N_2	0.3333	1.0000	2.0000

N_3		0.0000	0.0000
N_4			0.0000

2.1.5.2 BWR RHR MDP FTR LESS THAN 1H

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 5.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8894201	0.9722892	0.9885281	0.9999447	1.0000000	1.525E+01	4.345E-01
α_2	5.13E-05	2.77E-02	1.15E-02	1.11E-01	0.00E+00	4.345E-01	1.525E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9119790	0.9691249	0.9773997	0.9979504	1.0000000	3.456E+01	1.101E+00
α_2	7.46E-04	2.34E-02	1.52E-02	7.38E-02	0.00E+00	8.337E-01	3.482E+01
α_3	2.64E-07	7.49E-03	1.52E-03	3.55E-02	0.00E+00	2.672E-01	3.539E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9162955	0.9649926	0.9706754	0.9942239	1.0000000	5.114E+01	1.855E+00
α_2	1.92E-03	2.32E-02	1.75E-02	6.39E-02	0.00E+00	1.228E+00	5.176E+01
α_3	8.61E-06	7.63E-03	2.84E-03	3.15E-02	0.00E+00	4.043E-01	5.259E+01
α_4	1.82E-08	4.20E-03	5.77E-04	2.11E-02	0.00E+00	2.227E-01	5.277E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	5.00	5.00	5.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.5.3 BWR RHR MDP FAIL TO RUN LESS THAN AND > 1 HOUR

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 16.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9358690	0.9840136	0.9935003	0.9999683	1.0000000	2.675E+01	4.345E-01
α_2	2.90E-05	1.60E-02	6.50E-03	6.41E-02	0.00E+00	4.345E-01	2.675E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9331861	0.9766544	0.9829892	0.9984657	1.0000000	4.606E+01	1.101E+00
α_2	5.60E-04	1.77E-02	1.15E-02	5.60E-02	0.00E+00	8.337E-01	4.632E+01
α_3	1.99E-07	5.67E-03	1.14E-03	2.69E-02	0.00E+00	2.672E-01	4.689E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9310249	0.9712351	0.9759625	0.9952705	1.0000000	6.264E+01	1.855E+00
α_2	1.58E-03	1.90E-02	1.43E-02	5.26E-02	0.00E+00	1.228E+00	6.326E+01
α_3	7.06E-06	6.27E-03	2.32E-03	2.59E-02	0.00E+00	4.043E-01	6.409E+01
α_4	1.49E-08	3.45E-03	4.73E-04	1.73E-02	0.00E+00	2.227E-01	6.427E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	16.50	16.50	16.50
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000

N_4			0.0000

2.1.5.4 BWR RHR MDP FAIL TO RUN >1H

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 11.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9215382	0.9804098	0.9919877	0.9999611	1.0000000	2.175E+01	4.345E-01
α_2	3.57E-05	1.96E-02	8.01E-03	7.85E-02	0.00E+00	4.345E-01	2.175E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9253684	0.9738855	0.9809396	0.9982777	1.0000000	4.106E+01	1.101E+00
α_2	6.28E-04	1.98E-02	1.28E-02	6.26E-02	0.00E+00	8.337E-01	4.132E+01
α_3	2.22E-07	6.34E-03	1.28E-03	3.01E-02	0.00E+00	2.672E-01	4.189E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9253076	0.9688175	0.9739191	0.9948644	1.0000000	5.764E+01	1.855E+00
α_2	1.71E-03	2.06E-02	1.56E-02	5.70E-02	0.00E+00	1.228E+00	5.826E+01
α_3	7.66E-06	6.80E-03	2.52E-03	2.81E-02	0.00E+00	4.043E-01	5.909E+01
α_4	1.62E-08	3.74E-03	5.13E-04	1.88E-02	0.00E+00	2.227E-01	5.927E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	11.50	11.50	11.50
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.6 AFW Motor-Driven Pumps

2.1.6.1 AFW MOTOR DRIVEN PUMP FAIL TO START SPAR: MDP-FS-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 44.7
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9069235	0.9604720	0.9665835	0.9930869	0.9607946	4.701E+01	1.935E+00
α_2	6.92E-03	3.95E-02	3.34E-02	9.31E-02	3.92E-02	1.935E+00	4.701E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9269559	0.9643765	0.9678764	0.9898157	0.9645327	8.394E+01	3.101E+00
α_2	2.36E-03	1.82E-02	1.47E-02	4.61E-02	1.33E-02	1.584E+00	8.546E+01
α_3	2.11E-03	1.74E-02	1.39E-02	4.49E-02	2.22E-02	1.517E+00	8.553E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9347529	0.9654366	0.9679465	0.9875420	0.9680758	1.182E+02	4.230E+00
α_2	2.86E-03	1.62E-02	1.36E-02	3.82E-02	1.01E-02	1.978E+00	1.204E+02
α_3	1.21E-03	1.15E-02	8.94E-03	3.04E-02	1.34E-02	1.404E+00	1.210E+02
α_4	2.28E-04	6.93E-03	4.49E-03	2.19E-02	8.40E-03	8.477E-01	1.215E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.61E-01	9.65E-01	9.68E-01
α_2	3.92E-02	1.33E-02	1.01E-02
α_3		2.22E-02	1.34E-02
α_4			8.40E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.61E-01	9.65E-01	9.68E-01
Beta	3.92E-02	3.55E-02	3.19E-02
Gamma		6.25E-01	6.84E-01
Delta			3.85E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	35.76	53.64	71.52
N_1	1.0000	0.7500	0.5000
N_2	1.5000	0.7500	0.7500
N_3		1.2500	1.0000
N_4			0.6250

2.1.6.2 AFW MOTOR DRIVEN PUMP FTR LESS THAN 1H

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.5
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8773742	0.9632512	0.9778433	0.9993247	0.9682540	1.838E+01	7.012E-01
α_2	6.72E-04	3.67E-02	2.22E-02	1.23E-01	3.17E-02	7.012E-01	1.838E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8959808	0.9561217	0.9630387	0.9925784	0.9361179	4.099E+01	1.881E+00
α_2	5.02E-03	3.74E-02	3.05E-02	9.36E-02	6.31E-02	1.604E+00	4.126E+01
α_3	3.30E-07	6.47E-03	1.40E-03	3.03E-02	8.19E-04	2.772E-01	4.259E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8946061	0.9470217	0.9516471	0.9836113	0.9034385	6.039E+01	3.378E+00
α_2	1.08E-02	4.26E-02	3.79E-02	9.04E-02	9.42E-02	2.714E+00	6.105E+01
α_3	1.34E-05	6.91E-03	2.81E-03	2.77E-02	2.28E-03	4.403E-01	6.332E+01
α_4	1.60E-08	3.51E-03	4.85E-04	1.75E-02	6.34E-05	2.237E-01	6.354E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.68E-01	9.36E-01	9.03E-01
α_2	3.17E-02	6.31E-02	9.42E-02
α_3		8.19E-04	2.28E-03
α_4			6.34E-05

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.68E-01	9.36E-01	9.03E-01
Beta	3.17E-02	6.39E-02	9.66E-02
Gamma		1.28E-02	2.43E-02
Delta			2.70E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	5.67	8.50	11.33
N_1	2.4667	2.9300	2.9160
N_2	0.2667	0.7700	1.4860
N_3		0.0100	0.0360
N_4			0.0010

2.1.6.3 AFW MOTOR DRIVEN PUMP FAIL TO RUN SPAR: MDP-FR-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 18.2
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9079464	0.9725533	0.9835968	0.9995012	0.9820628	2.485E+01	7.012E-01
α_2	4.96E-04	2.74E-02	1.64E-02	9.21E-02	1.79E-02	7.012E-01	2.485E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9148482	0.9642186	0.9699423	0.9939835	0.9643998	5.069E+01	1.881E+00
α_2	4.07E-03	3.05E-02	2.48E-02	7.66E-02	3.51E-02	1.604E+00	5.096E+01
α_3	2.68E-07	5.27E-03	1.14E-03	2.47E-02	4.56E-04	2.772E-01	5.229E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9120815	0.9559554	0.9598717	0.9864372	0.9469443	7.332E+01	3.378E+00
α_2	8.98E-03	3.54E-02	3.14E-02	7.54E-02	5.18E-02	2.714E+00	7.398E+01
α_3	1.11E-05	5.74E-03	2.33E-03	2.30E-02	1.25E-03	4.403E-01	7.626E+01
α_4	1.33E-08	2.92E-03	4.03E-04	1.46E-02	3.48E-05	2.237E-01	7.647E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.82E-01	9.64E-01	9.47E-01
α_2	1.79E-02	3.51E-02	5.18E-02
α_3		4.56E-04	1.25E-03
α_4			3.48E-05

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.82E-01	9.64E-01	9.47E-01
Beta	1.79E-02	3.56E-02	5.31E-02
Gamma		1.28E-02	2.43E-02
Delta			2.70E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	12.13	18.20	24.27
N_1	2.4667	2.9300	2.9160
N_2	0.2667	0.7700	1.4860
N_3		0.0100	0.0360
N_4			0.0010

2.1.6.4 AFW MOTOR DRIVEN PUMP FAIL TO RUN >1H

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 9.7
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9146731	0.9786796	0.9912576	0.9999576	1.0000000	1.995E+01	4.345E-01
α_2	3.90E-05	2.13E-02	8.74E-03	8.53E-02	0.00E+00	4.345E-01	1.995E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9220873	0.9727207	0.9800754	0.9981992	1.0000000	3.925E+01	1.101E+00
α_2	6.57E-04	2.07E-02	1.34E-02	6.53E-02	0.00E+00	8.337E-01	3.952E+01
α_3	2.32E-07	6.62E-03	1.34E-03	3.14E-02	0.00E+00	2.672E-01	4.009E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9230161	0.9678446	0.9730958	0.9947056	1.0000000	5.584E+01	1.855E+00
α_2	1.76E-03	2.13E-02	1.61E-02	5.87E-02	0.00E+00	1.228E+00	5.646E+01
α_3	7.90E-06	7.01E-03	2.60E-03	2.89E-02	0.00E+00	4.043E-01	5.729E+01
α_4	1.67E-08	3.86E-03	5.29E-04	1.93E-02	0.00E+00	2.227E-01	5.747E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	9.70	9.70	9.70
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.7 AFW Pump Volutes

2.1.7.1 AFW PUMP VOLUTES (MDP,TDP,EDP) FAIL TO RUN SPAR: PMP-FR-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Engine Driven Pump/Centrifugal/Pump
Components/Pump/Motor Driven Pump/Centrifugal/Pump
Components/Pump/Turbine Driven Pump/Centrifugal/Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 22.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9425951	0.9845873	0.9924368	0.9999156	0.9958333	3.415E+01	5.345E-01
α_2	8.70E-05	1.54E-02	7.56E-03	5.74E-02	4.17E-03	5.345E-01	3.415E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9449545	0.9792398	0.9838230	0.9978492	0.9921919	6.514E+01	1.381E+00
α_2	1.09E-03	1.66E-02	1.21E-02	4.76E-02	7.53E-03	1.104E+00	6.541E+01
α_3	2.11E-07	4.17E-03	8.96E-04	1.95E-02	2.79E-04	2.772E-01	6.624E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9446804	0.9751325	0.9783710	0.9945150	0.9890216	9.325E+01	2.378E+00
α_2	2.62E-03	1.79E-02	1.47E-02	4.43E-02	1.02E-02	1.714E+00	9.392E+01
α_3	8.88E-06	4.60E-03	1.87E-03	1.85E-02	7.56E-04	4.403E-01	9.519E+01
α_4	1.06E-08	2.34E-03	3.23E-04	1.17E-02	2.10E-05	2.237E-01	9.541E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.96E-01	9.92E-01	9.89E-01
α_2	4.17E-03	7.53E-03	1.02E-02
α_3		2.79E-04	7.56E-04
α_4			2.10E-05

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.96E-01	9.92E-01	9.89E-01
Beta	4.17E-03	7.81E-03	1.10E-02
Gamma		3.57E-02	7.07E-02
Delta			2.70E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	22.10	33.15	44.20
N_1	1.8000	2.4300	2.9160

N_2	0.1000	0.2700	0.4860
N_3		0.0100	0.0360
N_4			0.0010

2.1.8 Service Water Motor-Driven Pumps

2.1.8.1 NORMALLY RUNNING SERVICE WATER MDP FAIL TO START

Systems/Raw Water/Normally operating service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 30.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9575751	0.9894484	0.9957400	0.9999791	1.0000000	4.075E+01	4.345E-01
α_2	1.90E-05	1.06E-02	4.26E-03	4.24E-02	0.00E+00	4.345E-01	4.075E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483340	0.9819988	0.9869254	0.9988233	1.0000000	6.006E+01	1.101E+00
α_2	4.30E-04	1.36E-02	8.81E-03	4.33E-02	0.00E+00	8.337E-01	6.032E+01
α_3	1.53E-07	4.37E-03	8.78E-04	2.07E-02	0.00E+00	2.672E-01	6.089E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9431894	0.9763657	0.9802871	0.9961328	1.0000000	7.664E+01	1.855E+00
α_2	1.29E-03	1.56E-02	1.18E-02	4.33E-02	0.00E+00	1.228E+00	7.726E+01
α_3	5.79E-06	5.15E-03	1.91E-03	2.13E-02	0.00E+00	4.043E-01	7.809E+01
α_4	1.22E-08	2.84E-03	3.88E-04	1.42E-02	0.00E+00	2.227E-01	7.827E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9460868	0.9728244	0.9752133	0.9913996	1.0000000	1.267E+02	3.538E+00
α_2	3.12E-03	1.62E-02	1.38E-02	3.76E-02	0.00E+00	2.114E+00	1.281E+02
α_3	3.66E-04	7.51E-03	5.18E-03	2.26E-02	0.00E+00	9.774E-01	1.292E+02
α_4	1.89E-06	2.88E-03	9.68E-04	1.22E-02	0.00E+00	3.744E-01	1.298E+02
α_5	4.58E-21	5.55E-04	3.14E-07	3.21E-03	0.00E+00	7.228E-02	1.301E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9468055	0.9717987	0.9738504	0.9897878	1.0000000	1.474E+02	4.279E+00
α_2	3.03E-03	1.48E-02	1.27E-02	3.36E-02	0.00E+00	2.239E+00	1.495E+02
α_3	5.29E-04	7.53E-03	5.50E-03	2.14E-02	0.00E+00	1.142E+00	1.506E+02
α_4	3.49E-05	3.90E-03	2.04E-03	1.41E-02	0.00E+00	5.922E-01	1.511E+02
α_5	6.12E-09	1.46E-03	1.98E-04	7.34E-03	0.00E+00	2.222E-01	1.515E+02
α_6	9.29E-19	5.49E-04	9.59E-07	3.20E-03	0.00E+00	8.324E-02	1.516E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	30.50	30.50	30.50	30.50	30.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.1.8.2 NORMALLY RUNNING SERVICE WATER MDP FAIL TO RUN

Systems/Raw Water/Normally operating service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 71.0
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9298302	0.9711828	0.9761426	0.9955637	0.9736842	5.958E+01	1.768E+00
α_2	4.43E-03	2.88E-02	2.39E-02	7.02E-02	2.63E-02	1.768E+00	5.958E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9396694	0.9706511	0.9735748	0.9916423	0.9733333	1.026E+02	3.101E+00
α_2	2.79E-03	1.74E-02	1.44E-02	4.20E-02	1.33E-02	1.834E+00	1.038E+02
α_3	1.05E-03	1.20E-02	9.08E-03	3.29E-02	1.33E-02	1.267E+00	1.044E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444555	0.9704054	0.9725148	0.9891524	0.9747899	1.428E+02	4.355E+00
α_2	3.86E-03	1.68E-02	1.47E-02	3.71E-02	1.26E-02	2.478E+00	1.447E+02
α_3	5.65E-04	7.84E-03	5.76E-03	2.23E-02	7.56E-03	1.154E+00	1.460E+02
α_4	9.62E-05	4.91E-03	2.93E-03	1.65E-02	5.04E-03	7.227E-01	1.464E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9500344	0.9706684	0.9720632	0.9865322	0.9756510	2.164E+02	6.538E+00
α_2	5.03E-03	1.59E-02	1.45E-02	3.17E-02	1.17E-02	3.552E+00	2.194E+02
α_3	1.14E-03	7.75E-03	6.33E-03	1.92E-02	6.09E-03	1.727E+00	2.212E+02
α_4	1.83E-04	4.20E-03	2.84E-03	1.29E-02	4.57E-03	9.369E-01	2.220E+02
α_5	2.92E-07	1.45E-03	3.95E-04	6.46E-03	2.03E-03	3.223E-01	2.226E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525927	0.9711321	0.9722930	0.9856948	0.9764281	2.606E+02	7.747E+00
α_2	4.66E-03	1.41E-02	1.29E-02	2.76E-02	1.05E-02	3.786E+00	2.646E+02
α_3	1.33E-03	7.46E-03	6.27E-03	1.76E-02	5.84E-03	2.001E+00	2.664E+02
α_4	2.96E-04	4.24E-03	3.09E-03	1.21E-02	3.72E-03	1.139E+00	2.672E+02
α_5	2.36E-05	2.28E-03	1.22E-03	8.15E-03	2.65E-03	6.128E-01	2.678E+02
α_6	1.39E-09	7.76E-04	8.96E-05	3.96E-03	8.49E-04	2.082E-01	2.682E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.74E-01	9.73E-01	9.75E-01	9.76E-01	9.76E-01
α_2	2.63E-02	1.33E-02	1.26E-02	1.17E-02	1.05E-02
α_3		1.33E-02	7.56E-03	6.09E-03	5.84E-03
α_4			5.04E-03	4.57E-03	3.72E-03
α_5				2.03E-03	2.65E-03
α_6					8.49E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.74E-01	9.73E-01	9.75E-01	9.76E-01	9.76E-01
Beta	2.63E-02	2.67E-02	2.52E-02	2.43E-02	2.36E-02
Gamma		5.00E-01	5.00E-01	5.21E-01	5.54E-01
Delta			4.00E-01	5.20E-01	5.53E-01
Epsilon				3.08E-01	4.85E-01
Mu					2.42E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	47.33	71.00	94.67	118.33	142.00
N_1	2.0000	2.0000	2.0000	1.8750	1.6875
N_2	1.3333	1.0000	1.2500	1.4375	1.5469
N_3		1.0000	0.7500	0.7500	0.8594
N_4			0.5000	0.5625	0.5469
N_5				0.2500	0.3906
N_6					0.1250

2.1.8.3 STANDBY SERVICE WATER MDP FAIL TO START

Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 152.9
Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9594384	0.9844645	0.9877498	0.9982415	0.9876969	9.232E+01	1.457E+00
α_2	1.76E-03	1.55E-02	1.22E-02	4.06E-02	1.23E-02	1.457E+00	9.232E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9508213	0.9745411	0.9765730	0.9913264	0.9771412	1.500E+02	3.918E+00
α_2	7.21E-03	2.29E-02	2.09E-02	4.56E-02	2.18E-02	3.526E+00	1.504E+02
α_3	2.32E-06	2.55E-03	9.07E-04	1.07E-02	1.01E-03	3.922E-01	1.535E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9494730	0.9707202	0.9721942	0.9869268	0.9734825	2.047E+02	6.174E+00
α_2	8.64E-03	2.24E-02	2.10E-02	4.14E-02	2.15E-02	4.733E+00	2.061E+02
α_3	3.95E-04	5.48E-03	4.02E-03	1.56E-02	4.61E-03	1.156E+00	2.097E+02
α_4	9.00E-08	1.35E-03	3.04E-04	6.29E-03	3.84E-04	2.852E-01	2.106E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9557924	0.9727487	0.9737831	0.9861590	0.9768063	2.939E+02	8.233E+00
α_2	6.16E-03	1.59E-02	1.48E-02	2.93E-02	1.33E-02	4.805E+00	2.973E+02
α_3	1.97E-03	8.42E-03	7.36E-03	1.85E-02	7.74E-03	2.544E+00	2.996E+02
α_4	6.56E-05	2.58E-03	1.60E-03	8.45E-03	2.01E-03	7.807E-01	3.013E+02
α_5	5.47E-16	3.43E-04	2.50E-06	1.99E-03	1.54E-04	1.035E-01	3.020E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9593519	0.9743097	0.9751729	0.9863132	0.9791239	3.538E+02	9.328E+00
α_2	4.53E-03	1.23E-02	1.14E-02	2.30E-02	9.17E-03	4.458E+00	3.586E+02
α_3	2.11E-03	7.97E-03	7.08E-03	1.68E-02	7.24E-03	2.893E+00	3.602E+02
α_4	4.34E-04	3.96E-03	3.09E-03	1.04E-02	3.50E-03	1.438E+00	3.617E+02
α_5	2.35E-06	1.21E-03	4.91E-04	4.87E-03	9.04E-04	4.410E-01	3.627E+02
α_6	1.16E-16	2.72E-04	1.51E-06	1.58E-03	6.46E-05	9.886E-02	3.630E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.88E-01	9.77E-01	9.73E-01	9.77E-01	9.79E-01
α_2	1.23E-02	2.18E-02	2.15E-02	1.33E-02	9.17E-03
α_3		1.01E-03	4.61E-03	7.74E-03	7.24E-03
α_4			3.84E-04	2.01E-03	3.50E-03
α_5				1.54E-04	9.04E-04
α_6					6.46E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.88E-01	9.77E-01	9.73E-01	9.77E-01	9.79E-01
Beta	1.23E-02	2.29E-02	2.65E-02	2.32E-02	2.09E-02
Gamma		4.44E-02	1.88E-01	4.27E-01	5.61E-01
Delta			7.68E-02	2.18E-01	3.82E-01
Epsilon				7.14E-02	2.17E-01
Mu					6.67E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	76.45	114.68	152.90	191.13	229.35
N_1	5.6220	5.7411	5.6521	6.5954	7.4886
N_2	1.0223	2.6920	3.5052	2.6910	2.2189
N_3		0.1250	0.7513	1.5662	1.7508
N_4			0.0625	0.4063	0.8456
N_5				0.0313	0.2188
N_6					0.0156

2.1.8.4 STANDBY SERVICE WATER MDP FAIL TO RUN

Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 121.2
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9421340	0.9774424	0.9819757	0.9972494	0.9808552	6.589E+01	1.521E+00
α_2	2.75E-03	2.26E-02	1.80E-02	5.79E-02	1.91E-02	1.521E+00	6.589E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9349094	0.9663721	0.9690609	0.9886482	0.9672080	1.105E+02	3.846E+00
α_2	8.76E-03	2.90E-02	2.63E-02	5.86E-02	2.97E-02	3.322E+00	1.110E+02
α_3	2.30E-05	4.58E-03	2.18E-03	1.73E-02	3.06E-03	5.236E-01	1.138E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9315834	0.9600163	0.9619455	0.9818660	0.9594371	1.518E+02	6.322E+00
α_2	1.13E-02	2.95E-02	2.76E-02	5.45E-02	3.13E-02	4.672E+00	1.535E+02
α_3	9.79E-04	9.02E-03	7.05E-03	2.38E-02	9.28E-03	1.427E+00	1.567E+02
α_4	6.35E-09	1.41E-03	1.94E-04	7.07E-03	7.45E-06	2.235E-01	1.579E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9433036	0.9649326	0.9662360	0.9821074	0.9652407	2.279E+02	8.282E+00
α_2	7.90E-03	2.03E-02	1.90E-02	3.74E-02	1.97E-02	4.806E+00	2.314E+02
α_3	2.17E-03	9.99E-03	8.64E-03	2.24E-02	1.01E-02	2.359E+00	2.338E+02
α_4	2.53E-04	4.42E-03	3.13E-03	1.30E-02	4.91E-03	1.045E+00	2.351E+02
α_5	2.67E-21	3.06E-04	1.75E-07	1.77E-03	7.33E-07	7.238E-02	2.361E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9481087	0.9671447	0.9682383	0.9824532	0.9689632	2.747E+02	9.330E+00
α_2	5.95E-03	1.59E-02	1.48E-02	2.98E-02	1.40E-02	4.524E+00	2.795E+02
α_3	2.32E-03	9.42E-03	8.29E-03	2.04E-02	9.42E-03	2.675E+00	2.813E+02
α_4	4.97E-04	4.86E-03	3.76E-03	1.30E-02	4.85E-03	1.381E+00	2.826E+02
α_5	3.42E-05	2.35E-03	1.33E-03	8.13E-03	2.73E-03	6.673E-01	2.833E+02
α_6	4.95E-19	2.93E-04	5.12E-07	1.71E-03	0.00E+00	8.324E-02	2.839E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.81E-01	9.67E-01	9.59E-01	9.65E-01	9.69E-01
α_2	1.91E-02	2.97E-02	3.13E-02	1.97E-02	1.40E-02
α_3		3.06E-03	9.28E-03	1.01E-02	9.42E-03
α_4			7.45E-06	4.91E-03	4.85E-03
α_5				7.33E-07	2.73E-03
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.81E-01	9.67E-01	9.59E-01	9.65E-01	9.69E-01
Beta	1.91E-02	3.28E-02	4.06E-02	3.48E-02	3.10E-02
Gamma		9.34E-02	2.29E-01	4.33E-01	5.48E-01
Delta			8.01E-04	3.27E-01	4.46E-01
Epsilon				1.49E-04	3.61E-01
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	51.42	77.13	102.84	128.55	154.25
N_1	4.2213	3.8432	2.8282	3.1894	3.4580
N_2	1.0860	2.4888	3.4441	2.6916	2.2848
N_3		0.2564	1.0223	1.3819	1.5330
N_4			0.0008	0.6703	0.7888
N_5				0.0001	0.4451
N_6					0.0000

2.1.8.5 SERVICE WATER MDP FAIL TO START

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 183.4
Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650714	0.9866375	0.9894743	0.9984937	0.9896047	1.076E+02	1.457E+00
α_2	1.51E-03	1.34E-02	1.05E-02	3.49E-02	1.04E-02	1.457E+00	1.076E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9571358	0.9778357	0.9796120	0.9924644	0.9807200	1.728E+02	3.918E+00
α_2	6.27E-03	1.99E-02	1.82E-02	3.97E-02	1.84E-02	3.526E+00	1.732E+02
α_3	2.02E-06	2.22E-03	7.89E-04	9.28E-03	8.56E-04	3.922E-01	1.764E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9558048	0.9744201	0.9757227	0.9885943	0.9776651	2.352E+02	6.174E+00
α_2	7.54E-03	1.96E-02	1.83E-02	3.62E-02	1.81E-02	4.733E+00	2.366E+02
α_3	3.45E-04	4.79E-03	3.51E-03	1.36E-02	3.89E-03	1.156E+00	2.402E+02
α_4	7.86E-08	1.18E-03	2.65E-04	5.49E-03	3.23E-04	2.852E-01	2.411E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9607147	0.9758023	0.9767315	0.9877250	0.9804824	3.320E+02	8.233E+00
α_2	5.47E-03	1.41E-02	1.32E-02	2.60E-02	1.12E-02	4.805E+00	3.354E+02
α_3	1.75E-03	7.48E-03	6.54E-03	1.64E-02	6.51E-03	2.544E+00	3.377E+02
α_4	5.82E-05	2.29E-03	1.42E-03	7.50E-03	1.69E-03	7.807E-01	3.395E+02
α_5	4.86E-16	3.04E-04	2.22E-06	1.76E-03	1.30E-04	1.035E-01	3.401E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9638702	0.9771844	0.9779611	0.9878550	0.9824443	3.995E+02	9.328E+00
α_2	4.02E-03	1.09E-02	1.01E-02	2.05E-02	7.71E-03	4.458E+00	4.044E+02
α_3	1.87E-03	7.07E-03	6.29E-03	1.50E-02	6.09E-03	2.893E+00	4.060E+02
α_4	3.85E-04	3.52E-03	2.75E-03	9.28E-03	2.94E-03	1.438E+00	4.074E+02
α_5	2.09E-06	1.08E-03	4.36E-04	4.33E-03	7.61E-04	4.410E-01	4.084E+02
α_6	1.03E-16	2.42E-04	1.34E-06	1.41E-03	5.43E-05	9.886E-02	4.088E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.90E-01	9.81E-01	9.78E-01	9.80E-01	9.82E-01
α_2	1.04E-02	1.84E-02	1.81E-02	1.12E-02	7.71E-03
α_3		8.56E-04	3.89E-03	6.51E-03	6.09E-03
α_4			3.23E-04	1.69E-03	2.94E-03
α_5				1.30E-04	7.61E-04
α_6					5.43E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.90E-01	9.81E-01	9.78E-01	9.80E-01	9.82E-01
Beta	1.04E-02	1.93E-02	2.23E-02	1.95E-02	1.76E-02
Gamma		4.44E-02	1.88E-01	4.27E-01	5.61E-01
Delta			7.68E-02	2.18E-01	3.82E-01
Epsilon				7.14E-02	2.17E-01
Mu					6.67E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	91.70	137.55	183.40	229.25	275.10
N_1	5.6220	5.7411	5.6521	6.5954	7.4886
N_2	1.0223	2.6920	3.5052	2.6910	2.2189
N_3		0.1250	0.7513	1.5662	1.7508
N_4			0.0625	0.4063	0.8456
N_5				0.0313	0.2188
N_6					0.0156

2.1.8.6 SERVICE WATER MDP FAIL TO RUN

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run >1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 198.7
Total Number of Common-Cause Failure Events: 11

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9469451	0.9746939	0.9773997	0.9931945	0.9762691	1.120E+02	2.909E+00
α_2	6.80E-03	2.53E-02	2.26E-02	5.31E-02	2.37E-02	2.909E+00	1.120E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9436326	0.9675226	0.9691968	0.9856883	0.9682063	1.786E+02	5.996E+00
α_2	8.98E-03	2.42E-02	2.25E-02	4.52E-02	2.36E-02	4.464E+00	1.801E+02
α_3	1.01E-03	8.30E-03	6.60E-03	2.14E-02	8.21E-03	1.531E+00	1.831E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9425030	0.9637495	0.9649739	0.9808101	0.9643183	2.418E+02	9.093E+00
α_2	1.09E-02	2.46E-02	2.33E-02	4.25E-02	2.43E-02	6.165E+00	2.447E+02
α_3	1.76E-03	8.78E-03	7.52E-03	2.01E-02	8.87E-03	2.204E+00	2.486E+02
α_4	5.70E-05	2.89E-03	1.72E-03	9.70E-03	2.47E-03	7.245E-01	2.501E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496802	0.9667558	0.9676361	0.9808224	0.9676457	3.396E+02	1.168E+01
α_2	8.57E-03	1.87E-02	1.78E-02	3.19E-02	1.77E-02	6.569E+00	3.447E+02
α_3	2.60E-03	9.03E-03	8.12E-03	1.86E-02	8.73E-03	3.173E+00	3.481E+02
α_4	6.06E-04	4.59E-03	3.69E-03	1.17E-02	4.92E-03	1.613E+00	3.496E+02
α_5	1.87E-07	9.18E-04	2.51E-04	4.10E-03	9.95E-04	3.225E-01	3.509E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9532165	0.9683763	0.9691127	0.9810108	0.9698604	4.079E+02	1.332E+01
α_2	6.98E-03	1.54E-02	1.46E-02	2.63E-02	1.41E-02	6.469E+00	4.148E+02
α_3	2.77E-03	8.65E-03	7.88E-03	1.71E-02	8.33E-03	3.642E+00	4.176E+02
α_4	7.92E-04	4.61E-03	3.86E-03	1.10E-02	4.50E-03	1.943E+00	4.193E+02

α_5	1.48E-04	2.51E-03	1.78E-03	7.37E-03	2.79E-03	1.059E+00	4.202E+02
α_6	8.84E-10	4.94E-04	5.71E-05	2.52E-03	4.17E-04	2.083E-01	4.210E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.76E-01	9.68E-01	9.64E-01	9.68E-01	9.70E-01
α_2	2.37E-02	2.36E-02	2.43E-02	1.77E-02	1.41E-02
α_3		8.21E-03	8.87E-03	8.73E-03	8.33E-03
α_4			2.47E-03	4.92E-03	4.50E-03
α_5				9.95E-04	2.79E-03
α_6					4.17E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.76E-01	9.68E-01	9.64E-01	9.68E-01	9.70E-01
Beta	2.37E-02	3.18E-02	3.57E-02	3.24E-02	3.01E-02
Gamma		2.58E-01	3.18E-01	4.53E-01	5.32E-01
Delta			2.18E-01	4.04E-01	4.81E-01
Epsilon				1.68E-01	4.16E-01
Mu					1.30E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	95.03	142.55	190.06	237.58	285.09
N_1	6.7613	6.5115	5.5572	5.8215	5.9002
N_2	2.4743	3.6306	4.9371	4.4543	4.2300
N_3		1.2642	1.7993	2.1955	2.5002
N_4			0.5018	1.2382	1.3509
N_5				0.2503	0.8368
N_6					0.1250

2.1.8.7 SERVICE WATER MDP FAIL TO RUN EXEE

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run >1H
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.1
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8555188	0.9550451	0.9713398	0.9988661	0.9479167	1.631E+01	7.679E-01
α_2	1.14E-03	4.50E-02	2.87E-02	1.44E-01	5.21E-02	7.679E-01	1.631E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8794522	0.9471555	0.9545049	0.9896758	0.8901099	3.765E+01	2.101E+00
α_2	7.56E-03	4.61E-02	3.87E-02	1.10E-01	1.10E-01	1.834E+00	3.792E+01
α_3	2.36E-07	6.72E-03	1.36E-03	3.19E-02	0.00E+00	2.672E-01	3.949E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8879931	0.9437298	0.9486430	0.9826617	0.8710602	5.627E+01	3.355E+00
α_2	9.67E-03	4.16E-02	3.65E-02	9.07E-02	1.07E-01	2.478E+00	5.715E+01
α_3	1.50E-04	1.10E-02	6.19E-03	3.81E-02	2.15E-02	6.543E-01	5.897E+01
α_4	1.61E-08	3.73E-03	5.12E-04	1.87E-02	0.00E+00	2.227E-01	5.940E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9143461	0.9513082	0.9539381	0.9792831	0.8575668	1.082E+02	5.538E+00
α_2	9.93E-03	3.12E-02	2.85E-02	6.18E-02	1.02E-01	3.552E+00	1.102E+02
α_3	1.50E-03	1.30E-02	1.03E-02	3.38E-02	3.56E-02	1.477E+00	1.123E+02
α_4	7.06E-06	3.84E-03	1.54E-03	1.55E-02	4.45E-03	4.369E-01	1.133E+02
α_5	5.25E-21	6.35E-04	3.59E-07	3.68E-03	0.00E+00	7.228E-02	1.137E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9175019	0.9509547	0.9531316	0.9769799	0.8490638	1.308E+02	6.747E+00
α_2	9.16E-03	2.75E-02	2.53E-02	5.36E-02	9.46E-02	3.786E+00	1.338E+02
α_3	2.25E-03	1.36E-02	1.14E-02	3.28E-02	4.49E-02	1.876E+00	1.357E+02

α_4	1.32E-04	5.55E-03	3.41E-03	1.83E-02	1.05E-02	7.641E-01	1.368E+02
α_5	1.65E-08	1.73E-03	2.73E-04	8.49E-03	9.55E-04	2.378E-01	1.373E+02
α_6	1.02E-18	6.05E-04	1.06E-06	3.53E-03	0.00E+00	8.324E-02	1.375E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.48E-01	8.90E-01	8.71E-01	8.58E-01	8.49E-01
α_2	5.21E-02	1.10E-01	1.07E-01	1.02E-01	9.46E-02
α_3		0.00E+00	2.15E-02	3.56E-02	4.49E-02
α_4			0.00E+00	4.45E-03	1.05E-02
α_5				0.00E+00	9.55E-04
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.48E-01	8.90E-01	8.71E-01	8.58E-01	8.49E-01
Beta	5.21E-02	1.10E-01	1.29E-01	1.42E-01	1.51E-01
Gamma		0.00E+00	1.67E-01	2.81E-01	3.73E-01
Delta			0.00E+00	1.11E-01	2.03E-01
Epsilon				0.00E+00	8.33E-02
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	4.07	6.10	8.13	10.17	12.20
N_1	2.0000	2.0000	2.0000	1.8750	1.6875
N_2	0.3333	1.0000	1.2500	1.4375	1.5469
N_3		0.0000	0.2500	0.5000	0.7344
N_4			0.0000	0.0625	0.1719
N_5				0.0000	0.0156
N_6					0.0000

2.1.9 PWR High Pressure Safety Injection Pump

2.1.9.1 HIGH PRESSURE INJECTION MOTOR DRIVEN PUMP FAIL TO START

Systems/Clean Water/High pressure injection
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 162.7
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783352	0.9917736	0.9935597	0.9990971	0.9938913	1.729E+02	1.435E+00
α_2	9.01E-04	8.23E-03	6.44E-03	2.17E-02	6.11E-03	1.435E+00	1.729E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9822643	0.9923800	0.9935353	0.9985514	0.9959192	2.736E+02	2.101E+00
α_2	4.64E-04	4.84E-03	3.71E-03	1.31E-02	2.04E-03	1.334E+00	2.744E+02
α_3	6.67E-05	2.78E-03	1.71E-03	9.15E-03	2.04E-03	7.672E-01	2.749E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9838172	0.9923741	0.9932347	0.9980067	0.9969363	3.715E+02	2.855E+00
α_2	4.53E-04	3.95E-03	3.11E-03	1.03E-02	7.66E-04	1.478E+00	3.729E+02
α_3	9.53E-05	2.42E-03	1.61E-03	7.49E-03	1.53E-03	9.043E-01	3.735E+02
α_4	3.66E-06	1.26E-03	5.46E-04	4.95E-03	7.66E-04	4.727E-01	3.739E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.94E-01	9.96E-01	9.97E-01
α_2	6.11E-03	2.04E-03	7.66E-04
α_3		2.04E-03	1.53E-03
α_4			7.66E-04

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.94E-01	9.96E-01	9.97E-01
Beta	6.11E-03	4.08E-03	3.06E-03
Gamma		5.00E-01	7.50E-01
Delta			3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	162.70	244.05	325.40
N_1	0.0000	0.0000	0.0000
N_2	1.0000	0.5000	0.2500
N_3		0.5000	0.5000
N_4			0.2500

2.1.9.2 HIGH PRESSURE INJECTION MOTOR DRIVEN PUMP FTR LESS THAN 1H

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8687697	0.9670332	0.9862439	0.9999401	1.0000000	1.275E+01	4.345E-01
α_2	6.16E-05	3.30E-02	1.38E-02	1.31E-01	0.00E+00	4.345E-01	1.275E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9054638	0.9667968	0.9756611	0.9977908	1.0000000	3.206E+01	1.101E+00
α_2	8.04E-04	2.51E-02	1.64E-02	7.93E-02	0.00E+00	8.337E-01	3.232E+01
α_3	2.84E-07	8.06E-03	1.63E-03	3.82E-02	0.00E+00	2.672E-01	3.289E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9122217	0.9632593	0.9692097	0.9939302	1.0000000	4.864E+01	1.855E+00
α_2	2.02E-03	2.43E-02	1.84E-02	6.70E-02	0.00E+00	1.228E+00	4.926E+01
α_3	9.04E-06	8.01E-03	2.98E-03	3.31E-02	0.00E+00	4.043E-01	5.009E+01
α_4	1.91E-08	4.41E-03	6.05E-04	2.21E-02	0.00E+00	2.227E-01	5.027E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	2.50	2.50	2.50
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.9.3 HIGH PRESSURE INJECTION MOTOR DRIVEN PUMP FAIL TO RUN

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 146.4
Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496413	0.9753634	0.9777773	0.9928420	0.9768085	1.261E+02	3.185E+00
α_2	7.16E-03	2.46E-02	2.22E-02	5.04E-02	2.32E-02	3.185E+00	1.261E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9455134	0.9679200	0.9694239	0.9851886	0.9685905	1.992E+02	6.602E+00
α_2	1.11E-02	2.65E-02	2.50E-02	4.72E-02	2.64E-02	5.460E+00	2.003E+02
α_3	3.90E-04	5.55E-03	4.05E-03	1.58E-02	5.00E-03	1.142E+00	2.047E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521365	0.9704595	0.9715739	0.9849746	0.9723499	2.711E+02	8.253E+00
α_2	6.22E-03	1.65E-02	1.53E-02	3.06E-02	1.46E-02	4.605E+00	2.748E+02
α_3	2.92E-03	1.07E-02	9.55E-03	2.24E-02	1.12E-02	2.988E+00	2.764E+02
α_4	3.30E-05	2.36E-03	1.33E-03	8.21E-03	1.89E-03	6.602E-01	2.787E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.77E-01	9.69E-01	9.72E-01
α_2	2.32E-02	2.64E-02	1.46E-02
α_3		5.00E-03	1.12E-02
α_4			1.89E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.77E-01	9.69E-01	9.72E-01
Beta	2.32E-02	3.14E-02	2.77E-02
Gamma		1.59E-01	4.72E-01
Delta			1.45E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	111.54	167.31	223.09
N_1	4.2993	2.3230	1.9016
N_2	2.7503	4.6260	3.3770
N_3		0.8750	2.5833
N_4			0.4375

2.1.9.4 HIGH PRESSURE INJECTION MOTOR DRIVEN PUMP FAIL TO RUN >1H

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 143.9
Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9488954	0.9749949	0.9774431	0.9927337	0.9764300	1.242E+02	3.185E+00
α_2	7.27E-03	2.50E-02	2.26E-02	5.11E-02	2.36E-02	3.185E+00	1.242E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9447533	0.9674683	0.9689967	0.9849729	0.9680696	1.963E+02	6.602E+00
α_2	1.13E-02	2.69E-02	2.54E-02	4.78E-02	2.69E-02	5.460E+00	1.975E+02
α_3	3.96E-04	5.63E-03	4.11E-03	1.60E-02	5.08E-03	1.142E+00	2.018E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514794	0.9700512	0.9711801	0.9847651	0.9718870	2.673E+02	8.253E+00
α_2	6.31E-03	1.67E-02	1.56E-02	3.11E-02	1.48E-02	4.605E+00	2.710E+02
α_3	2.96E-03	1.08E-02	9.68E-03	2.27E-02	1.14E-02	2.988E+00	2.726E+02
α_4	3.35E-05	2.40E-03	1.35E-03	8.32E-03	1.92E-03	6.602E-01	2.749E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.76E-01	9.68E-01	9.72E-01
α_2	2.36E-02	2.69E-02	1.48E-02
α_3		5.08E-03	1.14E-02
α_4			1.92E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.76E-01	9.68E-01	9.72E-01
Beta	2.36E-02	3.19E-02	2.81E-02
Gamma		1.59E-01	4.72E-01
Delta			1.45E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	109.64	164.46	219.28
N_1	4.2993	2.3230	1.9016
N_2	2.7503	4.6260	3.3770
N_3		0.8750	2.5833
N_4			0.4375

2.1.10 PWR Residual Heat Removal Pump

2.1.10.1 PWR RHR MDP FAIL TO START

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 34.5
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9065899	0.9626699	0.9696071	0.9949820	0.9637787	4.138E+01	1.605E+00
α_2	5.02E-03	3.73E-02	3.04E-02	9.34E-02	3.62E-02	1.605E+00	4.138E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9292644	0.9674091	0.9713040	0.9922173	0.9695416	7.583E+01	2.555E+00
α_2	3.41E-03	2.24E-02	1.85E-02	5.49E-02	1.94E-02	1.759E+00	7.662E+01
α_3	2.76E-04	1.01E-02	6.39E-03	3.28E-02	1.11E-02	7.954E-01	7.759E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9354425	0.9671132	0.9698799	0.9893132	0.9715045	1.074E+02	3.651E+00
α_2	3.88E-03	1.95E-02	1.67E-02	4.48E-02	1.49E-02	2.170E+00	1.089E+02
α_3	4.72E-04	9.04E-03	6.31E-03	2.69E-02	9.51E-03	1.004E+00	1.100E+02
α_4	1.33E-05	4.30E-03	1.89E-03	1.68E-02	4.05E-03	4.777E-01	1.105E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.64E-01	9.70E-01	9.72E-01
α_2	3.62E-02	1.94E-02	1.49E-02
α_3		1.11E-02	9.51E-03
α_4			4.05E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.64E-01	9.70E-01	9.72E-01
Beta	3.62E-02	3.05E-02	2.85E-02
Gamma		3.63E-01	4.76E-01
Delta			2.99E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	29.57	44.36	59.14
N_1	1.5600	1.9145	2.0960
N_2	1.1700	0.9255	0.9419

N_3		0.5282	0.5993
N_4			0.2551

2.1.10.2 PWR RHR MDP FTR LESS THAN 1H

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 5.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7823766	0.9140003	0.9302121	0.9899557	0.8333333	1.525E+01	1.435E+00
α_2	1.00E-02	8.60E-02	6.98E-02	2.18E-01	1.67E-01	1.435E+00	1.525E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8776507	0.9463457	0.9537958	0.9895069	0.8823529	3.706E+01	2.101E+00
α_2	3.35E-03	3.41E-02	2.65E-02	9.08E-02	5.88E-02	1.334E+00	3.782E+01
α_3	4.79E-04	1.96E-02	1.22E-02	6.39E-02	5.88E-02	7.672E-01	3.839E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8989389	0.9516015	0.9566355	0.9870376	0.9090909	5.614E+01	2.855E+00
α_2	2.92E-03	2.51E-02	1.99E-02	6.48E-02	2.27E-02	1.478E+00	5.751E+01
α_3	6.13E-04	1.53E-02	1.03E-02	4.72E-02	4.55E-02	9.043E-01	5.809E+01
α_4	2.35E-05	8.01E-03	3.50E-03	3.13E-02	2.27E-02	4.727E-01	5.852E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	8.33E-01	8.82E-01	9.09E-01
α_2	1.67E-01	5.88E-02	2.27E-02
α_3		5.88E-02	4.55E-02
α_4			2.27E-02

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	8.33E-01	8.82E-01	9.09E-01
Beta	1.67E-01	1.18E-01	9.09E-02
Gamma		5.00E-01	7.50E-01
Delta			3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	5.00	7.50	10.00
N_1	0.0000	0.0000	0.0000
N_2	1.0000	0.5000	0.2500
N_3		0.5000	0.5000
N_4			0.2500

2.1.10.3 PWR RHR MDP FAIL TO RUN

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 15.4
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8635650	0.9470276	0.9576735	0.9939828	0.9390244	2.565E+01	1.435E+00
α_2	6.01E-03	5.30E-02	4.23E-02	1.36E-01	6.10E-02	1.435E+00	2.565E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9118919	0.9616319	0.9671239	0.9925763	0.9585062	5.266E+01	2.101E+00
α_2	2.37E-03	2.44E-02	1.88E-02	6.52E-02	2.07E-02	1.334E+00	5.342E+01
α_3	3.40E-04	1.40E-02	8.69E-03	4.58E-02	2.07E-02	7.672E-01	5.399E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9249026	0.9642181	0.9680341	0.9904843	0.9685535	7.694E+01	2.855E+00
α_2	2.15E-03	1.85E-02	1.47E-02	4.81E-02	7.86E-03	1.478E+00	7.831E+01
α_3	4.51E-04	1.13E-02	7.59E-03	3.50E-02	1.57E-02	9.043E-01	7.889E+01
α_4	1.73E-05	5.92E-03	2.58E-03	2.32E-02	7.86E-03	4.727E-01	7.932E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.39E-01	9.59E-01	9.69E-01
α_2	6.10E-02	2.07E-02	7.86E-03
α_3		2.07E-02	1.57E-02
α_4			7.86E-03

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.39E-01	9.59E-01	9.69E-01
Beta	6.10E-02	4.15E-02	3.14E-02
Gamma		5.00E-01	7.50E-01
Delta			3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	15.40	23.10	30.80
N_1	0.0000	0.0000	0.0000
N_2	1.0000	0.5000	0.2500
N_3		0.5000	0.5000

N_4			0.2500

2.1.10.4 PWR RHR MDP FAIL TO RUN >1H

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 10.4
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9174772	0.9793876	0.9915568	0.9999590	1.0000000	2.065E+01	4.345E-01
α_2	3.77E-05	2.06E-02	8.44E-03	8.25E-02	0.00E+00	4.345E-01	2.065E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9233970	0.9731858	0.9804207	0.9982305	1.0000000	3.995E+01	1.101E+00
α_2	6.46E-04	2.03E-02	1.32E-02	6.42E-02	0.00E+00	8.337E-01	4.022E+01
α_3	2.28E-07	6.51E-03	1.31E-03	3.09E-02	0.00E+00	2.672E-01	4.079E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9239261	0.9682301	0.9734221	0.9947705	1.0000000	5.654E+01	1.855E+00
α_2	1.74E-03	2.10E-02	1.59E-02	5.80E-02	0.00E+00	1.228E+00	5.716E+01
α_3	7.81E-06	6.92E-03	2.57E-03	2.86E-02	0.00E+00	4.043E-01	5.799E+01
α_4	1.65E-08	3.81E-03	5.23E-04	1.91E-02	0.00E+00	2.227E-01	5.817E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	10.40	10.40	10.40
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.11BWR Standby Liquid Control Pump

2.1.11.1 STANDBY LIQUID CONTROL MDP FAIL TO START

Systems/Clean Water/Standby liquid control
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 18.5
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9397543	0.9848651	0.9937109	0.9999657	0.9994650	2.893E+01	4.445E-01
α_2	3.15E-05	1.51E-02	6.29E-03	6.02E-02	5.35E-04	4.445E-01	2.893E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9452973	0.9807611	0.9858964	0.9986686	0.9990007	5.755E+01	1.129E+00
α_2	5.09E-04	1.47E-02	9.63E-03	4.60E-02	9.64E-04	8.607E-01	5.782E+01
α_3	1.66E-07	4.57E-03	9.26E-04	2.17E-02	3.57E-05	2.682E-01	5.841E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9467131	0.9776483	0.9812677	0.9962091	0.9985995	8.343E+01	1.907E+00
α_2	1.33E-03	1.50E-02	1.14E-02	4.09E-02	1.30E-03	1.277E+00	8.406E+01
α_3	5.69E-06	4.78E-03	1.79E-03	1.97E-02	9.64E-05	4.079E-01	8.493E+01
α_4	1.13E-08	2.61E-03	3.57E-04	1.31E-02	2.68E-06	2.228E-01	8.511E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.99E-01	9.99E-01	9.99E-01
α_2	5.35E-04	9.64E-04	1.30E-03
α_3		3.57E-05	9.64E-05
α_4			2.68E-06

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.99E-01	9.99E-01	9.99E-01
Beta	5.35E-04	9.99E-04	1.40E-03
Gamma		3.57E-02	7.07E-02
Delta			2.70E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	18.50	27.75	37.00
N_1	0.1800	0.2430	0.2916
N_2	0.0100	0.0270	0.0486
N_3		0.0010	0.0036
N_4			0.0001

2.1.11.2 STANDBY LIQUID CONTROL MDP FAIL TO RUN LESS THAN 1H

Systems/Clean Water/Standby liquid control
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8636859	0.9657333	0.9856734	0.9999376	1.0000000	1.225E+01	4.345E-01
α_2	6.41E-05	3.43E-02	1.43E-02	1.36E-01	0.00E+00	4.345E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9040424	0.9662885	0.9752807	0.9977558	1.0000000	3.156E+01	1.101E+00
α_2	8.16E-04	2.55E-02	1.67E-02	8.05E-02	0.00E+00	8.337E-01	3.182E+01
α_3	2.88E-07	8.18E-03	1.66E-03	3.88E-02	0.00E+00	2.672E-01	3.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113590	0.9628918	0.9688972	0.9938678	1.0000000	4.814E+01	1.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	1.93E-08	4.45E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.977E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	2.00	2.00	2.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.11.3 STANDBY LIQUID CONTROL MDP FAIL TO RUN

Systems/Clean Water/Standby liquid control
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 4.2
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8835558	0.9707994	0.9878843	0.9999416	1.0000000	1.445E+01	4.345E-01
α_2	5.42E-05	2.92E-02	1.21E-02	1.16E-01	0.00E+00	4.345E-01	1.445E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9099934	0.9684162	0.9768710	0.9979019	1.0000000	3.375E+01	1.101E+00
α_2	7.64E-04	2.39E-02	1.56E-02	7.55E-02	0.00E+00	8.337E-01	3.402E+01
α_3	2.70E-07	7.67E-03	1.55E-03	3.64E-02	0.00E+00	2.672E-01	3.459E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9150335	0.9644560	0.9702204	0.9941331	1.0000000	5.034E+01	1.855E+00
α_2	1.95E-03	2.35E-02	1.78E-02	6.48E-02	0.00E+00	1.228E+00	5.096E+01
α_3	8.74E-06	7.75E-03	2.88E-03	3.20E-02	0.00E+00	4.043E-01	5.179E+01
α_4	1.84E-08	4.27E-03	5.85E-04	2.14E-02	0.00E+00	2.227E-01	5.197E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	4.20	4.20	4.20
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.11.4 STANDBY LIQUID CONTROL MDP FAIL TO RUN >1H

Systems/Clean Water/Standby liquid control
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.2
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8657672	0.9662653	0.9859072	0.9999386	1.0000000	1.245E+01	4.345E-01
α_2	6.31E-05	3.37E-02	1.41E-02	1.34E-01	0.00E+00	4.345E-01	1.245E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9046116	0.9664937	0.9754343	0.9977699	1.0000000	3.176E+01	1.101E+00
α_2	8.11E-04	2.54E-02	1.66E-02	8.00E-02	0.00E+00	8.337E-01	3.202E+01
α_3	2.87E-07	8.13E-03	1.65E-03	3.86E-02	0.00E+00	2.672E-01	3.259E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9117061	0.9630396	0.9690230	0.9938929	1.0000000	4.834E+01	1.855E+00
α_2	2.03E-03	2.45E-02	1.85E-02	6.74E-02	0.00E+00	1.228E+00	4.896E+01
α_3	9.10E-06	8.06E-03	3.00E-03	3.33E-02	0.00E+00	4.043E-01	4.979E+01
α_4	1.92E-08	4.44E-03	6.09E-04	2.22E-02	0.00E+00	2.227E-01	4.997E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	2.20	2.20	2.20
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.1.12 Component Cooling Water Pumps

2.1.12.1 CCW MOTOR DRIVEN PUMP FAIL TO START

Systems/Clean Water/Component cooling water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 92.7
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9830613	0.9957969	0.9983221	0.9999932	1.0000000	1.029E+02	4.345E-01
α_2	7.47E-06	4.20E-03	1.68E-03	1.69E-02	0.00E+00	4.345E-01	1.029E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742655	0.9910756	0.9935503	0.9994173	1.0000000	1.223E+02	1.101E+00
α_2	2.12E-04	6.76E-03	4.35E-03	2.15E-02	0.00E+00	8.337E-01	1.225E+02
α_3	7.53E-08	2.17E-03	4.33E-04	1.03E-02	0.00E+00	2.672E-01	1.231E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3
α_1	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00
α_3		0.00E+00

MGL	CCCG=2	CCCG=3
1-Beta	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00
Gamma		0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3
Adj. Ind. Events	92.70	92.70
N_1	0.0000	0.0000
N_2	0.0000	0.0000
N_3		0.0000

2.1.12.2 CCW MOTOR DRIVEN PUMP FAIL TO RUN

Systems/Clean Water/Component cooling water
Components/Pump/Motor Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 72.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9589658	0.9891315	0.9948302	0.9999456	0.9977457	4.713E+01	5.179E-01
α_2	5.21E-05	1.09E-02	5.17E-03	4.10E-02	2.25E-03	5.179E-01	4.713E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9579263	0.9842886	0.9878547	0.9984464	0.9954812	8.463E+01	1.351E+00
α_2	7.93E-04	1.26E-02	9.08E-03	3.65E-02	4.52E-03	1.084E+00	8.490E+01
α_3	1.08E-07	3.11E-03	6.23E-04	1.47E-02	0.00E+00	2.672E-01	8.571E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3
α_1	9.98E-01	9.95E-01
α_2	2.25E-03	4.52E-03
α_3		0.00E+00

MGL	CCCG=2	CCCG=3
1-Beta	9.98E-01	9.95E-01
Beta	2.25E-03	4.52E-03
Gamma		0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3
Adj. Ind. Events	36.05	54.07
N_1	0.8333	1.0000
N_2	0.0833	0.2500
N_3		0.0000

2.1.13 Positive Displacement Pumps

2.1.13.1 POSITIVE DISPLACEMENT PUMP FAIL TO START

Components/Pump/Motor Driven Pump/Positive Displacement
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 112.6
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9856038	0.9963998	0.9985299	0.9999934	0.9999113	1.230E+02	4.445E-01
α_2	7.34E-06	3.60E-03	1.47E-03	1.44E-02	8.87E-05	4.445E-01	1.230E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9838294	0.9943507	0.9958940	0.9996106	0.9998345	1.987E+02	1.129E+00
α_2	1.48E-04	4.31E-03	2.81E-03	1.36E-02	1.60E-04	8.607E-01	1.990E+02
α_3	4.84E-08	1.34E-03	2.70E-04	6.36E-03	5.91E-06	2.682E-01	1.996E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9832637	0.9930269	0.9941838	0.9988307	0.9997681	2.716E+02	1.907E+00
α_2	4.12E-04	4.67E-03	3.53E-03	1.28E-02	2.15E-04	1.277E+00	2.723E+02
α_3	1.77E-06	1.49E-03	5.54E-04	6.15E-03	1.60E-05	4.079E-01	2.731E+02
α_4	3.51E-09	8.14E-04	1.11E-04	4.08E-03	4.43E-07	2.228E-01	2.733E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	8.87E-05	1.60E-04	2.15E-04
α_3		5.91E-06	1.60E-05
α_4			4.43E-07

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	8.87E-05	1.66E-04	2.32E-04
Gamma		3.57E-02	7.07E-02
Delta			2.70E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	112.60	168.90	225.20
N_1	0.1800	0.2430	0.2916
N_2	0.0100	0.0270	0.0486
N_3		0.0010	0.0036
N_4			0.0001

2.1.13.2 POSITIVE DISPLACEMENT PUMP FAIL TO RUN

Components/Pump/Motor Driven Pump/Positive Displacement
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 99.4
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9504921	0.9797508	0.9832908	0.9969060	0.9825991	8.554E+01	1.768E+00
α_2	3.10E-03	2.02E-02	1.67E-02	4.95E-02	1.74E-02	1.768E+00	8.554E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9408412	0.9680144	0.9701596	0.9878499	0.9690775	1.392E+02	4.601E+00
α_2	9.96E-03	2.84E-02	2.62E-02	5.42E-02	2.87E-02	4.084E+00	1.398E+02
α_3	1.69E-05	3.60E-03	1.69E-03	1.36E-02	2.21E-03	5.172E-01	1.433E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9479553	0.9701520	0.9717232	0.9869763	0.9729777	1.917E+02	5.897E+00
α_2	5.47E-03	1.76E-02	1.60E-02	3.52E-02	1.50E-02	3.478E+00	1.941E+02
α_3	1.96E-03	1.05E-02	8.88E-03	2.45E-02	1.11E-02	2.071E+00	1.955E+02
α_4	6.61E-07	1.76E-03	5.37E-04	7.67E-03	8.36E-04	3.477E-01	1.972E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.83E-01	9.69E-01	9.73E-01
α_2	1.74E-02	2.87E-02	1.50E-02
α_3		2.21E-03	1.11E-02
α_4			8.36E-04

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.83E-01	9.69E-01	9.73E-01
Beta	1.74E-02	3.09E-02	2.70E-02
Gamma		7.14E-02	4.43E-01
Delta			6.98E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	72.29	108.44	144.58
N_1	3.0000	1.2500	0.9444
N_2	1.3333	3.2500	2.2500
N_3		0.2500	1.6667
N_4			0.1250

2.2 Turbine Driven Pumps

2.2.1 Pooled Turbine Driven Pumps

2.2.1.1 TURBINE DRIVEN PUMP FAIL TO START SPAR: TDP-FS

Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 213.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9831709	0.9936153	0.9950053	0.9992995	0.9953271	2.232E+02	1.435E+00
α_2	6.98E-04	6.38E-03	4.99E-03	1.68E-02	4.67E-03	1.435E+00	2.232E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9860617	0.9940172	0.9949234	0.9988687	0.9968799	3.491E+02	2.101E+00
α_2	3.64E-04	3.80E-03	2.91E-03	1.03E-02	1.56E-03	1.334E+00	3.498E+02
α_3	5.24E-05	2.18E-03	1.34E-03	7.19E-03	1.56E-03	7.672E-01	3.504E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9872301	0.9939892	0.9946693	0.9984299	0.9976581	4.721E+02	2.855E+00
α_2	3.57E-04	3.11E-03	2.45E-03	8.13E-03	5.85E-04	1.478E+00	4.735E+02
α_3	7.51E-05	1.90E-03	1.27E-03	5.91E-03	1.17E-03	9.043E-01	4.741E+02
α_4	2.89E-06	9.95E-04	4.31E-04	3.90E-03	5.85E-04	4.727E-01	4.745E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.95E-01	9.97E-01	9.98E-01
α_2	4.67E-03	1.56E-03	5.85E-04
α_3		1.56E-03	1.17E-03
α_4			5.85E-04

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.95E-01	9.97E-01	9.98E-01
Beta	4.67E-03	3.12E-03	2.34E-03
Gamma		5.00E-01	7.50E-01
Delta			3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. IEs	213.00	319.50	426.00
N_1	0.0000	0.0000	0.0000

N_2	1.0000	0.5000	0.2500
N_3		0.5000	0.5000
N_4			0.2500

2.2.1.2 TURBINE DRIVEN PUMP FTR LESS THAN 1H

Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 69.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9781964	0.9945875	0.9978356	0.9999913	1.0000000	7.985E+01	4.345E-01
α_2	9.64E-06	5.41E-03	2.17E-03	2.18E-02	0.00E+00	4.345E-01	7.985E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9683750	0.9890193	0.9920591	0.9992824	1.0000000	9.915E+01	1.101E+00
α_2	2.61E-04	8.32E-03	5.35E-03	2.65E-02	0.00E+00	8.337E-01	9.942E+01
α_3	9.27E-08	2.67E-03	5.34E-04	1.26E-02	0.00E+00	2.672E-01	9.999E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9619469	0.9842243	0.9868790	0.9974329	1.0000000	1.157E+02	1.855E+00
α_2	8.58E-04	1.04E-02	7.83E-03	2.90E-02	0.00E+00	1.228E+00	1.164E+02
α_3	3.85E-06	3.44E-03	1.27E-03	1.42E-02	0.00E+00	4.043E-01	1.172E+02
α_4	8.14E-09	1.89E-03	2.58E-04	9.48E-03	0.00E+00	2.227E-01	1.174E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	69.60	69.60	69.60
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.1.3 TDP FTR LESS THAN AND > 1 HOUR ALL SYSTEMS SPAR: TDP-FR

Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 91.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9827786	0.9957266	0.9982939	0.9999931	1.0000000	1.012E+02	4.345E-01
α_2	7.60E-06	4.27E-03	1.71E-03	1.72E-02	0.00E+00	4.345E-01	1.012E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9739120	0.9909509	0.9934596	0.9994092	1.0000000	1.206E+02	1.101E+00
α_2	2.15E-04	6.85E-03	4.41E-03	2.18E-02	0.00E+00	8.337E-01	1.208E+02
α_3	7.63E-08	2.20E-03	4.39E-04	1.04E-02	0.00E+00	2.672E-01	1.214E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677658	0.9866532	0.9889045	0.9978316	1.0000000	1.371E+02	1.855E+00
α_2	7.25E-04	8.84E-03	6.62E-03	2.45E-02	0.00E+00	1.228E+00	1.378E+02
α_3	3.26E-06	2.91E-03	1.07E-03	1.20E-02	0.00E+00	4.043E-01	1.386E+02
α_4	6.88E-09	1.60E-03	2.18E-04	8.02E-03	0.00E+00	2.227E-01	1.388E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	91.00	91.00	91.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.1.4 TURBINE DRIVEN PUMP FAIL TO RUN >1H

Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 21.4
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9456081	0.9864553	0.9945078	0.9999731	1.0000000	3.165E+01	4.345E-01
α_2	2.45E-05	1.35E-02	5.49E-03	5.44E-02	0.00E+00	4.345E-01	3.165E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9394055	0.9788520	0.9846108	0.9986078	1.0000000	5.096E+01	1.101E+00
α_2	5.07E-04	1.60E-02	1.04E-02	5.08E-02	0.00E+00	8.337E-01	5.122E+01
α_3	1.80E-07	5.13E-03	1.03E-03	2.43E-02	0.00E+00	2.672E-01	5.179E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9358362	0.9732663	0.9776766	0.9956106	1.0000000	6.754E+01	1.855E+00
α_2	1.46E-03	1.77E-02	1.33E-02	4.89E-02	0.00E+00	1.228E+00	6.816E+01
α_3	6.56E-06	5.83E-03	2.16E-03	2.41E-02	0.00E+00	4.043E-01	6.899E+01
α_4	1.38E-08	3.21E-03	4.39E-04	1.61E-02	0.00E+00	2.227E-01	6.917E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	21.40	21.40	21.40
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.1.5 TDP FTR NORMAL RUNNING ALL SYSTEMS

Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 98.2
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9839155	0.9960092	0.9984073	0.9999860	1.0000000	1.084E+02	4.345E-01
α_2	7.09E-06	3.99E-03	1.59E-03	1.61E-02	0.00E+00	4.345E-01	1.084E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753642	0.9914565	0.9938270	0.9994423	1.0000000	1.278E+02	1.101E+00
α_2	2.03E-04	6.47E-03	4.16E-03	2.06E-02	0.00E+00	8.337E-01	1.280E+02
α_3	7.20E-08	2.07E-03	4.15E-04	9.84E-03	0.00E+00	2.672E-01	1.286E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693434	0.9873106	0.9894538	0.9979346	1.0000000	1.443E+02	1.855E+00
α_2	6.89E-04	8.40E-03	6.29E-03	2.33E-02	0.00E+00	1.228E+00	1.450E+02
α_3	3.09E-06	2.77E-03	1.02E-03	1.14E-02	0.00E+00	4.043E-01	1.458E+02
α_4	6.54E-09	1.52E-03	2.07E-04	7.63E-03	0.00E+00	2.227E-01	1.460E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	98.20	98.20	98.20
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.2 AFW Turbine-Driven Pumps

2.2.2.1 AFW TURBINE DRIVEN PUMP FAIL TO START SPAR: TDP-FS-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 89.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9824336	0.9956409	0.9982595	0.9999930	1.0000000	9.925E+01	4.345E-01
α_2	7.75E-06	4.36E-03	1.74E-03	1.76E-02	0.00E+00	4.345E-01	9.925E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734782	0.9907996	0.9933496	0.9993992	1.0000000	1.186E+02	1.101E+00
α_2	2.18E-04	6.97E-03	4.48E-03	2.22E-02	0.00E+00	8.337E-01	1.188E+02
α_3	7.76E-08	2.23E-03	4.47E-04	1.06E-02	0.00E+00	2.672E-01	1.194E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9672976	0.9864584	0.9887417	0.9977997	1.0000000	1.351E+02	1.855E+00
α_2	7.35E-04	8.96E-03	6.71E-03	2.49E-02	0.00E+00	1.228E+00	1.358E+02
α_3	3.30E-06	2.95E-03	1.09E-03	1.22E-02	0.00E+00	4.043E-01	1.366E+02
α_4	6.98E-09	1.63E-03	2.21E-04	8.14E-03	0.00E+00	2.227E-01	1.368E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. IEs	89.00	89.00	89.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000

N_3		0.0000	0.0000
N_4			0.0000

2.2.2.2 AFW TURBINE DRIVEN PUMP FTR LESS THAN 1H

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 44.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680161	0.9920535	0.9968089	0.9999842	1.0000000	5.425E+01	4.345E-01
α_2	1.42E-05	7.95E-03	3.19E-03	3.20E-02	0.00E+00	4.345E-01	5.425E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9576064	0.9852539	0.9893069	0.9990344	1.0000000	7.356E+01	1.101E+00
α_2	3.51E-04	1.12E-02	7.21E-03	3.55E-02	0.00E+00	8.337E-01	7.382E+01
α_3	1.25E-07	3.58E-03	7.18E-04	1.70E-02	0.00E+00	2.672E-01	7.439E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514489	0.9798341	0.9832013	0.9967085	1.0000000	9.014E+01	1.855E+00
α_2	1.10E-03	1.34E-02	1.00E-02	3.70E-02	0.00E+00	1.228E+00	9.076E+01
α_3	4.93E-06	4.40E-03	1.62E-03	1.82E-02	0.00E+00	4.043E-01	9.159E+01
α_4	1.04E-08	2.42E-03	3.30E-04	1.21E-02	0.00E+00	2.227E-01	9.177E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	44.00	44.00	44.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.2.3 AFW TURBINE DRIVEN PUMP FAIL TO RUN SPAR: TDP-FR-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 59.3
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749961	0.9937908	0.9975089	0.9999877	1.0000000	6.955E+01	4.345E-01
α_2	1.11E-05	6.21E-03	2.49E-03	2.50E-02	0.00E+00	4.345E-01	6.955E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9647703	0.9877620	0.9911438	0.9991997	1.0000000	8.885E+01	1.101E+00
α_2	2.91E-04	9.27E-03	5.97E-03	2.95E-02	0.00E+00	8.337E-01	8.912E+01
α_3	1.03E-07	2.97E-03	5.95E-04	1.41E-02	0.00E+00	2.672E-01	8.969E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9583177	0.9827098	0.9856117	0.9971836	1.0000000	1.054E+02	1.855E+00
α_2	9.41E-04	1.14E-02	8.58E-03	3.17E-02	0.00E+00	1.228E+00	1.061E+02
α_3	4.22E-06	3.77E-03	1.39E-03	1.56E-02	0.00E+00	4.043E-01	1.069E+02
α_4	8.92E-09	2.08E-03	2.83E-04	1.04E-02	0.00E+00	2.227E-01	1.071E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	59.30	59.30	59.30
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.2.4 AFW TURBINE DRIVEN PUMP FAIL TO RUN >1H

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 15.3
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9329282	0.9832752	0.9931927	0.9999668	1.0000000	2.555E+01	4.345E-01
α_2	3.04E-05	1.67E-02	6.81E-03	6.71E-02	0.00E+00	4.345E-01	2.555E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9314583	0.9760449	0.9825386	0.9984195	1.0000000	4.486E+01	1.101E+00
α_2	5.75E-04	1.81E-02	1.18E-02	5.74E-02	0.00E+00	8.337E-01	4.512E+01
α_3	2.04E-07	5.81E-03	1.17E-03	2.76E-02	0.00E+00	2.672E-01	4.569E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9297347	0.9706897	0.9755019	0.9951790	1.0000000	6.144E+01	1.855E+00
α_2	1.61E-03	1.94E-02	1.46E-02	5.36E-02	0.00E+00	1.228E+00	6.206E+01
α_3	7.19E-06	6.39E-03	2.37E-03	2.64E-02	0.00E+00	4.043E-01	6.289E+01
α_4	1.52E-08	3.52E-03	4.82E-04	1.76E-02	0.00E+00	2.227E-01	6.307E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	15.30	15.30	15.30
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.2.3 BWR High Pressure Coolant Injection and Reactor Core Isolation Cooling Pumps

2.2.3.1 COMBINED HPCI AND RCIC TDP FAIL TO START

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 108.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9684837	0.9880138	0.9906063	0.9986817	0.9908257	1.182E+02	1.435E+00
α_2	1.32E-03	1.20E-02	9.40E-03	3.15E-02	9.17E-03	1.435E+00	1.182E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	9.91E-01
α_2	9.17E-03

MGL	CCCG=2
1-Beta	9.91E-01
Beta	9.17E-03

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	108.00
N_1	0.0000
N_2	1.0000

2.2.3.2 COMBINED HPCI AND RCIC TDP FTR LESS THAN 1H

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 25.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9518734	0.9880233	0.9951605	0.9999763	1.0000000	3.585E+01	4.345E-01
α_2	2.16E-05	1.20E-02	4.84E-03	4.81E-02	0.00E+00	4.345E-01	3.585E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	25.60
N_1	0.0000
N_2	0.0000

2.2.3.3 COMBINED HPCI AND RCIC TDP FAIL TO RUN

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 31.7
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9587713	0.9897472	0.9958679	0.9999797	1.0000000	4.195E+01	4.345E-01
α_2	1.84E-05	1.03E-02	4.13E-03	4.12E-02	0.00E+00	4.345E-01	4.195E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	31.70
N_1	0.0000
N_2	0.0000

2.2.3.4 COMBINED HPCI AND RCIC TDP FAIL TO RUN >1H

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Pump/Turbine Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8965817	0.9741057	0.9893092	0.9999484	1.0000000	1.635E+01	4.345E-01
α_2	4.78E-05	2.59E-02	1.07E-02	1.03E-01	0.00E+00	4.345E-01	1.635E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	6.10
N_1	0.0000
N_2	0.0000

2.3 Motor Operated Valves

2.3.1 Pooled Motor Operated Valve Distributions

2.3.1.1 MOV FAIL TO OPEN/CLOSE ALL SYSTEMS SPAR: MOV-FTOC

Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 625.7
Total Number of Common-Cause Failure Events: 9

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9784780	0.9906376	0.9919967	0.9981374	0.9921411	2.310E+02	2.183E+00
α_2	1.86E-03	9.36E-03	8.00E-03	2.15E-02	7.86E-03	2.183E+00	2.310E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9778175	0.9883388	0.9892214	0.9958364	0.9905766	3.586E+02	4.231E+00
α_2	2.86E-03	9.39E-03	8.50E-03	1.89E-02	7.74E-03	3.406E+00	3.594E+02
α_3	6.87E-05	2.27E-03	1.45E-03	7.29E-03	1.68E-03	8.250E-01	3.620E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9761922	0.9859217	0.9865765	0.9934135	0.9885946	4.824E+02	6.888E+00
α_2	4.41E-03	1.08E-02	1.01E-02	1.94E-02	9.19E-03	5.282E+00	4.840E+02
α_3	1.59E-04	2.31E-03	1.68E-03	6.63E-03	1.65E-03	1.132E+00	4.881E+02
α_4	2.84E-06	9.68E-04	4.20E-04	3.79E-03	5.69E-04	4.737E-01	4.888E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9771455	0.9855829	0.9860758	0.9923281	0.9894019	6.404E+02	9.368E+00
α_2	3.78E-03	8.85E-03	8.35E-03	1.56E-02	6.61E-03	5.750E+00	6.441E+02
α_3	1.01E-03	4.10E-03	3.61E-03	8.90E-03	3.07E-03	2.666E+00	6.471E+02
α_4	2.63E-05	1.16E-03	7.07E-04	3.85E-03	6.92E-04	7.548E-01	6.490E+02
α_5	2.58E-10	3.04E-04	3.05E-05	1.57E-03	2.28E-04	1.974E-01	6.496E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9786542	0.9861617	0.9865728	0.9922620	0.9901100	7.692E+02	1.079E+01
α_2	2.86E-03	6.92E-03	6.51E-03	1.24E-02	4.80E-03	5.401E+00	7.746E+02
α_3	1.43E-03	4.56E-03	4.14E-03	9.11E-03	3.66E-03	3.556E+00	7.765E+02

α_4	1.25E-04	1.56E-03	1.16E-03	4.36E-03	9.51E-04	1.219E+00	7.788E+02
α_5	1.77E-06	6.07E-04	2.63E-04	2.38E-03	3.81E-04	4.733E-01	7.796E+02
α_6	9.57E-13	1.87E-04	6.97E-06	1.03E-03	9.49E-05	1.458E-01	7.799E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9793491	0.9860938	0.9864282	0.9916891	0.9910397	9.447E+02	1.332E+01
α_2	2.67E-03	6.16E-03	5.82E-03	1.08E-02	3.67E-03	5.904E+00	9.521E+02
α_3	1.36E-03	4.05E-03	3.72E-03	7.91E-03	2.94E-03	3.884E+00	9.541E+02
α_4	4.66E-04	2.31E-03	1.98E-03	5.31E-03	1.60E-03	2.216E+00	9.558E+02
α_5	3.87E-05	9.54E-04	6.38E-04	2.95E-03	5.11E-04	9.141E-01	9.571E+02
α_6	1.20E-07	3.58E-04	1.07E-04	1.57E-03	2.04E-04	3.427E-01	9.576E+02
α_7	1.67E-25	6.30E-05	6.30E-09	3.53E-04	4.07E-05	6.033E-02	9.579E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9805247	0.9866643	0.9869554	0.9918033	0.9917375	1.088E+03	1.470E+01
α_2	2.35E-03	5.40E-03	5.10E-03	9.46E-03	2.97E-03	5.950E+00	1.096E+03
α_3	1.16E-03	3.49E-03	3.19E-03	6.82E-03	2.40E-03	3.842E+00	1.098E+03
α_4	5.72E-04	2.38E-03	2.08E-03	5.18E-03	1.68E-03	2.620E+00	1.100E+03
α_5	1.31E-04	1.27E-03	9.80E-04	3.38E-03	7.84E-04	1.395E+00	1.101E+03
α_6	6.46E-06	5.69E-04	3.09E-04	2.01E-03	2.97E-04	6.272E-01	1.102E+03
α_7	5.96E-10	1.97E-04	2.50E-05	9.92E-04	1.07E-04	2.168E-01	1.102E+03
α_8	1.09E-30	4.42E-05	3.54E-10	2.33E-04	1.78E-05	4.875E-02	1.102E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.92E-01	9.91E-01	9.89E-01	9.89E-01	9.90E-01	9.91E-01	9.92E-01
α_2	7.86E-03	7.74E-03	9.19E-03	6.61E-03	4.80E-03	3.67E-03	2.97E-03
α_3		1.68E-03	1.65E-03	3.07E-03	3.66E-03	2.94E-03	2.40E-03
α_4			5.69E-04	6.92E-04	9.51E-04	1.60E-03	1.68E-03
α_5				2.28E-04	3.81E-04	5.11E-04	7.84E-04
α_6					9.49E-05	2.04E-04	2.97E-04
α_7						4.07E-05	1.07E-04
α_8							1.78E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.91E-01	9.89E-01	9.89E-01	9.90E-01	9.91E-01	9.92E-01
Beta	7.86E-03	9.42E-03	1.14E-02	1.06E-02	9.89E-03	8.96E-03	8.26E-03
Gamma		1.78E-01	1.94E-01	3.76E-01	5.15E-01	5.90E-01	6.40E-01
Delta			2.57E-01	2.30E-01	2.80E-01	4.45E-01	5.46E-01
Epsilon				2.48E-01	3.34E-01	3.21E-01	4.18E-01
Mu					1.99E-01	3.24E-01	3.50E-01
Omega						1.67E-01	2.96E-01
Sigma							1.43E-01

MOV FAIL TO OPEN/CLOSE ALL SYSTEMS SPAR: MOV-FTOC

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	216.59	324.88	433.18	541.47	649.77	758.06	866.35
N_1	4.1693	4.1814	3.0389	2.8019	2.5394	2.5414	2.4909
N_2	1.7487	2.5726	4.0544	3.6354	3.1614	2.8165	2.6055
N_3		0.5578	0.7272	1.6891	2.4144	2.2530	2.1032
N_4			0.2510	0.3804	0.6264	1.2272	1.4736
N_5				0.1252	0.2511	0.3923	0.6866
N_6					0.0625	0.1565	0.2602
N_7						0.0313	0.0938
N_8							0.0156

2.3.1.2 MOV FAIL TO OPEN ALL SYSTEMS

Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 356.9
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9617937	0.9847690	0.9876462	0.9979068	0.9875625	1.063E+02	1.645E+00
α_2	2.09E-03	1.52E-02	1.24E-02	3.82E-02	1.24E-02	1.645E+00	1.063E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9675689	0.9850348	0.9868345	0.9963610	0.9894569	1.732E+02	2.632E+00
α_2	1.62E-03	1.03E-02	8.53E-03	2.51E-02	6.75E-03	1.815E+00	1.740E+02
α_3	1.37E-04	4.65E-03	2.95E-03	1.49E-02	3.79E-03	8.173E-01	1.750E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696784	0.9845766	0.9858951	0.9949677	0.9903536	2.373E+02	3.717E+00
α_2	1.72E-03	8.88E-03	7.56E-03	2.05E-02	4.72E-03	2.139E+00	2.388E+02
α_3	2.99E-04	4.58E-03	3.31E-03	1.32E-02	3.63E-03	1.105E+00	2.399E+02
α_4	5.70E-06	1.96E-03	8.50E-04	7.68E-03	1.30E-03	4.727E-01	2.405E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706843	0.9834298	0.9843653	0.9929671	0.9912660	3.348E+02	5.641E+00
α_2	2.18E-03	8.35E-03	7.40E-03	1.77E-02	3.02E-03	2.841E+00	3.376E+02
α_3	8.79E-04	5.44E-03	4.51E-03	1.32E-02	3.64E-03	1.853E+00	3.386E+02
α_4	4.88E-05	2.20E-03	1.34E-03	7.30E-03	1.56E-03	7.494E-01	3.397E+02
α_5	4.87E-10	5.80E-04	5.80E-05	3.00E-03	5.19E-04	1.973E-01	3.402E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9730454	0.9842990	0.9850783	0.9928839	0.9925351	4.032E+02	6.432E+00
α_2	1.35E-03	5.99E-03	5.21E-03	1.33E-02	7.44E-04	2.454E+00	4.072E+02
α_3	1.28E-03	5.84E-03	5.06E-03	1.31E-02	4.34E-03	2.393E+00	4.072E+02
α_4	1.12E-04	2.36E-03	1.62E-03	7.15E-03	1.30E-03	9.672E-01	4.087E+02
α_5	3.33E-06	1.15E-03	4.98E-04	4.52E-03	8.67E-04	4.722E-01	4.092E+02
α_6	1.82E-12	3.56E-04	1.33E-05	1.97E-03	2.17E-04	1.457E-01	4.095E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735293	0.9835596	0.9841654	0.9915122	0.9934168	5.180E+02	8.658E+00
α_2	1.89E-03	6.32E-03	5.71E-03	1.29E-02	7.20E-04	3.330E+00	5.233E+02
α_3	9.94E-04	4.54E-03	3.93E-03	1.02E-02	2.26E-03	2.389E+00	5.242E+02
α_4	4.62E-04	3.23E-03	2.63E-03	8.06E-03	2.12E-03	1.701E+00	5.249E+02
α_5	4.95E-05	1.58E-03	1.02E-03	5.06E-03	9.30E-04	8.343E-01	5.258E+02
α_6	2.17E-07	6.50E-04	1.94E-04	2.85E-03	4.65E-04	3.425E-01	5.263E+02
α_7	3.03E-25	1.15E-04	1.14E-08	6.43E-04	9.30E-05	6.032E-02	5.266E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748809	0.9840279	0.9845513	0.9913797	0.9940545	6.003E+02	9.743E+00
α_2	1.91E-03	5.97E-03	5.43E-03	1.18E-02	7.66E-04	3.639E+00	6.064E+02
α_3	7.17E-04	3.60E-03	3.07E-03	8.28E-03	1.19E-03	2.196E+00	6.078E+02
α_4	4.95E-04	3.05E-03	2.53E-03	7.39E-03	1.86E-03	1.861E+00	6.081E+02
α_5	1.46E-04	1.94E-03	1.43E-03	5.47E-03	1.23E-03	1.181E+00	6.088E+02
α_6	9.38E-06	9.86E-04	5.20E-04	3.54E-03	6.11E-04	6.013E-01	6.094E+02
α_7	1.08E-09	3.55E-04	4.52E-05	1.79E-03	2.44E-04	2.167E-01	6.098E+02
α_8	1.96E-30	7.99E-05	6.40E-10	4.21E-04	4.07E-05	4.875E-02	6.099E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.88E-01	9.89E-01	9.90E-01	9.91E-01	9.93E-01	9.93E-01	9.94E-01
α_2	1.24E-02	6.75E-03	4.72E-03	3.02E-03	7.44E-04	7.20E-04	7.66E-04
α_3		3.79E-03	3.63E-03	3.64E-03	4.34E-03	2.26E-03	1.19E-03
α_4			1.30E-03	1.56E-03	1.30E-03	2.12E-03	1.86E-03
α_5				5.19E-04	8.67E-04	9.30E-04	1.23E-03
α_6					2.17E-04	4.65E-04	6.11E-04
α_7						9.30E-05	2.44E-04
α_8							4.07E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.89E-01	9.90E-01	9.91E-01	9.93E-01	9.93E-01	9.94E-01
Beta	1.24E-02	1.05E-02	9.65E-03	8.73E-03	7.46E-03	6.58E-03	5.95E-03
Gamma		3.59E-01	5.10E-01	6.54E-01	9.00E-01	8.91E-01	8.71E-01
Delta			2.63E-01	3.64E-01	3.55E-01	6.15E-01	7.70E-01
Epsilon				2.50E-01	4.55E-01	4.12E-01	5.33E-01
Mu					2.00E-01	3.75E-01	4.21E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	95.17	142.76	190.35	237.93	285.52	333.11	380.69
N_1	0.9293	0.9131	0.7766	0.6698	0.7430	0.7972	0.8319

N_2	1.2103	0.9808	0.9114	0.7268	0.2145	0.2419	0.2941
N_3		0.5501	0.7002	0.8755	1.2510	0.7583	0.4571
N_4			0.2500	0.3750	0.3750	0.7125	0.7145
N_5				0.1250	0.2500	0.3125	0.4725
N_6					0.0625	0.1563	0.2344
N_7						0.0313	0.0938
N_8							0.0156

2.3.1.3 MOV FAIL TO CLOSE ALL SYSTEMS

Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 239.3
Total Number of Common-Cause Failure Events: 5

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9762113	0.9921055	0.9945567	0.9996169	0.9952170	1.223E+02	9.729E-01
α_2	3.81E-04	7.89E-03	5.44E-03	2.38E-02	4.78E-03	9.729E-01	1.223E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9707526	0.9864086	0.9880064	0.9966140	0.9904807	1.960E+02	2.700E+00
α_2	2.73E-03	1.22E-02	1.06E-02	2.71E-02	9.47E-03	2.425E+00	1.963E+02
α_3	6.43E-08	1.38E-03	2.91E-04	6.51E-03	4.61E-05	2.750E-01	1.984E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9662827	0.9814515	0.9826214	0.9926157	0.9857789	2.659E+02	5.026E+00
α_2	5.89E-03	1.61E-02	1.50E-02	3.04E-02	1.41E-02	4.371E+00	2.666E+02
α_3	2.69E-06	1.59E-03	6.29E-04	6.44E-03	1.21E-04	4.313E-01	2.705E+02
α_4	3.74E-09	8.25E-04	1.13E-04	4.13E-03	4.48E-06	2.237E-01	2.707E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678702	0.9807520	0.9815928	0.9907508	0.9865809	3.702E+02	7.266E+00
α_2	5.29E-03	1.33E-02	1.25E-02	2.42E-02	1.05E-02	5.023E+00	3.725E+02
α_3	7.31E-04	4.74E-03	3.90E-03	1.16E-02	2.93E-03	1.791E+00	3.757E+02
α_4	7.30E-07	1.01E-03	3.44E-04	4.25E-03	1.94E-05	3.798E-01	3.771E+02
α_5	1.74E-21	1.92E-04	1.10E-07	1.11E-03	6.09E-07	7.245E-02	3.774E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693474	0.9809533	0.9816536	0.9901662	0.9868781	4.451E+02	8.641E+00
α_2	4.62E-03	1.14E-02	1.07E-02	2.07E-02	8.86E-03	5.186E+00	4.485E+02
α_3	1.07E-03	5.08E-03	4.37E-03	1.15E-02	3.50E-03	2.305E+00	4.514E+02
α_4	6.00E-05	1.86E-03	1.20E-03	5.91E-03	7.56E-04	8.436E-01	4.529E+02
α_5	2.18E-09	4.92E-04	6.73E-05	2.46E-03	3.17E-06	2.233E-01	4.535E+02
α_6	3.10E-19	1.83E-04	3.20E-07	1.07E-03	0.00E+00	8.324E-02	4.536E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9705241	0.9807671	0.9813171	0.9891210	0.9879516	5.665E+02	1.111E+01
α_2	4.16E-03	9.80E-03	9.24E-03	1.74E-02	6.65E-03	5.662E+00	5.719E+02

α_3	1.53E-03	5.41E-03	4.85E-03	1.12E-02	3.86E-03	3.126E+00	5.745E+02
α_4	3.07E-04	2.60E-03	2.06E-03	6.77E-03	1.33E-03	1.504E+00	5.761E+02
α_5	9.93E-06	1.04E-03	5.50E-04	3.74E-03	2.06E-04	6.016E-01	5.770E+02
α_6	1.18E-10	3.23E-04	2.76E-05	1.69E-03	5.22E-07	1.865E-01	5.774E+02
α_7	1.76E-48	5.03E-05	4.40E-14	1.89E-04	0.00E+00	2.907E-02	5.776E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9720795	0.9814079	0.9818839	0.9891035	0.9887785	6.555E+02	1.242E+01
α_2	3.59E-03	8.47E-03	7.98E-03	1.50E-02	5.23E-03	5.656E+00	6.622E+02
α_3	1.53E-03	5.07E-03	4.58E-03	1.03E-02	3.73E-03	3.384E+00	6.645E+02
α_4	4.77E-04	2.85E-03	2.37E-03	6.86E-03	1.72E-03	1.906E+00	6.660E+02
α_5	5.75E-05	1.38E-03	9.27E-04	4.25E-03	4.85E-04	9.225E-01	6.670E+02
α_6	5.39E-07	5.88E-04	2.09E-04	2.46E-03	5.85E-05	3.928E-01	6.675E+02
α_7	2.43E-14	1.84E-04	3.31E-06	1.05E-03	0.00E+00	1.230E-01	6.678E+02
α_8	4.56E-43	4.96E-05	7.06E-13	2.09E-04	0.00E+00	3.312E-02	6.679E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.95E-01	9.90E-01	9.86E-01	9.87E-01	9.87E-01	9.88E-01	9.89E-01
α_2	4.78E-03	9.47E-03	1.41E-02	1.05E-02	8.86E-03	6.65E-03	5.23E-03
α_3		4.61E-05	1.21E-04	2.93E-03	3.50E-03	3.86E-03	3.73E-03
α_4			4.48E-06	1.94E-05	7.56E-04	1.33E-03	1.72E-03
α_5				6.09E-07	3.17E-06	2.06E-04	4.85E-04
α_6					0.00E+00	5.22E-07	5.85E-05
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.90E-01	9.86E-01	9.87E-01	9.87E-01	9.88E-01	9.89E-01
Beta	4.78E-03	9.52E-03	1.42E-02	1.34E-02	1.31E-02	1.20E-02	1.12E-02
Gamma		4.85E-03	8.83E-03	2.20E-01	3.25E-01	4.48E-01	5.34E-01
Delta			3.57E-02	6.80E-03	1.78E-01	2.85E-01	3.78E-01
Epsilon				3.04E-02	4.18E-03	1.35E-01	2.40E-01
Mu					0.00E+00	2.53E-03	1.08E-01
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	108.77	163.16	217.55	271.93	326.32	380.70	435.09
N_1	3.2400	3.2683	2.2623	2.1320	1.7964	1.7442	1.6590
N_2	0.5383	1.5918	3.1430	2.9086	2.9469	2.5746	2.3115
N_3		0.0078	0.0270	0.8136	1.1634	1.4947	1.6461
N_4			0.0010	0.0054	0.2514	0.5147	0.7591
N_5				0.0002	0.0011	0.0798	0.2141
N_6					0.0000	0.0002	0.0258
N_7						0.0000	0.0000
N_8							0.0000

2.3.1.4 MOV SPURIOUS OPERATION ALL SYSTEMS

Components/Valve/Motor Operated Valve
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 43.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8993424	0.9707959	0.9833090	0.9996036	0.9814241	2.157E+01	6.488E-01
α_2	3.94E-04	2.92E-02	1.67E-02	1.01E-01	1.86E-02	6.488E-01	2.157E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9158139	0.9664452	0.9727358	0.9955181	0.9706806	4.611E+01	1.601E+00
α_2	2.33E-03	2.65E-02	2.02E-02	7.21E-02	2.51E-02	1.262E+00	4.645E+01
α_3	2.19E-06	7.10E-03	2.11E-03	3.12E-02	4.19E-03	3.386E-01	4.737E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9202233	0.9629350	0.9672376	0.9909334	0.9663278	6.786E+01	2.612E+00
α_2	3.72E-03	2.47E-02	2.04E-02	6.06E-02	2.29E-02	1.742E+00	6.873E+01
α_3	1.07E-04	8.98E-03	4.95E-03	3.16E-02	1.02E-02	6.329E-01	6.984E+01
α_4	3.10E-08	3.36E-03	5.29E-04	1.65E-02	6.35E-04	2.370E-01	7.024E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9348204	0.9649865	0.9673902	0.9869261	0.9666880	1.231E+02	4.467E+00
α_2	4.70E-03	1.99E-02	1.75E-02	4.35E-02	1.54E-02	2.543E+00	1.250E+02
α_3	1.17E-03	1.10E-02	8.59E-03	2.92E-02	1.54E-02	1.406E+00	1.262E+02
α_4	7.25E-06	3.49E-03	1.43E-03	1.40E-02	2.56E-03	4.458E-01	1.271E+02
α_5	4.67E-21	5.67E-04	3.20E-07	3.28E-03	0.00E+00	7.228E-02	1.275E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9389257	0.9658270	0.9678175	0.9859222	0.9699248	1.492E+02	5.279E+00
α_2	3.60E-03	1.59E-02	1.38E-02	3.51E-02	6.44E-03	2.453E+00	1.520E+02
α_3	1.61E-03	1.11E-02	9.06E-03	2.75E-02	1.72E-02	1.713E+00	1.528E+02
α_4	1.47E-04	5.22E-03	3.30E-03	1.68E-02	6.44E-03	8.065E-01	1.537E+02
α_5	6.01E-09	1.44E-03	1.95E-04	7.21E-03	0.00E+00	2.222E-01	1.542E+02
α_6	9.12E-19	5.39E-04	9.42E-07	3.14E-03	0.00E+00	8.324E-02	1.544E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9462428	0.9675061	0.9688612	0.9841555	0.9741100	2.217E+02	7.445E+00
α_2	3.79E-03	1.35E-02	1.21E-02	2.79E-02	0.00E+00	3.088E+00	2.260E+02
α_3	1.80E-03	9.30E-03	7.92E-03	2.15E-02	1.29E-02	2.131E+00	2.270E+02
α_4	7.57E-04	6.50E-03	5.13E-03	1.69E-02	1.29E-02	1.489E+00	2.276E+02
α_5	1.12E-05	2.28E-03	1.08E-03	8.61E-03	0.00E+00	5.218E-01	2.286E+02
α_6	2.93E-10	8.13E-04	6.94E-05	4.27E-03	0.00E+00	1.863E-01	2.289E+02
α_7	4.44E-48	1.27E-04	1.11E-13	4.78E-04	0.00E+00	2.907E-02	2.291E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9495438	0.9686852	0.9698388	0.9839038	0.9772727	2.617E+02	8.461E+00
α_2	3.72E-03	1.24E-02	1.12E-02	2.51E-02	0.00E+00	3.345E+00	2.668E+02
α_3	9.51E-04	6.43E-03	5.26E-03	1.59E-02	0.00E+00	1.738E+00	2.685E+02
α_4	1.55E-03	7.94E-03	6.77E-03	1.84E-02	2.27E-02	2.147E+00	2.680E+02
α_5	4.77E-05	2.62E-03	1.54E-03	8.87E-03	0.00E+00	7.083E-01	2.695E+02
α_6	7.68E-07	1.36E-03	4.45E-04	5.81E-03	0.00E+00	3.670E-01	2.698E+02
α_7	6.03E-14	4.55E-04	8.18E-06	2.59E-03	0.00E+00	1.230E-01	2.701E+02
α_8	1.13E-42	1.23E-04	1.75E-12	5.18E-04	0.00E+00	3.312E-02	2.702E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.81E-01	9.71E-01	9.66E-01	9.67E-01	9.70E-01	9.74E-01	9.77E-01
α_2	1.86E-02	2.51E-02	2.29E-02	1.54E-02	6.44E-03	0.00E+00	0.00E+00
α_3		4.19E-03	1.02E-02	1.54E-02	1.72E-02	1.29E-02	0.00E+00
α_4			6.35E-04	2.56E-03	6.44E-03	1.29E-02	2.27E-02
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.71E-01	9.66E-01	9.67E-01	9.70E-01	9.74E-01	9.77E-01
Beta	1.86E-02	2.93E-02	3.37E-02	3.33E-02	3.01E-02	2.59E-02	2.27E-02
Gamma		1.43E-01	3.21E-01	5.38E-01	7.86E-01	1.00E+00	1.00E+00
Delta			5.88E-02	1.43E-01	2.73E-01	5.00E-01	1.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	10.75	16.13	21.50	26.88	32.25	37.63	43.00
N_1	0.5714	0.4286	0.2286	0.0714	0.0000	0.0000	0.0000
N_2	0.2143	0.4286	0.5143	0.4286	0.2143	0.0000	0.0000

N_3		0.0714	0.2286	0.4286	0.5714	0.5000	0.0000
N_4			0.0143	0.0714	0.2143	0.5000	1.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.1.5 MOV FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS

Components/Valve/Motor Operated Valve
Failure Modes/Leak (Internal)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 67.1
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8943569	0.9613198	0.9705301	0.9967252	0.9623304	3.062E+01	1.232E+00
α_2	3.28E-03	3.87E-02	2.95E-02	1.06E-01	3.77E-02	1.232E+00	3.062E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9043648	0.9545014	0.9593518	0.9880450	0.9449907	5.876E+01	2.801E+00
α_2	7.20E-03	3.55E-02	3.06E-02	8.07E-02	4.38E-02	2.188E+00	5.937E+01
α_3	1.04E-04	9.96E-03	5.38E-03	3.54E-02	1.12E-02	6.134E-01	6.095E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9081957	0.9507680	0.9541417	0.9818098	0.9381949	8.401E+01	4.350E+00
α_2	8.36E-03	3.19E-02	2.84E-02	6.73E-02	3.94E-02	2.819E+00	8.555E+01
α_3	9.32E-04	1.30E-02	9.56E-03	3.69E-02	1.84E-02	1.149E+00	8.722E+01
α_4	3.33E-06	4.33E-03	1.50E-03	1.82E-02	3.96E-03	3.826E-01	8.798E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9243674	0.9551666	0.9571891	0.9790608	0.9364133	1.427E+02	6.697E+00
α_2	8.37E-03	2.53E-02	2.32E-02	4.93E-02	3.34E-02	3.773E+00	1.456E+02
α_3	2.32E-03	1.32E-02	1.11E-02	3.12E-02	2.00E-02	1.970E+00	1.474E+02
α_4	1.55E-04	5.42E-03	3.43E-03	1.75E-02	8.75E-03	8.093E-01	1.486E+02
α_5	4.67E-12	9.72E-04	3.59E-05	5.39E-03	1.47E-03	1.453E-01	1.492E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9277760	0.9555287	0.9572104	0.9775440	0.9366367	1.721E+02	8.009E+00
α_2	7.51E-03	2.19E-02	2.02E-02	4.24E-02	2.91E-02	3.953E+00	1.761E+02
α_3	2.39E-03	1.21E-02	1.03E-02	2.78E-02	1.75E-02	2.175E+00	1.779E+02
α_4	6.69E-04	7.25E-03	5.53E-03	1.97E-02	1.21E-02	1.306E+00	1.788E+02
α_5	6.24E-06	2.55E-03	1.07E-03	1.01E-02	4.02E-03	4.587E-01	1.796E+02
α_6	2.50E-14	6.49E-04	9.09E-06	3.72E-03	5.70E-04	1.168E-01	1.800E+02

CCCG = 7

MOV FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9383405	0.9601382	0.9613226	0.9779002	0.9432574	2.482E+02	1.031E+01
α_2	6.11E-03	1.68E-02	1.56E-02	3.17E-02	1.85E-02	4.344E+00	2.542E+02
α_3	2.66E-03	1.06E-02	9.35E-03	2.27E-02	1.62E-02	2.735E+00	2.558E+02
α_4	1.22E-03	7.32E-03	6.10E-03	1.76E-02	1.33E-02	1.893E+00	2.566E+02
α_5	1.84E-04	3.78E-03	2.61E-03	1.14E-02	6.71E-03	9.784E-01	2.576E+02
α_6	1.73E-07	1.20E-03	3.09E-04	5.43E-03	1.82E-03	3.099E-01	2.582E+02
α_7	2.71E-32	1.74E-04	4.59E-10	8.88E-04	2.34E-04	4.499E-02	2.585E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9429775	0.9624622	0.9634727	0.9784903	0.9491224	2.920E+02	1.139E+01
α_2	5.02E-03	1.40E-02	1.30E-02	2.66E-02	1.18E-02	4.252E+00	2.991E+02
α_3	2.28E-03	9.03E-03	7.98E-03	1.94E-02	1.30E-02	2.741E+00	3.006E+02
α_4	1.37E-03	7.06E-03	6.01E-03	1.63E-02	1.29E-02	2.141E+00	3.012E+02
α_5	4.74E-04	4.58E-03	3.55E-03	1.22E-02	8.84E-03	1.391E+00	3.020E+02
α_6	2.50E-05	2.09E-03	1.15E-03	7.37E-03	3.47E-03	6.347E-01	3.027E+02
α_7	2.52E-10	6.19E-04	5.41E-05	3.24E-03	8.40E-04	1.878E-01	3.032E+02
α_8	3.17E-35	1.35E-04	8.49E-11	6.57E-04	1.01E-04	4.094E-02	3.033E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.62E-01	9.45E-01	9.38E-01	9.36E-01	9.37E-01	9.43E-01	9.49E-01
α_2	3.77E-02	4.38E-02	3.94E-02	3.34E-02	2.91E-02	1.85E-02	1.18E-02
α_3		1.12E-02	1.84E-02	2.00E-02	1.75E-02	1.62E-02	1.30E-02
α_4			3.96E-03	8.75E-03	1.21E-02	1.33E-02	1.29E-02
α_5				1.47E-03	4.02E-03	6.71E-03	8.84E-03
α_6					5.70E-04	1.82E-03	3.47E-03
α_7						2.34E-04	8.40E-04
α_8							1.01E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.62E-01	9.45E-01	9.38E-01	9.36E-01	9.37E-01	9.43E-01	9.49E-01
Beta	3.77E-02	5.50E-02	6.18E-02	6.36E-02	6.34E-02	5.67E-02	5.09E-02
Gamma		2.04E-01	3.63E-01	4.75E-01	5.41E-01	6.74E-01	7.69E-01
Delta			1.77E-01	3.39E-01	4.88E-01	5.76E-01	6.68E-01
Epsilon				1.44E-01	2.75E-01	3.97E-01	5.07E-01
Mu					1.24E-01	2.34E-01	3.33E-01
Omega						1.14E-01	2.13E-01
Sigma							1.08E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	18.30	27.45	36.60	45.75	54.90	64.05	73.20
N_1	2.0718	1.7538	1.2781	0.7682	0.2365	0.1237	0.0648

N_2	0.7974	1.3538	1.5906	1.6588	1.7135	1.2566	0.9077
N_3		0.3462	0.7448	0.9921	1.0329	1.1038	1.0023
N_4			0.1600	0.4349	0.7135	0.9038	0.9948
N_5				0.0730	0.2365	0.4566	0.6823
N_6					0.0336	0.1237	0.2677
N_7						0.0159	0.0648
N_8							0.0078

2.3.2 PWR Containment Spray Motor Operated Valves

2.3.2.1 CONTAINMENT SPRAY MOV FAIL TO OPEN/CLOSE

Systems/Clean Water/Containment spray recirculation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 38.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9640878	0.9910740	0.9964093	0.9999823	1.0000000	4.825E+01	4.345E-01
α_2	1.60E-05	8.93E-03	3.59E-03	3.59E-02	0.00E+00	4.345E-01	4.825E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9539313	0.9839652	0.9883632	0.9989493	1.0000000	6.756E+01	1.101E+00
α_2	3.83E-04	1.21E-02	7.84E-03	3.86E-02	0.00E+00	8.337E-01	6.782E+01
α_3	1.36E-07	3.89E-03	7.81E-04	1.85E-02	0.00E+00	2.672E-01	6.839E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9480949	0.9784271	0.9820200	0.9964753	1.0000000	8.414E+01	1.855E+00
α_2	1.18E-03	1.43E-02	1.07E-02	3.95E-02	0.00E+00	1.228E+00	8.476E+01
α_3	5.28E-06	4.70E-03	1.74E-03	1.94E-02	0.00E+00	4.043E-01	8.559E+01
α_4	1.11E-08	2.59E-03	3.54E-04	1.30E-02	0.00E+00	2.227E-01	8.577E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9489954	0.9743045	0.9765703	0.9918786	1.0000000	1.342E+02	3.538E+00
α_2	2.95E-03	1.54E-02	1.31E-02	3.56E-02	0.00E+00	2.114E+00	1.356E+02
α_3	3.46E-04	7.10E-03	4.90E-03	2.14E-02	0.00E+00	9.774E-01	1.367E+02
α_4	1.79E-06	2.72E-03	9.15E-04	1.15E-02	0.00E+00	3.744E-01	1.373E+02
α_5	4.33E-21	5.25E-04	2.97E-07	3.04E-03	0.00E+00	7.228E-02	1.376E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9492876	0.9731272	0.9750877	0.9902746	1.0000000	1.549E+02	4.279E+00
α_2	2.89E-03	1.41E-02	1.21E-02	3.20E-02	0.00E+00	2.239E+00	1.570E+02
α_3	5.04E-04	7.17E-03	5.24E-03	2.04E-02	0.00E+00	1.142E+00	1.581E+02
α_4	3.32E-05	3.72E-03	1.95E-03	1.34E-02	0.00E+00	5.922E-01	1.586E+02
α_5	5.83E-09	1.40E-03	1.89E-04	6.99E-03	0.00E+00	2.222E-01	1.590E+02
α_6	8.85E-19	5.23E-04	9.14E-07	3.05E-03	0.00E+00	8.324E-02	1.591E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	38.00	38.00	38.00	38.00	38.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.2.2 CONTAINMENT SPRAY MOV FAIL TO OPEN

Systems/Clean Water/Containment spray recirculation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 24.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496646	0.9874708	0.9949278	0.9999752	1.0000000	3.425E+01	4.345E-01
α_2	2.26E-05	1.25E-02	5.07E-03	5.03E-02	0.00E+00	4.345E-01	3.425E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9422547	0.9798580	0.9853518	0.9986753	1.0000000	5.356E+01	1.101E+00
α_2	4.82E-04	1.53E-02	9.88E-03	4.84E-02	0.00E+00	8.337E-01	5.382E+01
α_3	1.71E-07	4.89E-03	9.84E-04	2.32E-02	0.00E+00	2.672E-01	5.439E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9381214	0.9742318	0.9784904	0.9957719	1.0000000	7.014E+01	1.855E+00
α_2	1.41E-03	1.71E-02	1.28E-02	4.72E-02	0.00E+00	1.228E+00	7.076E+01
α_3	6.32E-06	5.62E-03	2.08E-03	2.32E-02	0.00E+00	4.043E-01	7.159E+01
α_4	1.33E-08	3.09E-03	4.23E-04	1.55E-02	0.00E+00	2.227E-01	7.177E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432838	0.9713964	0.9739034	0.9909412	1.0000000	1.202E+02	3.538E+00
α_2	3.29E-03	1.71E-02	1.46E-02	3.95E-02	0.00E+00	2.114E+00	1.216E+02
α_3	3.86E-04	7.90E-03	5.46E-03	2.38E-02	0.00E+00	9.774E-01	1.227E+02
α_4	1.99E-06	3.03E-03	1.02E-03	1.29E-02	0.00E+00	3.744E-01	1.233E+02
α_5	4.82E-21	5.84E-04	3.30E-07	3.38E-03	0.00E+00	7.228E-02	1.236E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444490	0.9705365	0.9726742	0.9893246	1.0000000	1.409E+02	4.279E+00
α_2	3.17E-03	1.54E-02	1.33E-02	3.51E-02	0.00E+00	2.239E+00	1.430E+02
α_3	5.53E-04	7.86E-03	5.75E-03	2.24E-02	0.00E+00	1.142E+00	1.441E+02
α_4	3.64E-05	4.08E-03	2.14E-03	1.47E-02	0.00E+00	5.922E-01	1.446E+02
α_5	6.39E-09	1.53E-03	2.07E-04	7.67E-03	0.00E+00	2.222E-01	1.450E+02
α_6	9.71E-19	5.73E-04	1.00E-06	3.34E-03	0.00E+00	8.324E-02	1.451E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	24.00	24.00	24.00	24.00	24.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.2.3 CONTAINMENT SPRAY MOV FAIL TO CLOSE

Systems/Clean Water/Containment spray recirculation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 14.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9294222	0.9823942	0.9928249	0.9999651	1.0000000	2.425E+01	4.345E-01
α_2	3.20E-05	1.76E-02	7.18E-03	7.06E-02	0.00E+00	4.345E-01	2.425E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9294879	0.9753475	0.9820226	0.9983719	1.0000000	4.356E+01	1.101E+00
α_2	5.92E-04	1.87E-02	1.21E-02	5.91E-02	0.00E+00	8.337E-01	4.382E+01
α_3	2.10E-07	5.98E-03	1.21E-03	2.84E-02	0.00E+00	2.672E-01	4.439E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9282813	0.9700750	0.9749825	0.9950758	1.0000000	6.014E+01	1.855E+00
α_2	1.64E-03	1.98E-02	1.49E-02	5.47E-02	0.00E+00	1.228E+00	6.076E+01
α_3	7.35E-06	6.52E-03	2.42E-03	2.69E-02	0.00E+00	4.043E-01	6.159E+01
α_4	1.55E-08	3.59E-03	4.92E-04	1.80E-02	0.00E+00	2.227E-01	6.177E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9383532	0.9688806	0.9715895	0.9901321	1.0000000	1.102E+02	3.538E+00
α_2	3.58E-03	1.86E-02	1.59E-02	4.30E-02	0.00E+00	2.114E+00	1.116E+02
α_3	4.20E-04	8.60E-03	5.94E-03	2.58E-02	0.00E+00	9.774E-01	1.127E+02
α_4	2.16E-06	3.29E-03	1.11E-03	1.40E-02	0.00E+00	3.744E-01	1.133E+02
α_5	5.25E-21	6.36E-04	3.59E-07	3.68E-03	0.00E+00	7.228E-02	1.136E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9403807	0.9683575	0.9706389	0.9885240	1.0000000	1.309E+02	4.279E+00
α_2	3.40E-03	1.66E-02	1.42E-02	3.77E-02	0.00E+00	2.239E+00	1.330E+02
α_3	5.94E-04	8.44E-03	6.18E-03	2.40E-02	0.00E+00	1.142E+00	1.341E+02
α_4	3.92E-05	4.38E-03	2.29E-03	1.58E-02	0.00E+00	5.922E-01	1.346E+02
α_5	6.87E-09	1.64E-03	2.23E-04	8.23E-03	0.00E+00	2.222E-01	1.350E+02
α_6	1.04E-18	6.16E-04	1.08E-06	3.59E-03	0.00E+00	8.324E-02	1.351E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	14.00	14.00	14.00	14.00	14.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.3 BWR Residual Heat Removal Motor-Operated Valves

2.3.3.1 BWR RHR MOV FAIL TO OPEN/CLOSE

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 143.0
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9637549	0.9859368	0.9888052	0.9982981	0.9888603	1.064E+02	1.518E+00
α_2	1.70E-03	1.41E-02	1.12E-02	3.62E-02	1.11E-02	1.518E+00	1.064E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700245	0.9866356	0.9884285	0.9971100	0.9913941	1.736E+02	2.351E+00
α_2	1.16E-03	9.00E-03	7.22E-03	2.29E-02	5.16E-03	1.584E+00	1.743E+02
α_3	1.05E-04	4.36E-03	2.68E-03	1.43E-02	3.44E-03	7.672E-01	1.751E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9718605	0.9860876	0.9874106	0.9958064	0.9922347	2.378E+02	3.355E+00
α_2	1.45E-03	8.20E-03	6.89E-03	1.95E-02	3.88E-03	1.978E+00	2.392E+02
α_3	1.48E-04	3.75E-03	2.50E-03	1.16E-02	2.59E-03	9.043E-01	2.403E+02
α_4	5.69E-06	1.96E-03	8.49E-04	7.68E-03	1.29E-03	4.727E-01	2.407E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724393	0.9847247	0.9856611	0.9938048	0.9930856	3.355E+02	5.205E+00
α_2	2.15E-03	8.28E-03	7.34E-03	1.76E-02	2.94E-03	2.823E+00	3.379E+02
α_3	4.60E-04	4.21E-03	3.29E-03	1.11E-02	1.90E-03	1.436E+00	3.393E+02
α_4	4.87E-05	2.20E-03	1.33E-03	7.30E-03	1.56E-03	7.494E-01	3.400E+02
α_5	4.87E-10	5.79E-04	5.80E-05	2.99E-03	5.19E-04	1.973E-01	3.405E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740871	0.9850794	0.9858588	0.9933991	0.9936297	4.040E+02	6.119E+00
α_2	1.95E-03	7.22E-03	6.44E-03	1.52E-02	2.50E-03	2.961E+00	4.071E+02
α_3	4.76E-04	3.80E-03	3.03E-03	9.76E-03	1.44E-03	1.558E+00	4.085E+02
α_4	1.17E-04	2.39E-03	1.65E-03	7.21E-03	1.35E-03	9.811E-01	4.091E+02
α_5	3.32E-06	1.15E-03	4.98E-04	4.51E-03	8.65E-04	4.722E-01	4.096E+02
α_6	1.81E-12	3.55E-04	1.32E-05	1.97E-03	2.16E-04	1.457E-01	4.100E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740402	0.9839547	0.9845603	0.9917928	0.9940186	5.187E+02	8.459E+00
α_2	2.43E-03	7.29E-03	6.68E-03	1.42E-02	2.24E-03	3.842E+00	5.233E+02
α_3	7.04E-04	3.86E-03	3.26E-03	9.09E-03	1.20E-03	2.036E+00	5.252E+02
α_4	2.46E-04	2.54E-03	1.95E-03	6.87E-03	1.05E-03	1.341E+00	5.258E+02
α_5	5.00E-05	1.59E-03	1.02E-03	5.06E-03	9.35E-04	8.366E-01	5.264E+02
α_6	2.16E-07	6.50E-04	1.94E-04	2.85E-03	4.64E-04	3.425E-01	5.268E+02
α_7	3.02E-25	1.14E-04	1.14E-08	6.42E-04	9.28E-05	6.032E-02	5.271E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751179	0.9842081	0.9847311	0.9915089	0.9943230	6.010E+02	9.644E+00
α_2	2.37E-03	6.77E-03	6.24E-03	1.30E-02	2.05E-03	4.132E+00	6.065E+02
α_3	6.92E-04	3.54E-03	3.01E-03	8.18E-03	1.10E-03	2.160E+00	6.085E+02
α_4	2.66E-04	2.38E-03	1.87E-03	6.26E-03	8.03E-04	1.455E+00	6.092E+02
α_5	9.30E-05	1.69E-03	1.18E-03	4.99E-03	8.35E-04	1.029E+00	6.096E+02
α_6	9.40E-06	9.85E-04	5.20E-04	3.54E-03	6.11E-04	6.017E-01	6.101E+02
α_7	1.07E-09	3.55E-04	4.52E-05	1.79E-03	2.44E-04	2.167E-01	6.105E+02
α_8	1.96E-30	7.98E-05	6.39E-10	4.21E-04	4.06E-05	4.875E-02	6.106E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.89E-01	9.91E-01	9.92E-01	9.93E-01	9.94E-01	9.94E-01	9.94E-01
α_2	1.11E-02	5.16E-03	3.88E-03	2.94E-03	2.50E-03	2.24E-03	2.05E-03
α_3		3.44E-03	2.59E-03	1.90E-03	1.44E-03	1.20E-03	1.10E-03
α_4			1.29E-03	1.56E-03	1.35E-03	1.05E-03	8.03E-04
α_5				5.19E-04	8.65E-04	9.35E-04	8.35E-04
α_6					2.16E-04	4.64E-04	6.11E-04
α_7						9.28E-05	2.44E-04
α_8							4.06E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.91E-01	9.92E-01	9.93E-01	9.94E-01	9.94E-01	9.94E-01
Beta	1.11E-02	8.61E-03	7.77E-03	6.91E-03	6.37E-03	5.98E-03	5.68E-03
Gamma		4.00E-01	5.00E-01	5.75E-01	6.08E-01	6.25E-01	6.39E-01
Delta			3.33E-01	5.22E-01	6.27E-01	6.78E-01	6.98E-01
Epsilon				2.50E-01	4.46E-01	5.88E-01	6.83E-01
Mu					2.00E-01	3.73E-01	5.17E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	95.33	143.00	190.67	238.33	286.00	333.67	381.33
N_1	0.8333	1.0000	1.0000	1.0417	1.0417	1.0127	0.9645
N_2	1.0833	0.7500	0.7500	0.7083	0.7222	0.7546	0.7872

N_3		0.5000	0.5000	0.4583	0.4167	0.4051	0.4217
N_4			0.2500	0.3750	0.3889	0.3519	0.3086
N_5				0.1250	0.2500	0.3148	0.3210
N_6					0.0625	0.1563	0.2348
N_7						0.0313	0.0938
N_8							0.0156

2.3.3.2 BWR RHR MOV FAIL TO OPEN

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 87.2
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9619062	0.9854924	0.9886110	0.9984063	0.9886621	9.745E+01	1.435E+00
α_2	1.60E-03	1.45E-02	1.14E-02	3.81E-02	1.13E-02	1.435E+00	9.745E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9699691	0.9870680	0.9890046	0.9975404	0.9924127	1.604E+02	2.101E+00
α_2	7.89E-04	8.21E-03	6.30E-03	2.22E-02	3.79E-03	1.334E+00	1.611E+02
α_3	1.14E-04	4.72E-03	2.91E-03	1.55E-02	3.79E-03	7.672E-01	1.617E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9729255	0.9872194	0.9886396	0.9966466	0.9942987	2.205E+02	2.855E+00
α_2	7.61E-04	6.62E-03	5.21E-03	1.73E-02	1.43E-03	1.478E+00	2.219E+02
α_3	1.60E-04	4.05E-03	2.70E-03	1.25E-02	2.85E-03	9.043E-01	2.225E+02
α_4	6.15E-06	2.12E-03	9.17E-04	8.28E-03	1.43E-03	4.727E-01	2.229E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734157	0.9857601	0.9867620	0.9946753	0.9954338	3.142E+02	4.538E+00
α_2	1.44E-03	7.03E-03	6.02E-03	1.60E-02	5.71E-04	2.239E+00	3.165E+02
α_3	4.17E-04	4.24E-03	3.26E-03	1.14E-02	1.71E-03	1.352E+00	3.173E+02
α_4	5.21E-05	2.35E-03	1.43E-03	7.80E-03	1.71E-03	7.494E-01	3.179E+02
α_5	5.20E-10	6.19E-04	6.20E-05	3.20E-03	5.71E-04	1.973E-01	3.185E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752588	0.9862470	0.9870810	0.9943767	0.9961919	3.785E+02	5.279E+00
α_2	1.26E-03	6.00E-03	5.16E-03	1.36E-02	2.38E-04	2.302E+00	3.815E+02
α_3	3.75E-04	3.63E-03	2.81E-03	9.67E-03	9.52E-04	1.392E+00	3.824E+02
α_4	1.19E-04	2.52E-03	1.73E-03	7.63E-03	1.43E-03	9.672E-01	3.829E+02
α_5	3.55E-06	1.23E-03	5.32E-04	4.82E-03	9.52E-04	4.722E-01	3.833E+02
α_6	1.94E-12	3.80E-04	1.42E-05	2.10E-03	2.38E-04	1.457E-01	3.837E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750861	0.9850109	0.9856549	0.9927301	0.9967342	4.892E+02	7.445E+00
α_2	1.78E-03	6.28E-03	5.63E-03	1.30E-02	1.02E-04	3.119E+00	4.936E+02
α_3	5.52E-04	3.60E-03	2.96E-03	8.83E-03	5.10E-04	1.787E+00	4.949E+02
α_4	2.39E-04	2.62E-03	1.99E-03	7.15E-03	1.02E-03	1.301E+00	4.954E+02
α_5	5.24E-05	1.68E-03	1.08E-03	5.36E-03	1.02E-03	8.343E-01	4.959E+02
α_6	2.30E-07	6.90E-04	2.06E-04	3.02E-03	5.10E-04	3.425E-01	4.964E+02
α_7	3.21E-25	1.21E-04	1.21E-08	6.82E-04	1.02E-04	6.032E-02	4.966E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9762306	0.9853106	0.9858663	0.9924850	0.9971412	5.675E+02	8.461E+00
α_2	1.75E-03	5.83E-03	5.27E-03	1.18E-02	4.47E-05	3.360E+00	5.726E+02
α_3	5.05E-04	3.18E-03	2.63E-03	7.75E-03	2.68E-04	1.832E+00	5.742E+02
α_4	2.44E-04	2.40E-03	1.85E-03	6.41E-03	6.70E-04	1.381E+00	5.746E+02
α_5	9.58E-05	1.77E-03	1.24E-03	5.27E-03	8.93E-04	1.021E+00	5.750E+02
α_6	9.93E-06	1.04E-03	5.51E-04	3.75E-03	6.70E-04	6.013E-01	5.754E+02
α_7	1.14E-09	3.76E-04	4.79E-05	1.90E-03	2.68E-04	2.167E-01	5.758E+02
α_8	2.08E-30	8.46E-05	6.78E-10	4.46E-04	4.47E-05	4.875E-02	5.759E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.89E-01	9.92E-01	9.94E-01	9.95E-01	9.96E-01	9.97E-01	9.97E-01
α_2	1.13E-02	3.79E-03	1.43E-03	5.71E-04	2.38E-04	1.02E-04	4.47E-05
α_3		3.79E-03	2.85E-03	1.71E-03	9.52E-04	5.10E-04	2.68E-04
α_4			1.43E-03	1.71E-03	1.43E-03	1.02E-03	6.70E-04
α_5				5.71E-04	9.52E-04	1.02E-03	8.93E-04
α_6					2.38E-04	5.10E-04	6.70E-04
α_7						1.02E-04	2.68E-04
α_8							4.47E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.92E-01	9.94E-01	9.95E-01	9.96E-01	9.97E-01	9.97E-01
Beta	1.13E-02	7.59E-03	5.70E-03	4.57E-03	3.81E-03	3.27E-03	2.86E-03
Gamma		5.00E-01	7.50E-01	8.75E-01	9.38E-01	9.69E-01	9.84E-01
Delta			3.33E-01	5.71E-01	7.33E-01	8.39E-01	9.05E-01
Epsilon				2.50E-01	4.55E-01	6.15E-01	7.37E-01
Mu					2.00E-01	3.75E-01	5.24E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	87.20	130.80	174.40	218.00	261.60	305.20	348.80
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.5000	0.2500	0.1250	0.0625	0.0313	0.0156

N_3		0.5000	0.5000	0.3750	0.2500	0.1563	0.0938
N_4			0.2500	0.3750	0.3750	0.3125	0.2344
N_5				0.1250	0.2500	0.3125	0.3125
N_6					0.0625	0.1563	0.2344
N_7						0.0313	0.0938
N_8							0.0156

2.3.3.3 BWR RHR MOV FAIL TO CLOSE

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 52.8
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9486111	0.9863713	0.9935017	0.9999322	0.9969494	3.748E+01	5.179E-01
α_2	6.56E-05	1.36E-02	6.50E-03	5.14E-02	3.05E-03	5.179E-01	3.748E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9494889	0.9811081	0.9853791	0.9981221	0.9938800	7.015E+01	1.351E+00
α_2	9.56E-04	1.52E-02	1.09E-02	4.38E-02	6.12E-03	1.084E+00	7.042E+01
α_3	1.30E-07	3.74E-03	7.50E-04	1.77E-02	0.00E+00	2.672E-01	7.124E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9485922	0.9769767	0.9800142	0.9949809	0.9907919	9.994E+01	2.355E+00
α_2	2.50E-03	1.69E-02	1.39E-02	4.17E-02	9.21E-03	1.728E+00	1.006E+02
α_3	4.43E-06	3.95E-03	1.46E-03	1.63E-02	0.00E+00	4.043E-01	1.019E+02
α_4	9.36E-09	2.18E-03	2.97E-04	1.09E-02	0.00E+00	2.227E-01	1.021E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9523586	0.9748822	0.9767534	0.9910205	0.9901538	1.632E+02	4.205E+00
α_2	4.02E-03	1.61E-02	1.42E-02	3.47E-02	8.62E-03	2.698E+00	1.647E+02
α_3	3.77E-04	6.34E-03	4.51E-03	1.85E-02	1.23E-03	1.061E+00	1.663E+02
α_4	1.47E-06	2.24E-03	7.52E-04	9.50E-03	0.00E+00	3.744E-01	1.670E+02
α_5	3.56E-21	4.32E-04	2.44E-07	2.50E-03	0.00E+00	7.228E-02	1.673E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9543081	0.9746964	0.9762483	0.9897922	0.9896367	1.972E+02	5.119E+00
α_2	3.82E-03	1.43E-02	1.28E-02	3.02E-02	8.14E-03	2.899E+00	1.994E+02
α_3	5.99E-04	6.47E-03	4.93E-03	1.76E-02	2.06E-03	1.308E+00	2.010E+02
α_4	2.96E-05	3.00E-03	1.59E-03	1.07E-02	1.71E-04	6.061E-01	2.017E+02
α_5	4.58E-09	1.10E-03	1.49E-04	5.50E-03	0.00E+00	2.222E-01	2.021E+02
α_6	6.96E-19	4.11E-04	7.19E-07	2.40E-03	0.00E+00	8.324E-02	2.022E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9566333	0.9738213	0.9749248	0.9872519	0.9892627	2.775E+02	7.459E+00
α_2	4.44E-03	1.34E-02	1.23E-02	2.61E-02	7.66E-03	3.811E+00	2.811E+02
α_3	1.09E-03	6.60E-03	5.49E-03	1.59E-02	2.64E-03	1.880E+00	2.830E+02
α_4	1.99E-04	3.61E-03	2.53E-03	1.07E-02	4.17E-04	1.028E+00	2.839E+02
α_5	9.24E-06	1.84E-03	8.73E-04	6.94E-03	2.45E-05	5.241E-01	2.844E+02
α_6	2.36E-10	6.54E-04	5.58E-05	3.43E-03	0.00E+00	1.863E-01	2.847E+02
α_7	3.57E-48	1.02E-04	8.93E-14	3.84E-04	0.00E+00	2.907E-02	2.849E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9584163	0.9741160	0.9750591	0.9866010	0.9890236	3.253E+02	8.644E+00
α_2	4.32E-03	1.23E-02	1.14E-02	2.36E-02	7.16E-03	4.116E+00	3.298E+02
α_3	1.15E-03	6.19E-03	5.23E-03	1.45E-02	3.04E-03	2.066E+00	3.319E+02
α_4	2.95E-04	3.66E-03	2.73E-03	1.02E-02	6.89E-04	1.221E+00	3.327E+02
α_5	4.07E-05	2.15E-03	1.27E-03	7.24E-03	7.88E-05	7.168E-01	3.332E+02
α_6	6.27E-07	1.10E-03	3.60E-04	4.70E-03	3.58E-06	3.673E-01	3.336E+02
α_7	4.87E-14	3.68E-04	6.62E-06	2.10E-03	0.00E+00	1.230E-01	3.338E+02
α_8	9.13E-43	9.92E-05	1.41E-12	4.19E-04	0.00E+00	3.312E-02	3.339E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.97E-01	9.94E-01	9.91E-01	9.90E-01	9.90E-01	9.89E-01	9.89E-01
α_2	3.05E-03	6.12E-03	9.21E-03	8.62E-03	8.14E-03	7.66E-03	7.16E-03
α_3		0.00E+00	0.00E+00	1.23E-03	2.06E-03	2.64E-03	3.04E-03
α_4			0.00E+00	0.00E+00	1.71E-04	4.17E-04	6.89E-04
α_5				0.00E+00	0.00E+00	2.45E-05	7.88E-05
α_6					0.00E+00	0.00E+00	3.58E-06
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.97E-01	9.94E-01	9.91E-01	9.90E-01	9.90E-01	9.89E-01	9.89E-01
Beta	3.05E-03	6.12E-03	9.21E-03	9.85E-03	1.04E-02	1.07E-02	1.10E-02
Gamma		0.00E+00	0.00E+00	1.25E-01	2.15E-01	2.87E-01	3.48E-01
Delta			0.00E+00	0.00E+00	7.69E-02	1.43E-01	2.02E-01
Epsilon				0.00E+00	0.00E+00	5.56E-02	1.07E-01
Mu					0.00E+00	0.00E+00	4.35E-02
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	26.40	39.60	52.80	66.00	79.20	92.40	105.60
N_1	0.8333	1.0000	1.0000	1.0417	1.0417	1.0127	0.9645
N_2	0.0833	0.2500	0.5000	0.5833	0.6597	0.7234	0.7716

N_3		0.0000	0.0000	0.0833	0.1667	0.2488	0.3279
N_4			0.0000	0.0000	0.0139	0.0394	0.0743
N_5				0.0000	0.0000	0.0023	0.0085
N_6					0.0000	0.0000	0.0004
N_7						0.0000	0.0000
N_8							0.0000

2.3.4 BWR Isolation Condenser Motor-Operated Valves

2.3.4.1 ISO CONDENSER MOV FAIL TO OPEN/CLOSE

Systems/Clean Water/Isolation condenser
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9074745	0.9768633	0.9904870	0.9999540	1.0000000	1.835E+01	4.345E-01
α_2	4.25E-05	2.31E-02	9.51E-03	9.25E-02	0.00E+00	4.345E-01	1.835E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9189187	0.9715945	0.9792386	0.9981232	1.0000000	3.766E+01	1.101E+00
α_2	6.85E-04	2.15E-02	1.40E-02	6.80E-02	0.00E+00	8.337E-01	3.792E+01
α_3	2.42E-07	6.89E-03	1.39E-03	3.27E-02	0.00E+00	2.672E-01	3.849E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9208541	0.9669274	0.9723144	0.9945509	1.0000000	5.424E+01	1.855E+00
α_2	1.82E-03	2.19E-02	1.65E-02	6.04E-02	0.00E+00	1.228E+00	5.486E+01
α_3	8.13E-06	7.21E-03	2.68E-03	2.98E-02	0.00E+00	4.043E-01	5.569E+01
α_4	1.72E-08	3.97E-03	5.44E-04	1.99E-02	0.00E+00	2.227E-01	5.587E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9350204	0.9671774	0.9700259	0.9895832	1.0000000	1.043E+02	3.538E+00
α_2	3.78E-03	1.96E-02	1.67E-02	4.53E-02	0.00E+00	2.114E+00	1.057E+02
α_3	4.43E-04	9.07E-03	6.26E-03	2.73E-02	0.00E+00	9.774E-01	1.068E+02
α_4	2.28E-06	3.47E-03	1.17E-03	1.47E-02	0.00E+00	3.744E-01	1.074E+02
α_5	5.54E-21	6.70E-04	3.79E-07	3.88E-03	0.00E+00	7.228E-02	1.077E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9376917	0.9669138	0.9692934	0.9879927	1.0000000	1.250E+02	4.279E+00
α_2	3.56E-03	1.73E-02	1.49E-02	3.94E-02	0.00E+00	2.239E+00	1.271E+02
α_3	6.22E-04	8.83E-03	6.46E-03	2.51E-02	0.00E+00	1.142E+00	1.282E+02
α_4	4.10E-05	4.58E-03	2.40E-03	1.65E-02	0.00E+00	5.922E-01	1.287E+02
α_5	7.18E-09	1.72E-03	2.33E-04	8.61E-03	0.00E+00	2.222E-01	1.291E+02
α_6	1.09E-18	6.44E-04	1.13E-06	3.76E-03	0.00E+00	8.324E-02	1.292E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	8.10	8.10	8.10	8.10	8.10
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.4.2 ISO CONDENSER MOV FAIL TO OPEN

Systems/Clean Water/Isolation condenser
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8965817	0.9741057	0.9893092	0.9999484	1.0000000	1.635E+01	4.345E-01
α_2	4.78E-05	2.59E-02	1.07E-02	1.03E-01	0.00E+00	4.345E-01	1.635E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9145760	0.9700489	0.9780884	0.9980185	1.0000000	3.565E+01	1.101E+00
α_2	7.23E-04	2.27E-02	1.48E-02	7.17E-02	0.00E+00	8.337E-01	3.592E+01
α_3	2.56E-07	7.27E-03	1.47E-03	3.45E-02	0.00E+00	2.672E-01	3.649E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9179746	0.9657045	0.9712787	0.9943443	1.0000000	5.224E+01	1.855E+00
α_2	1.88E-03	2.27E-02	1.71E-02	6.26E-02	0.00E+00	1.228E+00	5.286E+01
α_3	8.43E-06	7.47E-03	2.78E-03	3.09E-02	0.00E+00	4.043E-01	5.369E+01
α_4	1.78E-08	4.12E-03	5.65E-04	2.06E-02	0.00E+00	2.227E-01	5.387E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9338074	0.9665570	0.9694561	0.9893830	1.0000000	1.023E+02	3.538E+00
α_2	3.85E-03	2.00E-02	1.70E-02	4.62E-02	0.00E+00	2.114E+00	1.037E+02
α_3	4.51E-04	9.24E-03	6.38E-03	2.78E-02	0.00E+00	9.774E-01	1.048E+02
α_4	2.33E-06	3.54E-03	1.19E-03	1.50E-02	0.00E+00	3.744E-01	1.054E+02
α_5	5.64E-21	6.83E-04	3.86E-07	3.96E-03	0.00E+00	7.228E-02	1.057E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9367243	0.9663941	0.9688130	0.9878013	1.0000000	1.230E+02	4.279E+00
α_2	3.62E-03	1.76E-02	1.51E-02	4.00E-02	0.00E+00	2.239E+00	1.251E+02
α_3	6.32E-04	8.97E-03	6.56E-03	2.55E-02	0.00E+00	1.142E+00	1.262E+02
α_4	4.16E-05	4.65E-03	2.44E-03	1.68E-02	0.00E+00	5.922E-01	1.267E+02
α_5	7.30E-09	1.75E-03	2.37E-04	8.74E-03	0.00E+00	2.222E-01	1.271E+02
α_6	1.11E-18	6.54E-04	1.14E-06	3.82E-03	0.00E+00	8.324E-02	1.272E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	6.10	6.10	6.10	6.10	6.10
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.4.3 ISO CONDENSER MOV FAIL TO CLOSE

Systems/Clean Water/Isolation condenser
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8636859	0.9657333	0.9856734	0.9999376	1.0000000	1.225E+01	4.345E-01
α_2	6.41E-05	3.43E-02	1.43E-02	1.36E-01	0.00E+00	4.345E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9040424	0.9662885	0.9752807	0.9977558	1.0000000	3.156E+01	1.101E+00
α_2	8.16E-04	2.55E-02	1.67E-02	8.05E-02	0.00E+00	8.337E-01	3.182E+01
α_3	2.88E-07	8.18E-03	1.66E-03	3.88E-02	0.00E+00	2.672E-01	3.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113590	0.9628918	0.9688972	0.9938678	1.0000000	4.814E+01	1.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	1.93E-08	4.45E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.977E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9311737	0.9652087	0.9682205	0.9889476	1.0000000	9.816E+01	3.538E+00
α_2	4.01E-03	2.08E-02	1.77E-02	4.80E-02	0.00E+00	2.114E+00	9.959E+01
α_3	4.70E-04	9.61E-03	6.64E-03	2.89E-02	0.00E+00	9.774E-01	1.007E+02
α_4	2.42E-06	3.68E-03	1.24E-03	1.56E-02	0.00E+00	3.744E-01	1.013E+02
α_5	5.87E-21	7.11E-04	4.02E-07	4.12E-03	0.00E+00	7.228E-02	1.016E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9346441	0.9652759	0.9677639	0.9873891	1.0000000	1.189E+02	4.279E+00
α_2	3.74E-03	1.82E-02	1.56E-02	4.13E-02	0.00E+00	2.239E+00	1.210E+02
α_3	6.53E-04	9.27E-03	6.78E-03	2.64E-02	0.00E+00	1.142E+00	1.221E+02
α_4	4.30E-05	4.81E-03	2.52E-03	1.73E-02	0.00E+00	5.922E-01	1.226E+02
α_5	7.54E-09	1.80E-03	2.45E-04	9.04E-03	0.00E+00	2.222E-01	1.230E+02
α_6	1.14E-18	6.76E-04	1.18E-06	3.94E-03	0.00E+00	8.324E-02	1.231E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	2.00	2.00	2.00	2.00	2.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.5 PWR Auxiliary Feedwater Motor-Operated Valves

2.3.5.1 AFW MOV FAIL TO OPEN/CLOSE SPAR: MOV-FTOC-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 84.8
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9394580	0.9805910	0.9871530	0.9993029	0.9872674	4.385E+01	8.679E-01
α_2	6.94E-04	1.94E-02	1.28E-02	6.05E-02	1.27E-02	8.679E-01	4.385E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9363563	0.9716312	0.9754201	0.9939440	0.9762141	7.880E+01	2.301E+00
α_2	4.37E-03	2.45E-02	2.07E-02	5.75E-02	2.28E-02	1.984E+00	7.912E+01
α_3	6.94E-07	3.91E-03	1.05E-03	1.76E-02	9.91E-04	3.172E-01	8.079E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9324476	0.9645920	0.9672697	0.9875889	0.9669339	1.105E+02	4.055E+00
α_2	8.30E-03	2.82E-02	2.55E-02	5.73E-02	3.01E-02	3.228E+00	1.113E+02
α_3	5.16E-05	5.28E-03	2.81E-03	1.89E-02	3.01E-03	6.043E-01	1.139E+02
α_4	8.35E-09	1.94E-03	2.65E-04	9.74E-03	0.00E+00	2.227E-01	1.143E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9413760	0.9659443	0.9676347	0.9847294	0.9676768	1.760E+02	6.205E+00
α_2	7.41E-03	2.17E-02	1.99E-02	4.18E-02	2.22E-02	3.948E+00	1.783E+02
α_3	1.56E-03	9.94E-03	8.21E-03	2.42E-02	1.01E-02	1.811E+00	1.804E+02
α_4	1.35E-06	2.05E-03	6.91E-04	8.73E-03	0.00E+00	3.744E-01	1.818E+02
α_5	3.27E-21	3.97E-04	2.24E-07	2.29E-03	0.00E+00	7.228E-02	1.821E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9449140	0.9668577	0.9682686	0.9839947	0.9695122	2.123E+02	7.279E+00
α_2	5.44E-03	1.68E-02	1.53E-02	3.30E-02	1.47E-02	3.684E+00	2.159E+02
α_3	2.81E-03	1.18E-02	1.03E-02	2.57E-02	1.47E-02	2.586E+00	2.170E+02
α_4	5.68E-05	3.20E-03	1.87E-03	1.09E-02	1.13E-03	7.033E-01	2.189E+02
α_5	4.22E-09	1.01E-03	1.37E-04	5.07E-03	0.00E+00	2.222E-01	2.194E+02
α_6	6.41E-19	3.79E-04	6.62E-07	2.21E-03	0.00E+00	8.324E-02	2.195E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9511481	0.9690120	0.9700359	0.9833843	0.9737533	2.953E+02	9.445E+00
α_2	4.87E-03	1.37E-02	1.27E-02	2.62E-02	9.59E-03	4.184E+00	3.006E+02
α_3	2.49E-03	9.43E-03	8.38E-03	2.00E-02	1.09E-02	2.876E+00	3.019E+02
α_4	6.98E-04	5.29E-03	4.25E-03	1.34E-02	5.44E-03	1.611E+00	3.032E+02
α_5	1.26E-05	1.83E-03	9.17E-04	6.76E-03	3.24E-04	5.588E-01	3.042E+02
α_6	2.20E-10	6.11E-04	5.21E-05	3.21E-03	0.00E+00	1.863E-01	3.046E+02
α_7	3.33E-48	9.54E-05	8.34E-14	3.59E-04	0.00E+00	2.907E-02	3.048E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9546162	0.9706474	0.9715267	0.9836902	0.9769585	3.459E+02	1.046E+01
α_2	4.15E-03	1.17E-02	1.08E-02	2.24E-02	6.43E-03	4.182E+00	3.522E+02
α_3	2.04E-03	7.89E-03	6.99E-03	1.68E-02	8.26E-03	2.813E+00	3.536E+02
α_4	9.59E-04	5.51E-03	4.61E-03	1.31E-02	6.27E-03	1.963E+00	3.544E+02
α_5	1.28E-04	2.71E-03	1.86E-03	8.21E-03	1.99E-03	9.671E-01	3.554E+02
α_6	7.65E-07	1.06E-03	3.63E-04	4.50E-03	9.48E-05	3.793E-01	3.560E+02
α_7	4.57E-14	3.45E-04	6.20E-06	1.96E-03	0.00E+00	1.230E-01	3.563E+02
α_8	8.55E-43	9.29E-05	1.32E-12	3.93E-04	0.00E+00	3.312E-02	3.564E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.87E-01	9.76E-01	9.67E-01	9.68E-01	9.70E-01	9.74E-01	9.77E-01
α_2	1.27E-02	2.28E-02	3.01E-02	2.22E-02	1.47E-02	9.59E-03	6.43E-03
α_3		9.91E-04	3.01E-03	1.01E-02	1.47E-02	1.09E-02	8.26E-03
α_4			0.00E+00	0.00E+00	1.13E-03	5.44E-03	6.27E-03
α_5				0.00E+00	0.00E+00	3.24E-04	1.99E-03
α_6					0.00E+00	0.00E+00	9.48E-05
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.76E-01	9.67E-01	9.68E-01	9.70E-01	9.74E-01	9.77E-01
Beta	1.27E-02	2.38E-02	3.31E-02	3.23E-02	3.05E-02	2.62E-02	2.30E-02
Gamma		4.17E-02	9.09E-02	3.13E-01	5.19E-01	6.35E-01	7.21E-01
Delta			0.00E+00	0.00E+00	7.14E-02	3.46E-01	5.03E-01
Epsilon				0.00E+00	0.00E+00	5.62E-02	2.49E-01
Mu					0.00E+00	0.00E+00	4.55E-02
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	31.80	47.70	63.60	79.50	95.40	111.30	127.20
N_1	1.8000	1.5500	0.7333	0.3333	0.0000	0.0000	0.0000
N_2	0.4333	1.1500	2.0000	1.8333	1.4444	1.0963	0.8375
N_3		0.0500	0.2000	0.8333	1.4444	1.2444	1.0751

N_4			0.0000	0.0000	0.1111	0.6222	0.8163
N_5				0.0000	0.0000	0.0370	0.2588
N_6					0.0000	0.0000	0.0123
N_7						0.0000	0.0000
N_8							0.0000

2.3.5.2 AFW MOV FAIL TO OPEN

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 44.2
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9156664	0.9757945	0.9864251	0.9997056	0.9871245	2.558E+01	6.345E-01
α_2	2.97E-04	2.42E-02	1.36E-02	8.43E-02	1.29E-02	6.345E-01	2.558E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9250774	0.9701917	0.9758225	0.9960299	0.9783080	5.211E+01	1.601E+00
α_2	2.17E-03	2.39E-02	1.83E-02	6.49E-02	1.95E-02	1.284E+00	5.242E+01
α_3	1.05E-06	5.91E-03	1.59E-03	2.65E-02	2.17E-03	3.172E-01	5.339E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9274150	0.9661591	0.9700450	0.9916056	0.9737418	7.580E+01	2.655E+00
α_2	3.74E-03	2.33E-02	1.94E-02	5.63E-02	1.97E-02	1.828E+00	7.663E+01
α_3	7.55E-05	7.70E-03	4.11E-03	2.75E-02	6.56E-03	6.043E-01	7.785E+01
α_4	1.22E-08	2.84E-03	3.88E-04	1.42E-02	0.00E+00	2.227E-01	7.824E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9387756	0.9670024	0.9692417	0.9875663	0.9735683	1.330E+02	4.538E+00
α_2	4.61E-03	1.90E-02	1.67E-02	4.12E-02	1.32E-02	2.614E+00	1.349E+02
α_3	1.24E-03	1.07E-02	8.48E-03	2.80E-02	1.32E-02	1.477E+00	1.361E+02
α_4	1.79E-06	2.72E-03	9.16E-04	1.16E-02	0.00E+00	3.744E-01	1.372E+02
α_5	4.33E-21	5.26E-04	2.97E-07	3.04E-03	0.00E+00	7.228E-02	1.375E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432629	0.9682809	0.9701384	0.9869412	0.9778761	1.611E+02	5.279E+00
α_2	2.76E-03	1.35E-02	1.16E-02	3.06E-02	0.00E+00	2.239E+00	1.642E+02
α_3	2.51E-03	1.29E-02	1.10E-02	2.97E-02	2.21E-02	2.142E+00	1.643E+02
α_4	3.18E-05	3.56E-03	1.86E-03	1.28E-02	0.00E+00	5.922E-01	1.658E+02
α_5	5.58E-09	1.34E-03	1.81E-04	6.69E-03	0.00E+00	2.222E-01	1.662E+02
α_6	8.47E-19	5.00E-04	8.74E-07	2.92E-03	0.00E+00	8.324E-02	1.663E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9492960	0.9693699	0.9706475	0.9850683	0.9809765	2.356E+02	7.445E+00

α_2	3.57E-03	1.27E-02	1.14E-02	2.63E-02	0.00E+00	3.088E+00	2.400E+02
α_3	1.87E-03	9.18E-03	7.87E-03	2.10E-02	1.14E-02	2.231E+00	2.408E+02
α_4	5.90E-04	5.71E-03	4.43E-03	1.52E-02	7.61E-03	1.389E+00	2.417E+02
α_5	1.05E-05	2.15E-03	1.02E-03	8.11E-03	0.00E+00	5.218E-01	2.425E+02
α_6	2.76E-10	7.66E-04	6.54E-05	4.02E-03	0.00E+00	1.863E-01	2.429E+02
α_7	4.18E-48	1.20E-04	1.05E-13	4.50E-04	0.00E+00	2.907E-02	2.430E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9523272	0.9704290	0.9715172	0.9848082	0.9833148	2.777E+02	8.461E+00
α_2	3.51E-03	1.17E-02	1.06E-02	2.37E-02	0.00E+00	3.345E+00	2.828E+02
α_3	1.39E-03	7.33E-03	6.22E-03	1.71E-02	6.01E-03	2.098E+00	2.840E+02
α_4	7.61E-04	5.68E-03	4.58E-03	1.44E-02	8.01E-03	1.627E+00	2.845E+02
α_5	1.07E-04	3.03E-03	1.98E-03	9.55E-03	2.67E-03	8.683E-01	2.853E+02
α_6	7.25E-07	1.28E-03	4.20E-04	5.49E-03	0.00E+00	3.670E-01	2.858E+02
α_7	5.69E-14	4.30E-04	7.73E-06	2.45E-03	0.00E+00	1.230E-01	2.860E+02
α_8	1.07E-42	1.16E-04	1.65E-12	4.89E-04	0.00E+00	3.312E-02	2.861E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.87E-01	9.78E-01	9.74E-01	9.74E-01	9.78E-01	9.81E-01	9.83E-01
α_2	1.29E-02	1.95E-02	1.97E-02	1.32E-02	0.00E+00	0.00E+00	0.00E+00
α_3		2.17E-03	6.56E-03	1.32E-02	2.21E-02	1.14E-02	6.01E-03
α_4			0.00E+00	0.00E+00	0.00E+00	7.61E-03	8.01E-03
α_5				0.00E+00	0.00E+00	0.00E+00	2.67E-03
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.78E-01	9.74E-01	9.74E-01	9.78E-01	9.81E-01	9.83E-01
Beta	1.29E-02	2.17E-02	2.63E-02	2.64E-02	2.21E-02	1.90E-02	1.67E-02
Gamma		1.00E-01	2.50E-01	5.00E-01	1.00E+00	1.00E+00	1.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	4.00E-01	6.40E-01
Epsilon				0.00E+00	0.00E+00	0.00E+00	2.50E-01
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	14.73	22.10	29.47	36.83	44.20	51.57	58.93
N_1	0.6000	0.4500	0.2000	0.0000	0.0000	0.0000	0.0000
N_2	0.2000	0.4500	0.6000	0.5000	0.0000	0.0000	0.0000
N_3		0.0500	0.2000	0.5000	1.0000	0.6000	0.3600
N_4			0.0000	0.0000	0.0000	0.4000	0.4800
N_5				0.0000	0.0000	0.0000	0.1600
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000

N_8							0.0000

2.3.5.3 AFW MOV FAIL TO CLOSE

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 37.6
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9159103	0.9754048	0.9857563	0.9996285	0.9858357	2.649E+01	6.679E-01
α_2	3.70E-04	2.46E-02	1.42E-02	8.41E-02	1.42E-02	6.679E-01	2.649E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9209108	0.9672662	0.9727558	0.9948154	0.9712644	5.321E+01	1.801E+00
α_2	3.46E-03	2.79E-02	2.24E-02	7.11E-02	2.87E-02	1.534E+00	5.348E+01
α_3	1.70E-07	4.86E-03	9.77E-04	2.30E-02	0.00E+00	2.672E-01	5.475E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9178468	0.9593137	0.9630916	0.9878582	0.9562682	7.675E+01	3.255E+00
α_2	8.07E-03	3.28E-02	2.90E-02	7.07E-02	4.37E-02	2.628E+00	7.738E+01
α_3	5.68E-06	5.05E-03	1.87E-03	2.09E-02	0.00E+00	4.043E-01	7.960E+01
α_4	1.20E-08	2.78E-03	3.80E-04	1.39E-02	0.00E+00	2.227E-01	7.978E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9330590	0.9626350	0.9648292	0.9847072	0.9579125	1.341E+02	5.205E+00
α_2	7.67E-03	2.47E-02	2.25E-02	4.95E-02	3.37E-02	3.448E+00	1.359E+02
α_3	8.76E-04	9.41E-03	7.19E-03	2.55E-02	8.42E-03	1.311E+00	1.380E+02
α_4	1.76E-06	2.69E-03	9.04E-04	1.14E-02	0.00E+00	3.744E-01	1.389E+02
α_5	4.28E-21	5.19E-04	2.93E-07	3.00E-03	0.00E+00	7.228E-02	1.392E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9360335	0.9627022	0.9645254	0.9831573	0.9575552	1.621E+02	6.279E+00
α_2	7.12E-03	2.19E-02	2.00E-02	4.30E-02	3.07E-02	3.684E+00	1.647E+02
α_3	1.22E-03	9.42E-03	7.56E-03	2.40E-02	9.43E-03	1.586E+00	1.668E+02
α_4	7.42E-05	4.18E-03	2.45E-03	1.42E-02	2.36E-03	7.033E-01	1.676E+02
α_5	5.51E-09	1.32E-03	1.79E-04	6.61E-03	0.00E+00	2.222E-01	1.681E+02
α_6	8.37E-19	4.94E-04	8.64E-07	2.88E-03	0.00E+00	8.324E-02	1.683E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9445136	0.9655496	0.9668126	0.9822881	0.9633968	2.367E+02	8.445E+00

α_2	6.06E-03	1.71E-02	1.58E-02	3.25E-02	2.01E-02	4.184E+00	2.410E+02
α_3	1.93E-03	9.28E-03	7.99E-03	2.11E-02	1.18E-02	2.276E+00	2.429E+02
α_4	3.93E-04	4.94E-03	3.68E-03	1.38E-02	4.07E-03	1.211E+00	2.439E+02
α_5	1.56E-05	2.28E-03	1.14E-03	8.41E-03	6.78E-04	5.588E-01	2.446E+02
α_6	2.74E-10	7.60E-04	6.48E-05	3.99E-03	0.00E+00	1.863E-01	2.449E+02
α_7	4.15E-48	1.19E-04	1.04E-13	4.46E-04	0.00E+00	2.907E-02	2.451E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483206	0.9671893	0.9682666	0.9823876	0.9678250	2.789E+02	9.461E+00
α_2	5.14E-03	1.45E-02	1.34E-02	2.77E-02	1.35E-02	4.182E+00	2.842E+02
α_3	1.92E-03	8.51E-03	7.40E-03	1.89E-02	1.15E-02	2.453E+00	2.859E+02
α_4	5.94E-04	5.14E-03	4.05E-03	1.34E-02	5.41E-03	1.483E+00	2.869E+02
α_5	7.90E-05	2.80E-03	1.77E-03	9.04E-03	1.59E-03	8.071E-01	2.875E+02
α_6	9.46E-07	1.32E-03	4.49E-04	5.56E-03	1.99E-04	3.793E-01	2.880E+02
α_7	5.65E-14	4.26E-04	7.67E-06	2.43E-03	0.00E+00	1.230E-01	2.882E+02
α_8	1.06E-42	1.15E-04	1.64E-12	4.85E-04	0.00E+00	3.312E-02	2.883E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.86E-01	9.71E-01	9.56E-01	9.58E-01	9.58E-01	9.63E-01	9.68E-01
α_2	1.42E-02	2.87E-02	4.37E-02	3.37E-02	3.07E-02	2.01E-02	1.35E-02
α_3		0.00E+00	0.00E+00	8.42E-03	9.43E-03	1.18E-02	1.15E-02
α_4			0.00E+00	0.00E+00	2.36E-03	4.07E-03	5.41E-03
α_5				0.00E+00	0.00E+00	6.78E-04	1.59E-03
α_6					0.00E+00	0.00E+00	1.99E-04
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.71E-01	9.56E-01	9.58E-01	9.58E-01	9.63E-01	9.68E-01
Beta	1.42E-02	2.87E-02	4.37E-02	4.21E-02	4.24E-02	3.66E-02	3.22E-02
Gamma		0.00E+00	0.00E+00	2.00E-01	2.78E-01	4.52E-01	5.81E-01
Delta			0.00E+00	0.00E+00	2.00E-01	2.87E-01	3.85E-01
Epsilon				0.00E+00	0.00E+00	1.43E-01	2.48E-01
Mu					0.00E+00	0.00E+00	1.11E-01
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	15.04	22.56	30.08	37.60	45.12	52.64	60.16
N_1	1.2000	1.1000	0.5333	0.3333	0.0000	0.0000	0.0000
N_2	0.2333	0.7000	1.4000	1.3333	1.4444	1.0963	0.8375
N_3		0.0000	0.0000	0.3333	0.4444	0.6444	0.7151
N_4			0.0000	0.0000	0.1111	0.2222	0.3363
N_5				0.0000	0.0000	0.0370	0.0988
N_6					0.0000	0.0000	0.0123
N_7						0.0000	0.0000

N_8							0.0000

2.3.6 PWR High Pressure Safety Injection Motor-Operated Valves

2.3.6.1 HIGH PRESSURE INJECTION MOV FAIL TO OPEN/CLOSE

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 72.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9789804	0.9947825	0.9979142	0.9999916	1.0000000	8.285E+01	4.345E-01
α_2	9.29E-06	5.22E-03	2.09E-03	2.10E-02	0.00E+00	4.345E-01	8.285E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9692890	0.9893383	0.9922911	0.9993033	1.0000000	1.022E+02	1.101E+00
α_2	2.53E-04	8.07E-03	5.20E-03	2.57E-02	0.00E+00	8.337E-01	1.024E+02
α_3	9.00E-08	2.59E-03	5.18E-04	1.23E-02	0.00E+00	2.672E-01	1.030E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9628869	0.9846168	0.9872072	0.9974974	1.0000000	1.187E+02	1.855E+00
α_2	8.36E-04	1.02E-02	7.63E-03	2.83E-02	0.00E+00	1.228E+00	1.194E+02
α_3	3.76E-06	3.35E-03	1.24E-03	1.39E-02	0.00E+00	4.043E-01	1.202E+02
α_4	7.93E-09	1.85E-03	2.52E-04	9.25E-03	0.00E+00	2.227E-01	1.204E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9591643	0.9794645	0.9812896	0.9935215	1.0000000	1.688E+02	3.538E+00
α_2	2.35E-03	1.23E-02	1.04E-02	2.84E-02	0.00E+00	2.114E+00	1.702E+02
α_3	2.76E-04	5.67E-03	3.91E-03	1.71E-02	0.00E+00	9.774E-01	1.713E+02
α_4	1.43E-06	2.17E-03	7.30E-04	9.23E-03	0.00E+00	3.744E-01	1.719E+02
α_5	3.46E-21	4.19E-04	2.37E-07	2.43E-03	0.00E+00	7.228E-02	1.722E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582725	0.9779244	0.9795466	0.9920320	1.0000000	1.895E+02	4.279E+00
α_2	2.37E-03	1.16E-02	9.92E-03	2.63E-02	0.00E+00	2.239E+00	1.916E+02
α_3	4.14E-04	5.89E-03	4.30E-03	1.68E-02	0.00E+00	1.142E+00	1.927E+02
α_4	2.73E-05	3.06E-03	1.60E-03	1.10E-02	0.00E+00	5.922E-01	1.932E+02
α_5	4.79E-09	1.15E-03	1.55E-04	5.74E-03	0.00E+00	2.222E-01	1.936E+02
α_6	7.27E-19	4.29E-04	7.50E-07	2.50E-03	0.00E+00	8.324E-02	1.937E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9580734	0.9755032	0.9767016	0.9888487	1.0000000	2.566E+02	6.445E+00
α_2	3.30E-03	1.17E-02	1.05E-02	2.43E-02	0.00E+00	3.088E+00	2.600E+02
α_3	8.34E-04	6.20E-03	5.00E-03	1.57E-02	0.00E+00	1.631E+00	2.615E+02
α_4	1.88E-04	3.76E-03	2.60E-03	1.13E-02	0.00E+00	9.889E-01	2.621E+02
α_5	9.74E-06	1.98E-03	9.38E-04	7.50E-03	0.00E+00	5.218E-01	2.626E+02
α_6	2.55E-10	7.08E-04	6.04E-05	3.72E-03	0.00E+00	1.863E-01	2.629E+02
α_7	3.86E-48	1.10E-04	9.67E-14	4.16E-04	0.00E+00	2.907E-02	2.631E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9586236	0.9750294	0.9760848	0.9878433	1.0000000	2.913E+02	7.461E+00
α_2	3.36E-03	1.12E-02	1.01E-02	2.27E-02	0.00E+00	3.345E+00	2.954E+02
α_3	8.60E-04	5.82E-03	4.76E-03	1.44E-02	0.00E+00	1.738E+00	2.971E+02
α_4	2.71E-04	3.84E-03	2.80E-03	1.09E-02	0.00E+00	1.147E+00	2.976E+02
α_5	4.31E-05	2.37E-03	1.39E-03	8.03E-03	0.00E+00	7.083E-01	2.981E+02
α_6	6.95E-07	1.23E-03	4.02E-04	5.25E-03	0.00E+00	3.670E-01	2.984E+02
α_7	5.45E-14	4.12E-04	7.40E-06	2.34E-03	0.00E+00	1.230E-01	2.987E+02
α_8	1.02E-42	1.11E-04	1.58E-12	4.68E-04	0.00E+00	3.312E-02	2.988E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	72.60	72.60	72.60	72.60	72.60	72.60	72.60
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.6.2 HIGH PRESSURE INJECTION MOTOR OPERATED VALVE FAIL TO OPEN

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 36.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9626346	0.9907115	0.9962611	0.9999816	1.0000000	4.635E+01	4.345E-01
α_2	1.67E-05	9.29E-03	3.74E-03	3.74E-02	0.00E+00	4.345E-01	4.635E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9526312	0.9835089	0.9880287	0.9989191	1.0000000	6.565E+01	1.101E+00
α_2	3.94E-04	1.25E-02	8.07E-03	3.97E-02	0.00E+00	8.337E-01	6.592E+01
α_3	1.40E-07	4.00E-03	8.04E-04	1.90E-02	0.00E+00	2.672E-01	6.649E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9469341	0.9779396	0.9816104	0.9963944	1.0000000	8.224E+01	1.855E+00
α_2	1.20E-03	1.46E-02	1.10E-02	4.04E-02	0.00E+00	1.228E+00	8.286E+01
α_3	5.40E-06	4.81E-03	1.78E-03	1.99E-02	0.00E+00	4.043E-01	8.369E+01
α_4	1.14E-08	2.65E-03	3.62E-04	1.33E-02	0.00E+00	2.227E-01	8.387E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9482886	0.9739450	0.9762408	0.9917636	1.0000000	1.323E+02	3.538E+00
α_2	2.99E-03	1.56E-02	1.33E-02	3.60E-02	0.00E+00	2.114E+00	1.337E+02
α_3	3.51E-04	7.20E-03	4.97E-03	2.17E-02	0.00E+00	9.774E-01	1.348E+02
α_4	1.81E-06	2.76E-03	9.28E-04	1.17E-02	0.00E+00	3.744E-01	1.354E+02
α_5	4.39E-21	5.32E-04	3.01E-07	3.08E-03	0.00E+00	7.228E-02	1.357E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9486810	0.9728026	0.9747855	0.9901557	1.0000000	1.530E+02	4.279E+00
α_2	2.92E-03	1.42E-02	1.22E-02	3.24E-02	0.00E+00	2.239E+00	1.551E+02
α_3	5.10E-04	7.26E-03	5.30E-03	2.07E-02	0.00E+00	1.142E+00	1.562E+02
α_4	3.36E-05	3.76E-03	1.97E-03	1.36E-02	0.00E+00	5.922E-01	1.567E+02
α_5	5.90E-09	1.41E-03	1.91E-04	7.08E-03	0.00E+00	2.222E-01	1.571E+02
α_6	8.96E-19	5.29E-04	9.25E-07	3.09E-03	0.00E+00	8.324E-02	1.572E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9513798	0.9715572	0.9729362	0.9870349	1.0000000	2.201E+02	6.445E+00
α_2	3.84E-03	1.36E-02	1.22E-02	2.82E-02	0.00E+00	3.088E+00	2.235E+02
α_3	9.70E-04	7.20E-03	5.81E-03	1.82E-02	0.00E+00	1.631E+00	2.250E+02
α_4	2.19E-04	4.36E-03	3.02E-03	1.31E-02	0.00E+00	9.889E-01	2.256E+02
α_5	1.13E-05	2.30E-03	1.09E-03	8.70E-03	0.00E+00	5.218E-01	2.261E+02
α_6	2.97E-10	8.22E-04	7.02E-05	4.31E-03	0.00E+00	1.863E-01	2.264E+02
α_7	4.48E-48	1.28E-04	1.12E-13	4.83E-04	0.00E+00	2.907E-02	2.266E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9529107	0.9715546	0.9727429	0.9861348	1.0000000	2.548E+02	7.461E+00
α_2	3.83E-03	1.28E-02	1.15E-02	2.58E-02	0.00E+00	3.345E+00	2.589E+02
α_3	9.80E-04	6.63E-03	5.42E-03	1.64E-02	0.00E+00	1.738E+00	2.606E+02
α_4	3.09E-04	4.37E-03	3.19E-03	1.25E-02	0.00E+00	1.147E+00	2.611E+02
α_5	4.91E-05	2.70E-03	1.59E-03	9.14E-03	0.00E+00	7.083E-01	2.616E+02
α_6	7.92E-07	1.40E-03	4.58E-04	5.98E-03	0.00E+00	3.670E-01	2.619E+02
α_7	6.21E-14	4.69E-04	8.43E-06	2.67E-03	0.00E+00	1.230E-01	2.622E+02
α_8	1.16E-42	1.26E-04	1.80E-12	5.34E-04	0.00E+00	3.312E-02	2.623E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	36.10	36.10	36.10	36.10	36.10	36.10	36.10
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.6.3 HIGH PRESSURE INJECTION MOTOR OPERATED VALVE FAIL TO CLOSE

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9590599	0.9898192	0.9958978	0.9999798	1.0000000	4.225E+01	4.345E-01
α_2	1.83E-05	1.02E-02	4.11E-03	4.09E-02	0.00E+00	4.345E-01	4.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9495596	0.9824297	0.9872369	0.9988523	1.0000000	6.156E+01	1.101E+00
α_2	4.20E-04	1.33E-02	8.60E-03	4.22E-02	0.00E+00	8.337E-01	6.182E+01
α_3	1.49E-07	4.26E-03	8.57E-04	2.02E-02	0.00E+00	2.672E-01	6.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9442433	0.9768089	0.9806599	0.9962065	1.0000000	7.814E+01	1.855E+00
α_2	1.27E-03	1.54E-02	1.15E-02	4.25E-02	0.00E+00	1.228E+00	7.876E+01
α_3	5.68E-06	5.05E-03	1.87E-03	2.09E-02	0.00E+00	4.043E-01	7.959E+01
α_4	1.20E-08	2.78E-03	3.80E-04	1.39E-02	0.00E+00	2.227E-01	7.977E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9466947	0.9731339	0.9754971	0.9914988	1.0000000	1.282E+02	3.538E+00
α_2	3.09E-03	1.61E-02	1.37E-02	3.72E-02	0.00E+00	2.114E+00	1.296E+02
α_3	3.62E-04	7.42E-03	5.12E-03	2.23E-02	0.00E+00	9.774E-01	1.307E+02
α_4	1.87E-06	2.84E-03	9.57E-04	1.21E-02	0.00E+00	3.744E-01	1.313E+02
α_5	4.53E-21	5.49E-04	3.10E-07	3.18E-03	0.00E+00	7.228E-02	1.316E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9473211	0.9720748	0.9741076	0.9898890	1.0000000	1.489E+02	4.279E+00
α_2	3.00E-03	1.46E-02	1.26E-02	3.33E-02	0.00E+00	2.239E+00	1.510E+02
α_3	5.24E-04	7.45E-03	5.45E-03	2.12E-02	0.00E+00	1.142E+00	1.521E+02
α_4	3.45E-05	3.87E-03	2.02E-03	1.39E-02	0.00E+00	5.922E-01	1.526E+02
α_5	6.06E-09	1.45E-03	1.97E-04	7.27E-03	0.00E+00	2.222E-01	1.530E+02
α_6	9.20E-19	5.43E-04	9.50E-07	3.17E-03	0.00E+00	8.324E-02	1.531E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9504915	0.9710331	0.9724313	0.9867931	1.0000000	2.161E+02	6.445E+00
α_2	3.91E-03	1.39E-02	1.24E-02	2.87E-02	0.00E+00	3.088E+00	2.194E+02
α_3	9.88E-04	7.33E-03	5.92E-03	1.85E-02	0.00E+00	1.631E+00	2.209E+02
α_4	2.23E-04	4.44E-03	3.08E-03	1.33E-02	0.00E+00	9.889E-01	2.215E+02
α_5	1.15E-05	2.35E-03	1.11E-03	8.86E-03	0.00E+00	5.218E-01	2.220E+02
α_6	3.02E-10	8.37E-04	7.15E-05	4.39E-03	0.00E+00	1.863E-01	2.223E+02
α_7	4.57E-48	1.31E-04	1.14E-13	4.92E-04	0.00E+00	2.907E-02	2.225E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521646	0.9711028	0.9723091	0.9859081	1.0000000	2.507E+02	7.461E+00
α_2	3.89E-03	1.30E-02	1.17E-02	2.62E-02	0.00E+00	3.345E+00	2.548E+02
α_3	9.96E-04	6.73E-03	5.51E-03	1.67E-02	0.00E+00	1.738E+00	2.565E+02
α_4	3.14E-04	4.44E-03	3.24E-03	1.27E-02	0.00E+00	1.147E+00	2.570E+02
α_5	4.99E-05	2.74E-03	1.61E-03	9.29E-03	0.00E+00	7.083E-01	2.575E+02
α_6	8.04E-07	1.42E-03	4.65E-04	6.08E-03	0.00E+00	3.670E-01	2.578E+02
α_7	6.31E-14	4.76E-04	8.56E-06	2.71E-03	0.00E+00	1.230E-01	2.581E+02
α_8	1.18E-42	1.28E-04	1.83E-12	5.42E-04	0.00E+00	3.312E-02	2.582E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	32.00	32.00	32.00	32.00	32.00	32.00	32.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.7 PWR Residual Heat Removal Motor-Operated Valves

2.3.7.1 PWR RHR MOV FAIL TO OPEN/CLOSE

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 103.7
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9262100	0.9814587	0.9922867	0.9999589	0.9993689	2.344E+01	4.429E-01
α_2	3.79E-05	1.85E-02	7.72E-03	7.38E-02	6.31E-04	4.429E-01	2.344E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9365886	0.9776831	0.9836249	0.9984547	0.9987370	4.932E+01	1.126E+00
α_2	5.89E-04	1.70E-02	1.12E-02	5.34E-02	1.26E-03	8.587E-01	4.959E+01
α_3	1.85E-07	5.30E-03	1.07E-03	2.51E-02	0.00E+00	2.672E-01	5.018E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9389955	0.9743824	0.9785104	0.9956467	0.9981043	7.246E+01	1.905E+00
α_2	1.54E-03	1.72E-02	1.31E-02	4.69E-02	1.90E-03	1.278E+00	7.309E+01
α_3	6.11E-06	5.44E-03	2.01E-03	2.25E-02	0.00E+00	4.043E-01	7.396E+01
α_4	1.29E-08	2.99E-03	4.09E-04	1.50E-02	0.00E+00	2.227E-01	7.414E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9461770	0.9726976	0.9750428	0.9912058	0.9974708	1.290E+02	3.622E+00
α_2	3.33E-03	1.66E-02	1.42E-02	3.79E-02	2.53E-03	2.198E+00	1.304E+02
α_3	3.59E-04	7.37E-03	5.09E-03	2.22E-02	0.00E+00	9.774E-01	1.317E+02
α_4	1.85E-06	2.82E-03	9.50E-04	1.20E-02	0.00E+00	3.744E-01	1.323E+02
α_5	4.49E-21	5.45E-04	3.08E-07	3.15E-03	0.00E+00	7.228E-02	1.326E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9486797	0.9726023	0.9745430	0.9898957	0.9968364	1.563E+02	4.404E+00
α_2	3.21E-03	1.47E-02	1.27E-02	3.29E-02	3.16E-03	2.364E+00	1.584E+02
α_3	4.99E-04	7.10E-03	5.19E-03	2.02E-02	0.00E+00	1.142E+00	1.596E+02
α_4	3.29E-05	3.68E-03	1.93E-03	1.33E-02	0.00E+00	5.922E-01	1.601E+02
α_5	5.77E-09	1.38E-03	1.87E-04	6.93E-03	0.00E+00	2.222E-01	1.605E+02
α_6	8.77E-19	5.18E-04	9.05E-07	3.02E-03	0.00E+00	8.324E-02	1.606E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9524388	0.9720160	0.9733385	0.9870820	0.9962013	2.299E+02	6.620E+00
α_2	4.07E-03	1.38E-02	1.24E-02	2.81E-02	3.80E-03	3.263E+00	2.333E+02
α_3	9.29E-04	6.90E-03	5.56E-03	1.74E-02	0.00E+00	1.631E+00	2.349E+02
α_4	2.09E-04	4.18E-03	2.89E-03	1.25E-02	0.00E+00	9.889E-01	2.356E+02
α_5	1.08E-05	2.21E-03	1.04E-03	8.34E-03	0.00E+00	5.218E-01	2.360E+02
α_6	2.84E-10	7.87E-04	6.72E-05	4.13E-03	0.00E+00	1.863E-01	2.364E+02
α_7	4.30E-48	1.23E-04	1.08E-13	4.62E-04	0.00E+00	2.907E-02	2.365E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9546022	0.9724028	0.9735225	0.9863745	0.9955654	2.711E+02	7.694E+00
α_2	4.07E-03	1.28E-02	1.17E-02	2.55E-02	4.43E-03	3.578E+00	2.752E+02
α_3	9.22E-04	6.24E-03	5.10E-03	1.54E-02	0.00E+00	1.738E+00	2.771E+02
α_4	2.91E-04	4.11E-03	3.00E-03	1.17E-02	0.00E+00	1.147E+00	2.777E+02
α_5	4.62E-05	2.54E-03	1.49E-03	8.60E-03	0.00E+00	7.083E-01	2.781E+02
α_6	7.45E-07	1.32E-03	4.31E-04	5.63E-03	0.00E+00	3.670E-01	2.784E+02
α_7	5.84E-14	4.41E-04	7.93E-06	2.51E-03	0.00E+00	1.230E-01	2.787E+02
α_8	1.09E-42	1.19E-04	1.69E-12	5.02E-04	0.00E+00	3.312E-02	2.788E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.99E-01	9.99E-01	9.98E-01	9.97E-01	9.97E-01	9.96E-01	9.96E-01
α_2	6.31E-04	1.26E-03	1.90E-03	2.53E-03	3.16E-03	3.80E-03	4.43E-03
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.99E-01	9.99E-01	9.98E-01	9.97E-01	9.97E-01	9.96E-01	9.96E-01
Beta	6.31E-04	1.26E-03	1.90E-03	2.53E-03	3.16E-03	3.80E-03	4.43E-03
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	12.96	19.44	25.92	32.41	38.89	45.37	51.85
N_1	0.2333	0.3250	0.4000	0.4583	0.5000	0.5250	0.5333
N_2	0.0083	0.0250	0.0500	0.0833	0.1250	0.1750	0.2333

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.7.2 PWR RHR MOV FAIL TO OPEN

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 65.6
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9080168	0.9768409	0.9902941	0.9999486	0.9990128	1.868E+01	4.429E-01
α_2	4.77E-05	2.32E-02	9.70E-03	9.20E-02	9.87E-04	4.429E-01	1.868E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9262734	0.9740017	0.9808821	0.9981986	0.9980237	4.218E+01	1.126E+00
α_2	6.88E-04	1.98E-02	1.31E-02	6.21E-02	1.98E-03	8.587E-01	4.245E+01
α_3	2.16E-07	6.17E-03	1.25E-03	2.93E-02	0.00E+00	2.672E-01	4.304E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9301589	0.9706192	0.9753204	0.9949995	0.9970326	6.294E+01	1.905E+00
α_2	1.77E-03	1.97E-02	1.50E-02	5.37E-02	2.97E-03	1.278E+00	6.356E+01
α_3	7.02E-06	6.24E-03	2.31E-03	2.58E-02	0.00E+00	4.043E-01	6.444E+01
α_4	1.48E-08	3.43E-03	4.70E-04	1.72E-02	0.00E+00	2.227E-01	6.462E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9409279	0.9700054	0.9725673	0.9903258	0.9960396	1.171E+02	3.622E+00
α_2	3.66E-03	1.82E-02	1.56E-02	4.16E-02	3.96E-03	2.198E+00	1.185E+02
α_3	3.95E-04	8.09E-03	5.59E-03	2.43E-02	0.00E+00	9.774E-01	1.198E+02
α_4	2.04E-06	3.10E-03	1.04E-03	1.32E-02	0.00E+00	3.744E-01	1.204E+02
α_5	4.94E-21	5.99E-04	3.38E-07	3.46E-03	0.00E+00	7.228E-02	1.207E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9437300	0.9699293	0.9720423	0.9888968	0.9950446	1.420E+02	4.404E+00
α_2	3.52E-03	1.61E-02	1.40E-02	3.61E-02	4.96E-03	2.364E+00	1.441E+02
α_3	5.49E-04	7.80E-03	5.70E-03	2.22E-02	0.00E+00	1.142E+00	1.453E+02
α_4	3.61E-05	4.04E-03	2.12E-03	1.46E-02	0.00E+00	5.922E-01	1.459E+02
α_5	6.34E-09	1.52E-03	2.06E-04	7.60E-03	0.00E+00	2.222E-01	1.462E+02
α_6	9.63E-19	5.68E-04	9.94E-07	3.32E-03	0.00E+00	8.324E-02	1.464E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9488698	0.9698948	0.9713070	0.9860874	0.9940476	2.133E+02	6.620E+00
α_2	4.38E-03	1.48E-02	1.34E-02	3.02E-02	5.95E-03	3.263E+00	2.166E+02
α_3	9.99E-04	7.42E-03	5.99E-03	1.87E-02	0.00E+00	1.631E+00	2.183E+02
α_4	2.25E-04	4.50E-03	3.11E-03	1.35E-02	0.00E+00	9.889E-01	2.189E+02
α_5	1.17E-05	2.37E-03	1.12E-03	8.97E-03	0.00E+00	5.218E-01	2.194E+02
α_6	3.06E-10	8.47E-04	7.23E-05	4.45E-03	0.00E+00	1.863E-01	2.197E+02
α_7	4.62E-48	1.32E-04	1.16E-13	4.98E-04	0.00E+00	2.907E-02	2.199E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9512933	0.9703789	0.9715767	0.9853597	0.9930487	2.521E+02	7.694E+00
α_2	4.37E-03	1.38E-02	1.25E-02	2.74E-02	6.95E-03	3.578E+00	2.562E+02
α_3	9.90E-04	6.69E-03	5.48E-03	1.66E-02	0.00E+00	1.738E+00	2.580E+02
α_4	3.12E-04	4.41E-03	3.23E-03	1.26E-02	0.00E+00	1.147E+00	2.586E+02
α_5	4.96E-05	2.73E-03	1.60E-03	9.23E-03	0.00E+00	7.083E-01	2.590E+02
α_6	7.99E-07	1.41E-03	4.62E-04	6.04E-03	0.00E+00	3.670E-01	2.594E+02
α_7	6.27E-14	4.73E-04	8.51E-06	2.69E-03	0.00E+00	1.230E-01	2.596E+02
α_8	1.17E-42	1.28E-04	1.82E-12	5.39E-04	0.00E+00	3.312E-02	2.597E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.99E-01	9.98E-01	9.97E-01	9.96E-01	9.95E-01	9.94E-01	9.93E-01
α_2	9.87E-04	1.98E-03	2.97E-03	3.96E-03	4.96E-03	5.95E-03	6.95E-03
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.99E-01	9.98E-01	9.97E-01	9.96E-01	9.95E-01	9.94E-01	9.93E-01
Beta	9.87E-04	1.98E-03	2.97E-03	3.96E-03	4.96E-03	5.95E-03	6.95E-03
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	8.20	12.30	16.40	20.50	24.60	28.70	32.80
N_1	0.2333	0.3250	0.4000	0.4583	0.5000	0.5250	0.5333
N_2	0.0083	0.0250	0.0500	0.0833	0.1250	0.1750	0.2333

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.7.3 PWR RHR MOV FAIL TO CLOSE

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9591552	0.9898430	0.9959025	0.9999799	1.0000000	4.235E+01	4.345E-01
α_2	1.82E-05	1.02E-02	4.10E-03	4.08E-02	0.00E+00	4.345E-01	4.235E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496392	0.9824577	0.9872575	0.9988542	1.0000000	6.165E+01	1.101E+00
α_2	4.19E-04	1.33E-02	8.59E-03	4.22E-02	0.00E+00	8.337E-01	6.192E+01
α_3	1.49E-07	4.26E-03	8.56E-04	2.02E-02	0.00E+00	2.672E-01	6.249E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9443122	0.9768379	0.9806842	0.9962113	1.0000000	7.824E+01	1.855E+00
α_2	1.26E-03	1.53E-02	1.15E-02	4.24E-02	0.00E+00	1.228E+00	7.886E+01
α_3	5.67E-06	5.05E-03	1.87E-03	2.09E-02	0.00E+00	4.043E-01	7.969E+01
α_4	1.20E-08	2.78E-03	3.80E-04	1.39E-02	0.00E+00	2.227E-01	7.987E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9467348	0.9731543	0.9755158	0.9915054	1.0000000	1.283E+02	3.538E+00
α_2	3.08E-03	1.60E-02	1.37E-02	3.71E-02	0.00E+00	2.114E+00	1.297E+02
α_3	3.62E-04	7.42E-03	5.12E-03	2.23E-02	0.00E+00	9.774E-01	1.308E+02
α_4	1.87E-06	2.84E-03	9.56E-04	1.21E-02	0.00E+00	3.744E-01	1.314E+02
α_5	4.52E-21	5.48E-04	3.10E-07	3.17E-03	0.00E+00	7.228E-02	1.317E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9473552	0.9720930	0.9741246	0.9898957	1.0000000	1.490E+02	4.279E+00
α_2	3.00E-03	1.46E-02	1.26E-02	3.32E-02	0.00E+00	2.239E+00	1.511E+02
α_3	5.24E-04	7.45E-03	5.44E-03	2.12E-02	0.00E+00	1.142E+00	1.522E+02
α_4	3.45E-05	3.86E-03	2.02E-03	1.39E-02	0.00E+00	5.922E-01	1.527E+02
α_5	6.06E-09	1.45E-03	1.96E-04	7.26E-03	0.00E+00	2.222E-01	1.531E+02
α_6	9.19E-19	5.43E-04	9.49E-07	3.17E-03	0.00E+00	8.324E-02	1.532E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9505136	0.9710461	0.9724437	0.9867991	1.0000000	2.161E+02	6.445E+00
α_2	3.91E-03	1.39E-02	1.24E-02	2.87E-02	0.00E+00	3.088E+00	2.195E+02
α_3	9.87E-04	7.33E-03	5.91E-03	1.85E-02	0.00E+00	1.631E+00	2.210E+02
α_4	2.23E-04	4.44E-03	3.07E-03	1.33E-02	0.00E+00	9.889E-01	2.216E+02
α_5	1.15E-05	2.34E-03	1.11E-03	8.86E-03	0.00E+00	5.218E-01	2.221E+02
α_6	3.02E-10	8.37E-04	7.14E-05	4.39E-03	0.00E+00	1.863E-01	2.224E+02
α_7	4.57E-48	1.31E-04	1.14E-13	4.92E-04	0.00E+00	2.907E-02	2.226E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521830	0.9711140	0.9723199	0.9859137	1.0000000	2.508E+02	7.461E+00
α_2	3.89E-03	1.29E-02	1.17E-02	2.62E-02	0.00E+00	3.345E+00	2.549E+02
α_3	9.95E-04	6.73E-03	5.51E-03	1.66E-02	0.00E+00	1.738E+00	2.566E+02
α_4	3.14E-04	4.44E-03	3.24E-03	1.26E-02	0.00E+00	1.147E+00	2.571E+02
α_5	4.99E-05	2.74E-03	1.61E-03	9.28E-03	0.00E+00	7.083E-01	2.576E+02
α_6	8.04E-07	1.42E-03	4.65E-04	6.08E-03	0.00E+00	3.670E-01	2.579E+02
α_7	6.30E-14	4.76E-04	8.56E-06	2.71E-03	0.00E+00	1.230E-01	2.582E+02
α_8	1.18E-42	1.28E-04	1.83E-12	5.42E-04	0.00E+00	3.312E-02	2.583E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	32.10	32.10	32.10	32.10	32.10	32.10	32.10
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.3.8 BWR High Pressure Coolant Injection and Reactor Core Isolation Cooling Motor-Operated Valves

2.3.8.1 COMBINED HPCI/RCIC MOTOR OPERATED VALVE FAIL TO OPEN/CLOSE

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 94.4
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9615000	0.9899962	0.9954624	0.9999610	0.9985177	4.864E+01	4.915E-01
α_2	3.65E-05	1.00E-02	4.54E-03	3.85E-02	1.48E-03	4.915E-01	4.864E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9608940	0.9857658	0.9892320	0.9987704	0.9973022	8.700E+01	1.256E+00
α_2	5.50E-04	1.11E-02	7.71E-03	3.33E-02	2.56E-03	9.813E-01	8.728E+01
α_3	1.46E-07	3.12E-03	6.59E-04	1.46E-02	1.35E-04	2.750E-01	8.798E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9604725	0.9828573	0.9853686	0.9966627	0.9963159	1.226E+02	2.138E+00
α_2	1.38E-03	1.19E-02	9.40E-03	3.09E-02	3.32E-03	1.483E+00	1.232E+02
α_3	5.89E-06	3.46E-03	1.37E-03	1.40E-02	3.55E-04	4.315E-01	1.243E+02
α_4	8.15E-09	1.79E-03	2.47E-04	8.97E-03	1.30E-05	2.237E-01	1.245E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9609674	0.9797852	0.9813974	0.9930914	0.9956843	1.915E+02	3.952E+00
α_2	2.85E-03	1.26E-02	1.10E-02	2.78E-02	3.59E-03	2.458E+00	1.930E+02
α_3	3.03E-04	5.33E-03	3.76E-03	1.57E-02	6.69E-04	1.041E+00	1.944E+02
α_4	1.41E-06	1.94E-03	6.65E-04	8.21E-03	5.64E-05	3.798E-01	1.951E+02
α_5	3.36E-21	3.71E-04	2.13E-07	2.14E-03	1.77E-06	7.245E-02	1.954E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9624715	0.9795417	0.9808795	0.9920390	0.9952063	2.312E+02	4.829E+00
α_2	2.77E-03	1.13E-02	9.94E-03	2.44E-02	3.70E-03	2.665E+00	2.334E+02
α_3	4.49E-04	5.30E-03	3.98E-03	1.46E-02	9.48E-04	1.251E+00	2.348E+02
α_4	2.56E-05	2.57E-03	1.37E-03	9.21E-03	1.33E-04	6.075E-01	2.354E+02

α_5	4.19E-09	9.46E-04	1.29E-04	4.73E-03	9.18E-06	2.233E-01	2.358E+02
α_6	5.96E-19	3.53E-04	6.16E-07	2.06E-03	0.00E+00	8.324E-02	2.360E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.99E-01	9.97E-01	9.96E-01	9.96E-01	9.95E-01
α_2	1.48E-03	2.56E-03	3.32E-03	3.59E-03	3.70E-03
α_3		1.35E-04	3.55E-04	6.69E-04	9.48E-04
α_4			1.30E-05	5.64E-05	1.33E-04
α_5				1.77E-06	9.18E-06
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.99E-01	9.97E-01	9.96E-01	9.96E-01	9.95E-01
Beta	1.48E-03	2.70E-03	3.68E-03	4.32E-03	4.79E-03
Gamma		5.02E-02	9.98E-02	1.68E-01	2.27E-01
Delta			3.55E-02	8.00E-02	1.30E-01
Epsilon				3.04E-02	6.47E-02
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	37.76	56.64	75.52	94.40	113.28
N_1	0.6360	0.8064	0.9056	0.9685	0.9977
N_2	0.0570	0.1476	0.2544	0.3437	0.4253
N_3		0.0078	0.0272	0.0641	0.1088
N_4			0.0010	0.0054	0.0152
N_5				0.0002	0.0011
N_6					0.0000

2.3.8.2 COMBINED HPCI AND RCIC MOTOR OPERATED VALVE FAIL TO OPEN

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 50.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9363741	0.9841141	0.9935117	0.9999676	0.9998809	2.704E+01	4.365E-01
α_2	2.96E-05	1.59E-02	6.49E-03	6.36E-02	1.19E-04	4.365E-01	2.704E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432822	0.9801830	0.9855645	0.9986813	0.9997658	5.474E+01	1.107E+00
α_2	4.85E-04	1.50E-02	9.76E-03	4.76E-02	2.32E-04	8.395E-01	5.501E+01
α_3	1.68E-07	4.79E-03	9.63E-04	2.27E-02	1.98E-06	2.673E-01	5.558E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9450881	0.9771182	0.9808973	0.9962266	0.9996546	7.971E+01	1.867E+00
α_2	1.28E-03	1.52E-02	1.15E-02	4.19E-02	3.39E-04	1.240E+00	8.034E+01
α_3	5.59E-06	4.96E-03	1.84E-03	2.05E-02	5.95E-06	4.045E-01	8.117E+01
α_4	1.18E-08	2.73E-03	3.73E-04	1.37E-02	0.00E+00	2.227E-01	8.136E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9502236	0.9748923	0.9770974	0.9920342	0.9995474	1.381E+02	3.557E+00
α_2	2.92E-03	1.51E-02	1.28E-02	3.48E-02	4.41E-04	2.133E+00	1.395E+02
α_3	3.37E-04	6.90E-03	4.76E-03	2.08E-02	1.19E-05	9.779E-01	1.407E+02
α_4	1.73E-06	2.64E-03	8.89E-04	1.12E-02	0.00E+00	3.744E-01	1.413E+02
α_5	4.21E-21	5.10E-04	2.88E-07	2.95E-03	0.00E+00	7.228E-02	1.416E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9526820	0.9749014	0.9767278	0.9908852	0.9994441	1.673E+02	4.307E+00
α_2	2.74E-03	1.32E-02	1.14E-02	3.00E-02	5.36E-04	2.266E+00	1.693E+02
α_3	4.69E-04	6.66E-03	4.87E-03	1.90E-02	1.99E-05	1.143E+00	1.704E+02
α_4	3.08E-05	3.45E-03	1.81E-03	1.25E-02	0.00E+00	5.922E-01	1.710E+02
α_5	5.41E-09	1.29E-03	1.75E-04	6.49E-03	0.00E+00	2.222E-01	1.714E+02
α_6	8.21E-19	4.85E-04	8.48E-07	2.83E-03	0.00E+00	8.324E-02	1.715E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01
α_2	1.19E-04	2.32E-04	3.39E-04	4.41E-04	5.36E-04
α_3		1.98E-06	5.95E-06	1.19E-05	1.99E-05
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01
Beta	1.19E-04	2.34E-04	3.45E-04	4.53E-04	5.56E-04
Gamma		8.47E-03	1.72E-02	2.63E-02	3.57E-02
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	16.70	25.05	33.40	41.75	50.10
N_1	0.0960	0.1382	0.1766	0.2115	0.2430
N_2	0.0020	0.0059	0.0114	0.0185	0.0270
N_3		0.0001	0.0002	0.0005	0.0010
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.3.8.3 COMBINED HPCI AND RCIC MOTOR OPERATED VALVE FAIL TO CLOSE

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 38.3
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9381616	0.9839109	0.9926687	0.9999391	0.9972145	2.994E+01	4.895E-01
α_2	5.79E-05	1.61E-02	7.33E-03	6.18E-02	2.79E-03	4.895E-01	2.994E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9430365	0.9792291	0.9842605	0.9982144	0.9949395	5.895E+01	1.250E+00
α_2	7.93E-04	1.62E-02	1.12E-02	4.86E-02	4.80E-03	9.754E-01	5.922E+01
α_3	2.14E-07	4.57E-03	9.68E-04	2.15E-02	2.62E-04	2.750E-01	5.992E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9439232	0.9756438	0.9791828	0.9952656	0.9931043	8.516E+01	2.126E+00
α_2	1.94E-03	1.69E-02	1.33E-02	4.38E-02	6.18E-03	1.471E+00	8.582E+01
α_3	8.40E-06	4.94E-03	1.96E-03	2.00E-02	6.87E-04	4.313E-01	8.686E+01
α_4	1.17E-08	2.56E-03	3.54E-04	1.28E-02	2.54E-05	2.237E-01	8.707E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9489905	0.9735579	0.9756561	0.9909634	0.9919560	1.448E+02	3.933E+00
α_2	3.70E-03	1.64E-02	1.43E-02	3.63E-02	6.63E-03	2.439E+00	1.463E+02
α_3	3.99E-04	7.00E-03	4.95E-03	2.06E-02	1.30E-03	1.041E+00	1.477E+02
α_4	1.86E-06	2.55E-03	8.74E-04	1.08E-02	1.10E-04	3.798E-01	1.483E+02
α_5	4.42E-21	4.87E-04	2.81E-07	2.82E-03	3.45E-06	7.245E-02	1.487E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9510856	0.9733191	0.9750572	0.9896222	0.9911037	1.751E+02	4.801E+00
α_2	3.57E-03	1.47E-02	1.29E-02	3.17E-02	6.78E-03	2.638E+00	1.773E+02
α_3	5.89E-04	6.94E-03	5.22E-03	1.92E-02	1.84E-03	1.250E+00	1.787E+02
α_4	3.36E-05	3.38E-03	1.80E-03	1.21E-02	2.60E-04	6.075E-01	1.793E+02
α_5	5.50E-09	1.24E-03	1.70E-04	6.21E-03	1.80E-05	2.233E-01	1.797E+02
α_6	7.83E-19	4.63E-04	8.08E-07	2.70E-03	0.00E+00	8.324E-02	1.799E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.97E-01	9.95E-01	9.93E-01	9.92E-01	9.91E-01
α_2	2.79E-03	4.80E-03	6.18E-03	6.63E-03	6.78E-03
α_3		2.62E-04	6.87E-04	1.30E-03	1.84E-03
α_4			2.54E-05	1.10E-04	2.60E-04
α_5				3.45E-06	1.80E-05
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.97E-01	9.95E-01	9.93E-01	9.92E-01	9.91E-01
Beta	2.79E-03	5.06E-03	6.90E-03	8.04E-03	8.90E-03
Gamma		5.18E-02	1.03E-01	1.75E-01	2.38E-01
Delta			3.57E-02	8.06E-02	1.31E-01
Epsilon				3.04E-02	6.47E-02
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	19.15	28.72	38.30	47.87	57.45
N_1	0.5400	0.6683	0.7290	0.7570	0.7547
N_2	0.0550	0.1418	0.2430	0.3252	0.3983
N_3		0.0078	0.0270	0.0636	0.1078
N_4			0.0010	0.0054	0.0152
N_5				0.0002	0.0011
N_6					0.0000

2.3.9 Pressurizer PORV Motor-Operated Block Valves

2.3.9.1 PRESSURIZER PORV BLOCK MOVS FAIL TO OPEN

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 7.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9017825	0.9754238	0.9898734	0.9999510	1.0000000	1.725E+01	4.345E-01
α_2	4.52E-05	2.46E-02	1.01E-02	9.82E-02	0.00E+00	4.345E-01	1.725E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9165865	0.9707647	0.9786214	0.9980670	1.0000000	3.656E+01	1.101E+00
α_2	7.05E-04	2.21E-02	1.44E-02	7.00E-02	0.00E+00	8.337E-01	3.682E+01
α_3	2.49E-07	7.10E-03	1.44E-03	3.37E-02	0.00E+00	2.672E-01	3.739E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9192917	0.9662658	0.9717542	0.9944392	1.0000000	5.314E+01	1.855E+00
α_2	1.85E-03	2.23E-02	1.68E-02	6.16E-02	0.00E+00	1.228E+00	5.376E+01
α_3	8.29E-06	7.35E-03	2.73E-03	3.04E-02	0.00E+00	4.043E-01	5.459E+01
α_4	1.75E-08	4.05E-03	5.55E-04	2.03E-02	0.00E+00	2.227E-01	5.477E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	7.00	7.00	7.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.3.9.2 PRESSURIZER PORV BLOCK MOVS FAIL TO CLOSE

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Motor Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 7.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9017825	0.9754238	0.9898734	0.9999510	1.0000000	1.725E+01	4.345E-01
α_2	4.52E-05	2.46E-02	1.01E-02	9.82E-02	0.00E+00	4.345E-01	1.725E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9165865	0.9707647	0.9786214	0.9980670	1.0000000	3.656E+01	1.101E+00
α_2	7.05E-04	2.21E-02	1.44E-02	7.00E-02	0.00E+00	8.337E-01	3.682E+01
α_3	2.49E-07	7.10E-03	1.44E-03	3.37E-02	0.00E+00	2.672E-01	3.739E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9192917	0.9662658	0.9717542	0.9944392	1.0000000	5.314E+01	1.855E+00
α_2	1.85E-03	2.23E-02	1.68E-02	6.16E-02	0.00E+00	1.228E+00	5.376E+01
α_3	8.29E-06	7.35E-03	2.73E-03	3.04E-02	0.00E+00	4.043E-01	5.459E+01
α_4	1.75E-08	4.05E-03	5.55E-04	2.03E-02	0.00E+00	2.227E-01	5.477E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	7.00	7.00	7.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.4 Air Operated Valves

2.4.1 Pooled Air Operated Valves

2.4.1.1 AOV FAIL TO OPEN/CLOSE ALL SYSTEMS SPAR: AOV-FTOC

Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 266.2
Total Number of Common-Cause Failure Events: 14

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9316032	0.9623349	0.9646721	0.9850685	0.9626036	1.257E+02	4.920E+00
α_2	1.49E-02	3.77E-02	3.53E-02	6.84E-02	3.74E-02	4.920E+00	1.257E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9365029	0.9608593	0.9623337	0.9801731	0.9602981	1.990E+02	8.105E+00
α_2	9.95E-03	2.47E-02	2.32E-02	4.46E-02	2.42E-02	5.111E+00	2.020E+02
α_3	3.96E-03	1.45E-02	1.29E-02	3.02E-02	1.55E-02	2.993E+00	2.041E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9408368	0.9614152	0.9625105	0.9782581	0.9614296	2.694E+02	1.081E+01
α_2	8.19E-03	1.96E-02	1.84E-02	3.48E-02	1.83E-02	5.485E+00	2.747E+02
α_3	3.25E-03	1.13E-02	1.02E-02	2.33E-02	1.19E-02	3.170E+00	2.771E+02
α_4	1.51E-03	7.70E-03	6.56E-03	1.78E-02	8.33E-03	2.157E+00	2.781E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9472881	0.9640640	0.9648620	0.9781269	0.9639091	3.735E+02	1.392E+01
α_2	7.93E-03	1.72E-02	1.64E-02	2.93E-02	1.58E-02	6.658E+00	3.807E+02
α_3	2.31E-03	8.12E-03	7.29E-03	1.68E-02	7.53E-03	3.144E+00	3.842E+02
α_4	2.02E-03	7.54E-03	6.72E-03	1.59E-02	8.86E-03	2.923E+00	3.845E+02
α_5	2.39E-04	3.09E-03	2.29E-03	8.68E-03	3.91E-03	1.197E+00	3.862E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9513912	0.9662194	0.9668848	0.9787643	0.9667553	4.485E+02	1.568E+01
α_2	6.66E-03	1.44E-02	1.37E-02	2.45E-02	1.30E-02	6.694E+00	4.575E+02
α_3	2.15E-03	7.18E-03	6.49E-03	1.46E-02	6.39E-03	3.333E+00	4.608E+02

α_4	1.37E-03	5.67E-03	4.98E-03	1.23E-02	5.95E-03	2.631E+00	4.615E+02
α_5	9.99E-04	4.86E-03	4.17E-03	1.11E-02	5.93E-03	2.255E+00	4.619E+02
α_6	3.93E-05	1.65E-03	1.01E-03	5.43E-03	1.99E-03	7.661E-01	4.634E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9560032	0.9686471	0.9691735	0.9794783	0.9698338	5.701E+02	1.845E+01
α_2	5.63E-03	1.19E-02	1.14E-02	2.01E-02	9.89E-03	7.023E+00	5.816E+02
α_3	2.48E-03	7.05E-03	6.50E-03	1.35E-02	6.33E-03	4.150E+00	5.845E+02
α_4	1.07E-03	4.46E-03	3.91E-03	9.71E-03	4.11E-03	2.624E+00	5.860E+02
α_5	9.63E-04	4.22E-03	3.67E-03	9.35E-03	4.93E-03	2.484E+00	5.861E+02
α_6	4.18E-04	2.90E-03	2.36E-03	7.23E-03	3.82E-03	1.709E+00	5.869E+02
α_7	2.05E-06	7.88E-04	3.35E-04	3.11E-03	1.09E-03	4.638E-01	5.881E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9591981	0.9705853	0.9710430	0.9803943	0.9723674	6.594E+02	1.998E+01
α_2	4.62E-03	9.97E-03	9.49E-03	1.69E-02	7.56E-03	6.771E+00	6.726E+02
α_3	2.55E-03	6.79E-03	6.31E-03	1.27E-02	6.34E-03	4.611E+00	6.748E+02
α_4	9.06E-04	3.81E-03	3.33E-03	8.33E-03	3.18E-03	2.588E+00	6.768E+02
α_5	7.40E-04	3.45E-03	2.98E-03	7.78E-03	3.61E-03	2.344E+00	6.770E+02
α_6	5.89E-04	3.10E-03	2.63E-03	7.23E-03	3.84E-03	2.108E+00	6.773E+02
α_7	1.52E-04	1.82E-03	1.37E-03	5.07E-03	2.46E-03	1.240E+00	6.781E+02
α_8	9.74E-08	4.75E-04	1.30E-04	2.12E-03	6.39E-04	3.229E-01	6.791E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.63E-01	9.60E-01	9.61E-01	9.64E-01	9.67E-01	9.70E-01	9.72E-01
α_2	3.74E-02	2.42E-02	1.83E-02	1.58E-02	1.30E-02	9.89E-03	7.56E-03
α_3		1.55E-02	1.19E-02	7.53E-03	6.39E-03	6.33E-03	6.34E-03
α_4			8.33E-03	8.86E-03	5.95E-03	4.11E-03	3.18E-03
α_5				3.91E-03	5.93E-03	4.93E-03	3.61E-03
α_6					1.99E-03	3.82E-03	3.84E-03
α_7						1.09E-03	2.46E-03
α_8							6.39E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.63E-01	9.60E-01	9.61E-01	9.64E-01	9.67E-01	9.70E-01	9.72E-01

Beta	3.74E-02	3.97E-02	3.86E-02	3.61E-02	3.32E-02	3.02E-02	2.76E-02
Gamma		3.89E-01	5.25E-01	5.62E-01	6.09E-01	6.72E-01	7.26E-01
Delta			4.12E-01	6.29E-01	6.84E-01	6.88E-01	6.84E-01
Epsilon				3.06E-01	5.71E-01	7.06E-01	7.68E-01
Mu					2.51E-01	4.99E-01	6.58E-01
Omega						2.22E-01	4.47E-01
Sigma							2.06E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	109.61	164.42	219.22	274.03	328.84	383.64	438.45
N_1	5.8458	4.9910	4.0502	3.2804	2.7147	2.4576	2.2219
N_2	4.4854	4.2777	4.2566	4.5436	4.4551	3.9356	3.4260
N_3		2.7262	2.7659	2.1668	2.1916	2.5192	2.8724
N_4			1.9347	2.5483	2.0392	1.6349	1.4412
N_5				1.1244	2.0325	1.9626	1.6357
N_6					0.6829	1.5223	1.7410
N_7						0.4347	1.1168
N_8							0.2898

2.4.1.2 AOV FAIL TO OPEN ALL SYSTEMS

Components/Valve/Air Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 156.8
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9478017	0.9803390	0.9846967	0.9979731	0.9841191	6.870E+01	1.378E+00
α_2	2.02E-03	1.97E-02	1.53E-02	5.22E-02	1.59E-02	1.378E+00	6.870E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9473436	0.9746281	0.9772479	0.9929582	0.9782936	1.158E+02	3.014E+00
α_2	4.06E-03	1.93E-02	1.66E-02	4.35E-02	1.65E-02	2.289E+00	1.165E+02
α_3	1.22E-04	6.11E-03	3.65E-03	2.05E-02	5.20E-03	7.256E-01	1.181E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9473767	0.9714253	0.9733176	0.9890154	0.9755751	1.599E+02	4.702E+00
α_2	5.32E-03	1.88E-02	1.69E-02	3.88E-02	1.60E-02	3.096E+00	1.615E+02
α_3	4.31E-04	6.68E-03	4.81E-03	1.93E-02	5.96E-03	1.099E+00	1.635E+02
α_4	1.32E-05	3.08E-03	1.43E-03	1.18E-02	2.44E-03	5.074E-01	1.641E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9509329	0.9705887	0.9718611	0.9858863	0.9747736	2.373E+02	7.191E+00
α_2	6.35E-03	1.76E-02	1.63E-02	3.32E-02	1.51E-02	4.295E+00	2.402E+02
α_3	1.06E-03	7.13E-03	5.84E-03	1.76E-02	5.29E-03	1.744E+00	2.428E+02
α_4	1.44E-04	3.69E-03	2.45E-03	1.14E-02	3.64E-03	9.010E-01	2.436E+02
α_5	1.88E-08	1.03E-03	1.83E-04	4.97E-03	1.24E-03	2.517E-01	2.442E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9523012	0.9701994	0.9712580	0.9844764	0.9740536	2.853E+02	8.764E+00
α_2	6.48E-03	1.66E-02	1.55E-02	3.04E-02	1.52E-02	4.875E+00	2.892E+02
α_3	1.04E-03	6.35E-03	5.27E-03	1.54E-02	4.20E-03	1.868E+00	2.922E+02
α_4	3.27E-04	4.12E-03	3.06E-03	1.15E-02	3.58E-03	1.211E+00	2.929E+02
α_5	2.14E-05	2.08E-03	1.11E-03	7.43E-03	2.26E-03	6.122E-01	2.935E+02
α_6	5.80E-10	6.72E-04	6.76E-05	3.47E-03	6.62E-04	1.976E-01	2.939E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9556014	0.9708112	0.9716120	0.9832947	0.9752159	3.799E+02	1.142E+01
α_2	6.26E-03	1.46E-02	1.38E-02	2.58E-02	1.31E-02	5.728E+00	3.856E+02

α_3	1.47E-03	6.38E-03	5.56E-03	1.41E-02	4.31E-03	2.498E+00	3.888E+02
α_4	5.25E-04	4.06E-03	3.25E-03	1.04E-02	2.99E-03	1.590E+00	3.898E+02
α_5	1.47E-04	2.64E-03	1.86E-03	7.81E-03	2.55E-03	1.034E+00	3.903E+02
α_6	3.44E-06	1.20E-03	5.20E-04	4.72E-03	1.42E-03	4.714E-01	3.909E+02
α_7	3.37E-16	2.63E-04	1.83E-06	1.52E-03	3.67E-04	1.027E-01	3.912E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9576773	0.9715510	0.9722380	0.9830792	0.9760366	4.420E+02	1.294E+01
α_2	5.91E-03	1.34E-02	1.27E-02	2.33E-02	1.20E-02	6.097E+00	4.488E+02
α_3	1.45E-03	5.89E-03	5.19E-03	1.28E-02	4.12E-03	2.682E+00	4.523E+02
α_4	5.54E-04	3.79E-03	3.10E-03	9.42E-03	2.53E-03	1.726E+00	4.532E+02
α_5	2.28E-04	2.73E-03	2.05E-03	7.58E-03	2.34E-03	1.243E+00	4.537E+02
α_6	4.43E-05	1.72E-03	1.07E-03	5.63E-03	1.82E-03	7.840E-01	4.542E+02
α_7	1.78E-07	7.25E-04	2.05E-04	3.21E-03	9.04E-04	3.298E-01	4.546E+02
α_8	1.10E-19	1.78E-04	2.51E-07	1.04E-03	2.09E-04	8.093E-02	4.549E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.84E-01	9.78E-01	9.76E-01	9.75E-01	9.74E-01	9.75E-01	9.76E-01
α_2	1.59E-02	1.65E-02	1.60E-02	1.51E-02	1.52E-02	1.31E-02	1.20E-02
α_3		5.20E-03	5.96E-03	5.29E-03	4.20E-03	4.31E-03	4.12E-03
α_4			2.44E-03	3.64E-03	3.58E-03	2.99E-03	2.53E-03
α_5				1.24E-03	2.26E-03	2.55E-03	2.34E-03
α_6					6.62E-04	1.42E-03	1.82E-03
α_7						3.67E-04	9.04E-04
α_8							2.09E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.78E-01	9.76E-01	9.75E-01	9.74E-01	9.75E-01	9.76E-01
Beta	1.59E-02	2.17E-02	2.44E-02	2.52E-02	2.59E-02	2.48E-02	2.40E-02
Gamma		2.40E-01	3.44E-01	4.03E-01	4.12E-01	4.70E-01	4.98E-01
Delta			2.91E-01	4.80E-01	6.07E-01	6.29E-01	6.54E-01
Epsilon				2.54E-01	4.49E-01	5.92E-01	6.75E-01
Mu					2.27E-01	4.12E-01	5.57E-01
Omega						2.05E-01	3.79E-01
Sigma							1.88E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	55.34	83.01	110.68	138.35	166.02	193.69	221.36
N_1	3.1134	3.2153	3.0416	2.7951	2.3552	2.1731	1.9076
N_2	0.9433	1.4549	1.8681	2.1806	2.6360	2.6397	2.7523
N_3		0.4583	0.6944	0.7662	0.7261	0.8663	0.9435
N_4			0.2847	0.5266	0.6186	0.6009	0.5797
N_5				0.1794	0.3900	0.5121	0.5345
N_6					0.1144	0.2851	0.4170
N_7						0.0737	0.2068
N_8							0.0478

2.4.1.3 AOV FAIL TO CLOSE ALL SYSTEMS

Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 98.4
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8959842	0.9495524	0.9545678	0.9859631	0.9473943	5.603E+01	2.977E+00
α_2	1.40E-02	5.04E-02	4.54E-02	1.04E-01	5.26E-02	2.977E+00	5.603E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9083614	0.9486475	0.9515836	0.9788923	0.9419274	9.591E+01	5.192E+00
α_2	9.04E-03	3.12E-02	2.82E-02	6.38E-02	3.30E-02	3.157E+00	9.794E+01
α_3	3.70E-03	2.01E-02	1.71E-02	4.71E-02	2.51E-02	2.035E+00	9.906E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9170304	0.9503238	0.9524576	0.9763378	0.9445882	1.332E+02	6.965E+00
α_2	7.30E-03	2.40E-02	2.18E-02	4.83E-02	2.32E-02	3.367E+00	1.368E+02
α_3	2.49E-03	1.41E-02	1.19E-02	3.33E-02	1.70E-02	1.976E+00	1.382E+02
α_4	1.55E-03	1.16E-02	9.35E-03	2.92E-02	1.52E-02	1.623E+00	1.386E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9315342	0.9565958	0.9580138	0.9768103	0.9496640	2.043E+02	9.269E+00
α_2	7.44E-03	2.04E-02	1.89E-02	3.84E-02	1.97E-02	4.352E+00	2.092E+02
α_3	1.68E-03	9.38E-03	7.90E-03	2.21E-02	9.01E-03	2.003E+00	2.115E+02
α_4	1.71E-03	9.46E-03	7.98E-03	2.23E-02	1.45E-02	2.021E+00	2.115E+02
α_5	1.59E-04	4.18E-03	2.77E-03	1.30E-02	7.20E-03	8.923E-01	2.126E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9384266	0.9602767	0.9614699	0.9780606	0.9563147	2.464E+02	1.019E+01
α_2	5.35E-03	1.56E-02	1.43E-02	3.00E-02	1.30E-02	3.996E+00	2.526E+02
α_3	1.99E-03	9.19E-03	7.94E-03	2.06E-02	8.98E-03	2.357E+00	2.543E+02
α_4	8.64E-04	6.38E-03	5.15E-03	1.61E-02	7.72E-03	1.638E+00	2.550E+02
α_5	8.34E-04	6.29E-03	5.06E-03	1.59E-02	1.03E-02	1.615E+00	2.550E+02
α_6	2.00E-05	2.30E-03	1.20E-03	8.31E-03	3.74E-03	5.892E-01	2.561E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9463237	0.9640945	0.9649804	0.9788396	0.9615796	3.350E+02	1.248E+01
α_2	4.55E-03	1.25E-02	1.16E-02	2.36E-02	8.06E-03	4.352E+00	3.431E+02

α_3	2.56E-03	9.00E-03	8.08E-03	1.86E-02	9.53E-03	3.128E+00	3.444E+02
α_4	7.10E-04	4.92E-03	4.01E-03	1.23E-02	4.60E-03	1.710E+00	3.458E+02
α_5	6.59E-04	4.78E-03	3.87E-03	1.20E-02	7.25E-03	1.660E+00	3.458E+02
α_6	3.17E-04	3.65E-03	2.75E-03	1.00E-02	6.89E-03	1.267E+00	3.462E+02
α_7	4.94E-07	1.03E-03	3.28E-04	4.45E-03	2.10E-03	3.589E-01	3.471E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9507809	0.9666405	0.9674048	0.9798863	0.9661666	3.912E+02	1.350E+01
α_2	3.40E-03	9.89E-03	9.09E-03	1.91E-02	3.69E-03	4.003E+00	4.007E+02
α_3	2.79E-03	8.83E-03	8.03E-03	1.76E-02	1.03E-02	3.574E+00	4.012E+02
α_4	6.66E-04	4.38E-03	3.60E-03	1.08E-02	3.51E-03	1.774E+00	4.030E+02
α_5	4.34E-04	3.70E-03	2.92E-03	9.62E-03	4.42E-03	1.497E+00	4.032E+02
α_6	4.03E-04	3.60E-03	2.82E-03	9.45E-03	6.10E-03	1.457E+00	4.033E+02
α_7	1.01E-04	2.32E-03	1.57E-03	7.10E-03	4.57E-03	9.391E-01	4.038E+02
α_8	1.63E-08	6.41E-04	1.21E-04	3.07E-03	1.27E-03	2.595E-01	4.045E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.47E-01	9.42E-01	9.45E-01	9.50E-01	9.56E-01	9.62E-01	9.66E-01
α_2	5.26E-02	3.30E-02	2.32E-02	1.97E-02	1.30E-02	8.06E-03	3.69E-03
α_3		2.51E-02	1.70E-02	9.01E-03	8.98E-03	9.53E-03	1.03E-02
α_4			1.52E-02	1.45E-02	7.72E-03	4.60E-03	3.51E-03
α_5				7.20E-03	1.03E-02	7.25E-03	4.42E-03
α_6					3.74E-03	6.89E-03	6.10E-03
α_7						2.10E-03	4.57E-03
α_8							1.27E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.47E-01	9.42E-01	9.45E-01	9.50E-01	9.56E-01	9.62E-01	9.66E-01
Beta	5.26E-02	5.81E-02	5.54E-02	5.03E-02	4.37E-02	3.84E-02	3.38E-02
Gamma		4.32E-01	5.81E-01	6.09E-01	7.03E-01	7.90E-01	8.91E-01
Delta			4.71E-01	7.06E-01	7.08E-01	6.86E-01	6.59E-01
Epsilon				3.32E-01	6.45E-01	7.79E-01	8.23E-01
Mu					2.67E-01	5.53E-01	7.30E-01
Omega						2.34E-01	4.89E-01
Sigma							2.17E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	43.05	64.57	86.10	107.62	129.15	150.67	172.20
N_1	2.7324	1.7757	1.0086	0.4854	0.3594	0.2845	0.3143
N_2	2.5421	2.3229	2.1386	2.2380	1.7566	1.2647	0.6581
N_3		1.7679	1.5714	1.0256	1.2155	1.4966	1.8352
N_4			1.4000	1.6467	1.0456	0.7216	0.6271
N_5				0.8200	1.3924	1.1381	0.7887
N_6					0.5060	1.0809	1.0896
N_7						0.3298	0.8162
N_8							0.2263

2.4.1.4 AOV SPURIOUS OPERATION ALL SYSTEMS

Components/Valve/Air Operated Valve
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 56.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9446081	0.9788358	0.9833405	0.9976606	0.9824869	6.635E+01	1.435E+00
α_2	2.34E-03	2.12E-02	1.67E-02	5.54E-02	1.75E-02	1.435E+00	6.635E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9579622	0.9818586	0.9845561	0.9965381	0.9882560	1.137E+02	2.101E+00
α_2	1.11E-03	1.15E-02	8.85E-03	3.10E-02	5.87E-03	1.334E+00	1.145E+02
α_3	1.60E-04	6.63E-03	4.08E-03	2.17E-02	5.87E-03	7.672E-01	1.150E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9625575	0.9822876	0.9842455	0.9953402	0.9911661	1.583E+02	2.855E+00
α_2	1.06E-03	9.17E-03	7.23E-03	2.39E-02	2.21E-03	1.478E+00	1.597E+02
α_3	2.22E-04	5.61E-03	3.74E-03	1.74E-02	4.42E-03	9.043E-01	1.603E+02
α_4	8.53E-06	2.93E-03	1.27E-03	1.15E-02	2.21E-03	4.727E-01	1.607E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648900	0.9811651	0.9824787	0.9929492	0.9929204	2.364E+02	4.538E+00
α_2	1.90E-03	9.29E-03	7.97E-03	2.12E-02	8.85E-04	2.239E+00	2.387E+02
α_3	5.52E-04	5.61E-03	4.32E-03	1.51E-02	2.65E-03	1.352E+00	2.396E+02
α_4	6.90E-05	3.11E-03	1.89E-03	1.03E-02	2.65E-03	7.494E-01	2.402E+02
α_5	6.89E-10	8.19E-04	8.21E-05	4.24E-03	8.85E-04	1.973E-01	2.408E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9673587	0.9818302	0.9829226	0.9925576	0.9940933	2.852E+02	5.279E+00
α_2	1.67E-03	7.92E-03	6.83E-03	1.79E-02	3.69E-04	2.302E+00	2.882E+02
α_3	4.96E-04	4.79E-03	3.71E-03	1.28E-02	1.48E-03	1.392E+00	2.891E+02
α_4	1.57E-04	3.33E-03	2.28E-03	1.01E-02	2.22E-03	9.672E-01	2.896E+02
α_5	4.69E-06	1.63E-03	7.03E-04	6.37E-03	1.48E-03	4.722E-01	2.900E+02
α_6	2.56E-12	5.02E-04	1.87E-05	2.78E-03	3.69E-04	1.457E-01	2.904E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9681248	0.9808042	0.9816227	0.9906765	0.9949329	3.804E+02	7.445E+00
α_2	2.28E-03	8.04E-03	7.21E-03	1.66E-02	1.58E-04	3.119E+00	3.847E+02
α_3	7.08E-04	4.61E-03	3.79E-03	1.13E-02	7.92E-04	1.787E+00	3.861E+02
α_4	3.07E-04	3.36E-03	2.55E-03	9.16E-03	1.58E-03	1.301E+00	3.865E+02
α_5	6.72E-05	2.15E-03	1.38E-03	6.87E-03	1.58E-03	8.343E-01	3.870E+02
α_6	2.94E-07	8.83E-04	2.63E-04	3.87E-03	7.92E-04	3.425E-01	3.875E+02
α_7	4.11E-25	1.56E-04	1.55E-08	8.74E-04	1.58E-04	6.032E-02	3.878E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9697094	0.9812641	0.9819679	0.9904080	0.9955634	4.431E+02	8.461E+00
α_2	2.24E-03	7.44E-03	6.73E-03	1.51E-02	6.93E-05	3.360E+00	4.482E+02
α_3	6.44E-04	4.06E-03	3.35E-03	9.88E-03	4.16E-04	1.832E+00	4.498E+02
α_4	3.12E-04	3.06E-03	2.36E-03	8.18E-03	1.04E-03	1.381E+00	4.502E+02
α_5	1.22E-04	2.26E-03	1.58E-03	6.72E-03	1.39E-03	1.021E+00	4.506E+02
α_6	1.27E-05	1.33E-03	7.03E-04	4.78E-03	1.04E-03	6.013E-01	4.510E+02
α_7	1.45E-09	4.80E-04	6.11E-05	2.42E-03	4.16E-04	2.167E-01	4.514E+02
α_8	2.65E-30	1.08E-04	8.65E-10	5.69E-04	6.93E-05	4.875E-02	4.515E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.82E-01	9.88E-01	9.91E-01	9.93E-01	9.94E-01	9.95E-01	9.96E-01
α_2	1.75E-02	5.87E-03	2.21E-03	8.85E-04	3.69E-04	1.58E-04	6.93E-05
α_3		5.87E-03	4.42E-03	2.65E-03	1.48E-03	7.92E-04	4.16E-04
α_4			2.21E-03	2.65E-03	2.22E-03	1.58E-03	1.04E-03
α_5				8.85E-04	1.48E-03	1.58E-03	1.39E-03
α_6					3.69E-04	7.92E-04	1.04E-03
α_7						1.58E-04	4.16E-04
α_8							6.93E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.88E-01	9.91E-01	9.93E-01	9.94E-01	9.95E-01	9.96E-01
Beta	1.75E-02	1.17E-02	8.83E-03	7.08E-03	5.91E-03	5.07E-03	4.44E-03
Gamma		5.00E-01	7.50E-01	8.75E-01	9.38E-01	9.69E-01	9.84E-01
Delta			3.33E-01	5.71E-01	7.33E-01	8.39E-01	9.05E-01
Epsilon				2.50E-01	4.55E-01	6.15E-01	7.37E-01
Mu					2.00E-01	3.75E-01	5.24E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	56.10	84.15	112.20	140.25	168.30	196.35	224.40
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.5000	0.2500	0.1250	0.0625	0.0313	0.0156
N_3		0.5000	0.5000	0.3750	0.2500	0.1563	0.0938
N_4			0.2500	0.3750	0.3750	0.3125	0.2344
N_5				0.1250	0.2500	0.3125	0.3125
N_6					0.0625	0.1563	0.2344
N_7						0.0313	0.0938
N_8							0.0156

2.4.2 BWR Isolation Condenser Air-Operated Valves

2.4.2.1 ISO CONDENSER AOV FAIL TO OPEN/CLOSE

Systems/Clean Water/Isolation condenser
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7072886	0.8822283	0.9029716	0.9858655	0.3333333	1.075E+01	1.435E+00
α_2	1.41E-02	1.18E-01	9.70E-02	2.93E-01	6.67E-01	1.435E+00	1.075E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8529310	0.9351698	0.9439761	0.9872253	0.4285714	3.031E+01	2.101E+00
α_2	8.23E-04	2.57E-02	1.68E-02	8.11E-02	0.00E+00	8.337E-01	3.157E+01
α_3	3.50E-03	3.91E-02	3.00E-02	1.06E-01	5.71E-01	1.267E+00	3.114E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8811767	0.9428882	0.9487187	0.9846286	0.5000000	4.714E+01	2.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	2.02E-03	2.45E-02	1.84E-02	6.75E-02	5.00E-01	1.223E+00	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9177321	0.9554852	0.9584355	0.9831432	0.5555556	9.741E+01	4.538E+00
α_2	4.00E-03	2.07E-02	1.77E-02	4.79E-02	0.00E+00	2.114E+00	9.984E+01
α_3	4.69E-04	9.59E-03	6.63E-03	2.88E-02	0.00E+00	9.774E-01	1.010E+02
α_4	3.10E-04	8.58E-03	5.65E-03	2.68E-02	2.22E-01	8.744E-01	1.011E+02
α_5	4.31E-05	5.61E-03	2.87E-03	2.05E-02	2.22E-01	5.723E-01	1.014E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9239513	0.9573334	0.9597819	0.9823620	0.6000000	1.184E+02	5.279E+00
α_2	3.72E-03	1.81E-02	1.56E-02	4.11E-02	0.00E+00	2.239E+00	1.215E+02
α_3	6.50E-04	9.23E-03	6.75E-03	2.63E-02	0.00E+00	1.142E+00	1.226E+02
α_4	2.20E-04	6.81E-03	4.40E-03	2.16E-02	1.00E-01	8.422E-01	1.229E+02
α_5	1.14E-04	5.84E-03	3.48E-03	1.96E-02	2.00E-01	7.222E-01	1.230E+02
α_6	7.21E-07	2.69E-03	7.75E-04	1.19E-02	1.00E-01	3.332E-01	1.234E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	3.33E-01	4.29E-01	5.00E-01	5.56E-01	6.00E-01
α_2	6.67E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		5.71E-01	0.00E+00	0.00E+00	0.00E+00
α_4			5.00E-01	2.22E-01	1.00E-01
α_5				2.22E-01	2.00E-01
α_6					1.00E-01

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	3.33E-01	4.29E-01	5.00E-01	5.56E-01	6.00E-01
Beta	6.67E-01	5.71E-01	5.00E-01	4.44E-01	4.00E-01
Gamma		1.00E+00	1.00E+00	1.00E+00	1.00E+00
Delta			1.00E+00	1.00E+00	1.00E+00
Epsilon				5.00E-01	7.50E-01
Mu					3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	0.50	0.75	1.00	1.25	1.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.0000	0.0000	0.0000	0.0000
N_3		1.0000	0.0000	0.0000	0.0000
N_4			1.0000	0.5000	0.2500
N_5				0.5000	0.5000
N_6					0.2500

2.4.2.2 ISO CONDENSER AOV FAIL TO OPEN

Systems/Clean Water/Isolation condenser
Components/Valve/Air Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8522320	0.9627996	0.9843829	0.9999318	1.0000000	1.125E+01	4.345E-01
α_2	7.00E-05	3.72E-02	1.56E-02	1.48E-01	0.00E+00	4.345E-01	1.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9010678	0.9652235	0.9744833	0.9976825	1.0000000	3.056E+01	1.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	2.98E-07	8.44E-03	1.71E-03	4.00E-02	0.00E+00	2.672E-01	3.139E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9095821	0.9621343	0.9682529	0.9937392	1.0000000	4.714E+01	1.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	1.97E-08	4.55E-03	6.24E-04	2.28E-02	0.00E+00	2.227E-01	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9304992	0.9648632	0.9678976	0.9888359	1.0000000	9.716E+01	3.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	2.45E-06	3.72E-03	1.25E-03	1.58E-02	0.00E+00	3.744E-01	1.003E+02
α_5	5.93E-21	7.18E-04	4.06E-07	4.16E-03	0.00E+00	7.228E-02	1.006E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9341158	0.9649918	0.9674994	0.9872843	1.0000000	1.179E+02	4.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02
α_4	4.33E-05	4.85E-03	2.54E-03	1.75E-02	0.00E+00	5.922E-01	1.216E+02
α_5	7.60E-09	1.82E-03	2.47E-04	9.11E-03	0.00E+00	2.222E-01	1.220E+02
α_6	1.15E-18	6.81E-04	1.19E-06	3.98E-03	0.00E+00	8.324E-02	1.221E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.00	1.00	1.00	1.00	1.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.4.2.3 ISO CONDENSER AOV FAIL TO CLOSE

Systems/Clean Water/Isolation condenser
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.6956542	0.8771870	0.8985732	0.9851945	0.0000000	1.025E+01	1.435E+00
α_2	1.48E-02	1.23E-01	1.01E-01	3.04E-01	1.00E+00	1.435E+00	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8495547	0.9336338	0.9426207	0.9869091	0.0000000	2.956E+01	2.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	3.59E-03	4.00E-02	3.08E-02	1.08E-01	1.00E+00	1.267E+00	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8788099	0.9417225	0.9476575	0.9843045	0.0000000	4.614E+01	2.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	2.06E-03	2.50E-02	1.88E-02	6.88E-02	1.00E+00	1.223E+00	4.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9167221	0.9549327	0.9579155	0.9829299	0.0000000	9.616E+01	4.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	3.14E-04	8.68E-03	5.72E-03	2.72E-02	5.00E-01	8.744E-01	9.982E+01
α_5	4.37E-05	5.68E-03	2.91E-03	2.07E-02	5.00E-01	5.723E-01	1.001E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9230306	0.9568097	0.9592861	0.9821415	0.0000000	1.169E+02	5.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02
α_4	2.23E-04	6.89E-03	4.45E-03	2.19E-02	2.50E-01	8.422E-01	1.214E+02
α_5	1.16E-04	5.91E-03	3.52E-03	1.98E-02	5.00E-01	7.222E-01	1.215E+02
α_6	7.30E-07	2.73E-03	7.85E-04	1.20E-02	2.50E-01	3.332E-01	1.219E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		1.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			1.00E+00	5.00E-01	2.50E-01
α_5				5.00E-01	5.00E-01
α_6					2.50E-01

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Gamma		1.00E+00	1.00E+00	1.00E+00	1.00E+00
Delta			1.00E+00	1.00E+00	1.00E+00
Epsilon				5.00E-01	7.50E-01
Mu					3.33E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	0.00	0.00	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.0000	0.0000	0.0000	0.0000
N_3		1.0000	0.0000	0.0000	0.0000
N_4			1.0000	0.5000	0.2500
N_5				0.5000	0.5000
N_6					0.2500

2.4.3 PWR Auxiliary Feedwater Air-Operated Valves

2.4.3.1 AFW AOV FAIL TO OPEN/CLOSE SPAR: AOV-FTOC-AFW

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 65.1
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9017271	0.9552125	0.9607305	0.9898141	0.9542011	5.160E+01	2.420E+00
α_2	1.02E-02	4.48E-02	3.93E-02	9.83E-02	4.58E-02	2.420E+00	5.160E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9168177	0.9560356	0.9592303	0.9843137	0.9521472	9.001E+01	4.139E+00
α_2	8.36E-03	3.09E-02	2.77E-02	6.47E-02	3.28E-02	2.914E+00	9.124E+01
α_3	1.07E-03	1.30E-02	9.77E-03	3.61E-02	1.51E-02	1.226E+00	9.292E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9214804	0.9546584	0.9569546	0.9800014	0.9508056	1.253E+02	5.953E+00
α_2	8.78E-03	2.74E-02	2.50E-02	5.41E-02	2.84E-02	3.596E+00	1.277E+02
α_3	1.60E-03	1.22E-02	9.80E-03	3.09E-02	1.43E-02	1.599E+00	1.297E+02
α_4	1.33E-04	5.77E-03	3.53E-03	1.90E-02	6.42E-03	7.574E-01	1.305E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9351241	0.9599970	0.9614998	0.9797280	0.9556266	1.946E+02	8.107E+00
α_2	7.05E-03	2.02E-02	1.86E-02	3.86E-02	1.91E-02	4.086E+00	1.986E+02
α_3	2.55E-03	1.17E-02	1.01E-02	2.62E-02	1.35E-02	2.369E+00	2.003E+02
α_4	5.56E-04	6.30E-03	4.76E-03	1.73E-02	8.76E-03	1.276E+00	2.014E+02
α_5	1.27E-06	1.86E-03	6.29E-04	7.88E-03	2.96E-03	3.767E-01	2.023E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9397968	0.9618615	0.9631173	0.9796308	0.9590513	2.345E+02	9.297E+00
α_2	5.88E-03	1.68E-02	1.55E-02	3.22E-02	1.51E-02	4.096E+00	2.397E+02
α_3	2.17E-03	9.83E-03	8.53E-03	2.20E-02	1.02E-02	2.397E+00	2.414E+02
α_4	9.74E-04	6.90E-03	5.61E-03	1.73E-02	8.90E-03	1.683E+00	2.421E+02
α_5	1.22E-04	3.54E-03	2.31E-03	1.11E-02	5.22E-03	8.622E-01	2.429E+02
α_6	2.78E-08	1.07E-03	2.02E-04	5.10E-03	1.44E-03	2.601E-01	2.435E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474237	0.9653334	0.9662605	0.9800740	0.9642160	3.211E+02	1.153E+01
α_2	4.94E-03	1.34E-02	1.24E-02	2.51E-02	9.60E-03	4.453E+00	3.282E+02
α_3	2.24E-03	8.57E-03	7.61E-03	1.82E-02	8.58E-03	2.851E+00	3.298E+02
α_4	1.18E-03	6.27E-03	5.31E-03	1.46E-02	7.71E-03	2.085E+00	3.306E+02
α_5	4.24E-04	4.15E-03	3.21E-03	1.11E-02	6.05E-03	1.381E+00	3.313E+02
α_6	2.15E-05	1.89E-03	1.03E-03	6.67E-03	3.11E-03	6.277E-01	3.320E+02
α_7	3.65E-13	4.03E-04	1.07E-05	2.26E-03	7.38E-04	1.340E-01	3.325E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9515256	0.9675462	0.9683439	0.9808391	0.9682897	3.753E+02	1.259E+01
α_2	4.10E-03	1.13E-02	1.04E-02	2.12E-02	6.31E-03	4.365E+00	3.835E+02
α_3	1.91E-03	7.33E-03	6.51E-03	1.56E-02	6.84E-03	2.845E+00	3.851E+02
α_4	1.12E-03	5.63E-03	4.80E-03	1.30E-02	6.41E-03	2.183E+00	3.857E+02
α_5	5.78E-04	4.24E-03	3.43E-03	1.07E-02	5.80E-03	1.646E+00	3.863E+02
α_6	1.47E-04	2.66E-03	1.87E-03	7.86E-03	4.10E-03	1.030E+00	3.869E+02
α_7	1.65E-06	1.09E-03	4.23E-04	4.45E-03	1.86E-03	4.236E-01	3.875E+02
α_8	5.24E-17	2.49E-04	1.19E-06	1.45E-03	3.92E-04	9.655E-02	3.878E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.54E-01	9.52E-01	9.51E-01	9.56E-01	9.59E-01	9.64E-01	9.68E-01
α_2	4.58E-02	3.28E-02	2.84E-02	1.91E-02	1.51E-02	9.60E-03	6.31E-03
α_3		1.51E-02	1.43E-02	1.35E-02	1.02E-02	8.58E-03	6.84E-03
α_4			6.42E-03	8.76E-03	8.90E-03	7.71E-03	6.41E-03
α_5				2.96E-03	5.22E-03	6.05E-03	5.80E-03
α_6					1.44E-03	3.11E-03	4.10E-03
α_7						7.38E-04	1.86E-03
α_8							3.92E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.54E-01	9.52E-01	9.51E-01	9.56E-01	9.59E-01	9.64E-01	9.68E-01
Beta	4.58E-02	4.79E-02	4.92E-02	4.44E-02	4.09E-02	3.58E-02	3.17E-02
Gamma		3.15E-01	4.22E-01	5.68E-01	6.30E-01	7.32E-01	8.01E-01
Delta			3.09E-01	4.64E-01	6.03E-01	6.72E-01	7.31E-01
Epsilon				2.52E-01	4.28E-01	5.62E-01	6.55E-01
Mu					2.17E-01	3.89E-01	5.23E-01
Omega						1.92E-01	3.54E-01
Sigma							1.74E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	39.06	58.59	78.12	97.65	117.18	136.71	156.24
N_1	2.2967	1.8650	1.0744	0.7534	0.3646	0.3464	0.3483
N_2	1.9850	2.0800	2.3683	1.9717	1.8563	1.3649	1.0203
N_3		0.9583	1.1944	1.3915	1.2547	1.2197	1.1069

N_4			0.5347	0.9016	1.0909	1.0963	1.0362
N_5				0.3044	0.6400	0.8593	0.9373
N_6					0.1769	0.4414	0.6634
N_7						0.1049	0.3006
N_8							0.0634

2.4.3.2 AFW AOV FAIL TO OPEN

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Air Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 35.1
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9001877	0.9632981	0.9719403	0.9968018	0.9651146	3.284E+01	1.251E+00
α_2	3.20E-03	3.67E-02	2.81E-02	9.98E-02	3.49E-02	1.251E+00	3.284E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9131178	0.9594763	0.9641044	0.9899860	0.9553593	6.237E+01	2.634E+00
α_2	5.01E-03	2.94E-02	2.47E-02	6.98E-02	3.13E-02	1.909E+00	6.310E+01
α_3	2.23E-04	1.12E-02	6.70E-03	3.73E-02	1.33E-02	7.256E-01	6.428E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9188146	0.9576490	0.9608899	0.9853928	0.9537160	8.915E+01	3.943E+00
α_2	5.43E-03	2.51E-02	2.18E-02	5.61E-02	2.46E-02	2.336E+00	9.076E+01
α_3	7.66E-04	1.18E-02	8.54E-03	3.40E-02	1.54E-02	1.099E+00	9.199E+01
α_4	2.33E-05	5.45E-03	2.53E-03	2.08E-02	6.31E-03	5.074E-01	9.259E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9323611	0.9608109	0.9627716	0.9825537	0.9541930	1.493E+02	6.091E+00
α_2	6.27E-03	2.11E-02	1.91E-02	4.28E-02	2.09E-02	3.279E+00	1.522E+02
α_3	1.48E-03	1.07E-02	8.67E-03	2.68E-02	1.23E-02	1.660E+00	1.538E+02
α_4	2.27E-04	5.80E-03	3.86E-03	1.80E-02	9.45E-03	9.010E-01	1.545E+02
α_5	2.95E-08	1.62E-03	2.88E-04	7.82E-03	3.22E-03	2.517E-01	1.552E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9356120	0.9612055	0.9628382	0.9812298	0.9548098	1.802E+02	7.274E+00
α_2	6.03E-03	1.90E-02	1.73E-02	3.78E-02	2.00E-02	3.566E+00	1.839E+02
α_3	1.30E-03	9.07E-03	7.40E-03	2.26E-02	8.44E-03	1.701E+00	1.858E+02
α_4	4.96E-04	6.38E-03	4.74E-03	1.79E-02	9.12E-03	1.197E+00	1.863E+02
α_5	3.36E-05	3.27E-03	1.75E-03	1.16E-02	5.88E-03	6.122E-01	1.869E+02
α_6	9.10E-10	1.05E-03	1.06E-04	5.45E-03	1.73E-03	1.976E-01	1.873E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9441034	0.9644631	0.9656184	0.9808854	0.9602380	2.578E+02	9.500E+00

α_2	5.36E-03	1.53E-02	1.41E-02	2.94E-02	1.31E-02	4.095E+00	2.632E+02
α_3	1.73E-03	8.41E-03	7.22E-03	1.92E-02	8.04E-03	2.249E+00	2.651E+02
α_4	7.21E-04	5.80E-03	4.62E-03	1.49E-02	7.31E-03	1.550E+00	2.658E+02
α_5	2.14E-04	3.86E-03	2.71E-03	1.14E-02	6.63E-03	1.032E+00	2.663E+02
α_6	5.05E-06	1.76E-03	7.62E-04	6.91E-03	3.71E-03	4.714E-01	2.669E+02
α_7	4.93E-16	3.84E-04	2.68E-06	2.23E-03	9.59E-04	1.027E-01	2.672E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9481149	0.9663599	0.9673457	0.9812338	0.9646646	3.030E+02	1.055E+01
α_2	4.60E-03	1.31E-02	1.21E-02	2.51E-02	8.80E-03	4.113E+00	3.094E+02
α_3	1.62E-03	7.51E-03	6.49E-03	1.69E-02	7.05E-03	2.354E+00	3.112E+02
α_4	7.22E-04	5.27E-03	4.26E-03	1.33E-02	5.79E-03	1.652E+00	3.119E+02
α_5	3.25E-04	3.94E-03	2.95E-03	1.09E-02	6.02E-03	1.234E+00	3.123E+02
α_6	6.42E-05	2.50E-03	1.55E-03	8.16E-03	4.77E-03	7.836E-01	3.128E+02
α_7	2.58E-07	1.05E-03	2.97E-04	4.66E-03	2.37E-03	3.298E-01	3.132E+02
α_8	1.60E-19	2.58E-04	3.65E-07	1.50E-03	5.47E-04	8.093E-02	3.135E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.65E-01	9.55E-01	9.54E-01	9.54E-01	9.55E-01	9.60E-01	9.65E-01
α_2	3.49E-02	3.13E-02	2.46E-02	2.09E-02	2.00E-02	1.31E-02	8.80E-03
α_3		1.33E-02	1.54E-02	1.23E-02	8.44E-03	8.04E-03	7.05E-03
α_4			6.31E-03	9.45E-03	9.12E-03	7.31E-03	5.79E-03
α_5				3.22E-03	5.88E-03	6.63E-03	6.02E-03
α_6					1.73E-03	3.71E-03	4.77E-03
α_7						9.59E-04	2.37E-03
α_8							5.47E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.65E-01	9.55E-01	9.54E-01	9.54E-01	9.55E-01	9.60E-01	9.65E-01
Beta	3.49E-02	4.46E-02	4.63E-02	4.58E-02	4.52E-02	3.98E-02	3.53E-02
Gamma		2.99E-01	4.69E-01	5.44E-01	5.57E-01	6.70E-01	7.51E-01
Delta			2.91E-01	5.08E-01	6.65E-01	6.98E-01	7.34E-01
Epsilon				2.54E-01	4.55E-01	6.07E-01	7.03E-01
Mu					2.27E-01	4.13E-01	5.61E-01
Omega						2.05E-01	3.79E-01
Sigma							1.88E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	21.06	31.59	42.12	52.65	63.18	73.71	84.24
N_1	1.5333	1.2250	0.8944	0.5359	0.1123	0.0619	0.0340
N_2	0.8167	1.0750	1.1083	1.1644	1.3270	1.0073	0.7686
N_3		0.4583	0.6944	0.6829	0.5594	0.6175	0.6156
N_4			0.2847	0.5266	0.6047	0.5615	0.5055
N_5				0.1794	0.3900	0.5097	0.5260
N_6					0.1144	0.2851	0.4166
N_7						0.0737	0.2068
N_8							0.0478

2.4.3.3 AFW AOV FAIL TO CLOSE

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 28.0
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9164222	0.9764622	0.9872513	0.9997686	0.9887264	2.501E+01	6.029E-01
α_2	2.33E-04	2.35E-02	1.27E-02	8.36E-02	1.13E-02	6.029E-01	2.501E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9236558	0.9695861	0.9753079	0.9959279	0.9771958	5.120E+01	1.606E+00
α_2	2.49E-03	2.54E-02	1.96E-02	6.78E-02	2.28E-02	1.339E+00	5.146E+01
α_3	1.77E-07	5.06E-03	1.02E-03	2.40E-02	0.00E+00	2.672E-01	5.253E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9222104	0.9628785	0.9668149	0.9900893	0.9653991	7.432E+01	2.865E+00
α_2	6.00E-03	2.90E-02	2.50E-02	6.56E-02	3.46E-02	2.238E+00	7.494E+01
α_3	5.89E-06	5.24E-03	1.94E-03	2.16E-02	0.00E+00	4.043E-01	7.678E+01
α_4	1.24E-08	2.89E-03	3.94E-04	1.44E-02	0.00E+00	2.227E-01	7.696E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379020	0.9664963	0.9687641	0.9873452	0.9719597	1.314E+02	4.554E+00
α_2	5.32E-03	2.06E-02	1.83E-02	4.37E-02	1.88E-02	2.797E+00	1.331E+02
α_3	8.99E-04	9.64E-03	7.37E-03	2.62E-02	9.21E-03	1.311E+00	1.346E+02
α_4	1.81E-06	2.75E-03	9.27E-04	1.17E-02	0.00E+00	3.744E-01	1.356E+02
α_5	4.39E-21	5.32E-04	3.00E-07	3.08E-03	0.00E+00	7.228E-02	1.359E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9424154	0.9677684	0.9696461	0.9866951	0.9763550	1.592E+02	5.302E+00
α_2	4.12E-03	1.65E-02	1.45E-02	3.53E-02	1.08E-02	2.706E+00	1.618E+02
α_3	1.25E-03	9.65E-03	7.75E-03	2.46E-02	1.03E-02	1.587E+00	1.629E+02
α_4	7.60E-05	4.28E-03	2.51E-03	1.45E-02	2.57E-03	7.033E-01	1.638E+02
α_5	5.64E-09	1.35E-03	1.83E-04	6.77E-03	0.00E+00	2.222E-01	1.643E+02
α_6	8.57E-19	5.06E-04	8.85E-07	2.95E-03	0.00E+00	8.324E-02	1.644E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9486565	0.9689522	0.9702408	0.9848396	0.9794965	2.333E+02	7.477E+00
α_2	4.34E-03	1.42E-02	1.29E-02	2.85E-02	6.49E-03	3.414E+00	2.374E+02
α_3	1.62E-03	8.63E-03	7.31E-03	2.01E-02	8.86E-03	2.077E+00	2.387E+02
α_4	4.00E-04	5.03E-03	3.74E-03	1.41E-02	4.42E-03	1.211E+00	2.396E+02
α_5	1.59E-05	2.32E-03	1.16E-03	8.56E-03	7.36E-04	5.588E-01	2.403E+02
α_6	2.79E-10	7.74E-04	6.60E-05	4.06E-03	0.00E+00	1.863E-01	2.406E+02
α_7	4.22E-48	1.21E-04	1.06E-13	4.54E-04	0.00E+00	2.907E-02	2.408E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9517178	0.9700150	0.9711124	0.9845640	0.9818475	2.750E+02	8.502E+00
α_2	4.00E-03	1.26E-02	1.15E-02	2.51E-02	4.12E-03	3.581E+00	2.800E+02
α_3	1.46E-03	7.53E-03	6.41E-03	1.74E-02	6.93E-03	2.136E+00	2.814E+02
α_4	5.61E-04	5.09E-03	3.98E-03	1.34E-02	5.17E-03	1.443E+00	2.821E+02
α_5	8.04E-05	2.85E-03	1.80E-03	9.19E-03	1.72E-03	8.071E-01	2.827E+02
α_6	9.62E-07	1.34E-03	4.56E-04	5.66E-03	2.15E-04	3.793E-01	2.832E+02
α_7	5.74E-14	4.34E-04	7.80E-06	2.47E-03	0.00E+00	1.230E-01	2.834E+02
α_8	1.08E-42	1.17E-04	1.66E-12	4.94E-04	0.00E+00	3.312E-02	2.835E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.89E-01	9.77E-01	9.65E-01	9.72E-01	9.76E-01	9.79E-01	9.82E-01
α_2	1.13E-02	2.28E-02	3.46E-02	1.88E-02	1.08E-02	6.49E-03	4.12E-03
α_3		0.00E+00	0.00E+00	9.21E-03	1.03E-02	8.86E-03	6.93E-03
α_4			0.00E+00	0.00E+00	2.57E-03	4.42E-03	5.17E-03
α_5				0.00E+00	0.00E+00	7.36E-04	1.72E-03
α_6					0.00E+00	0.00E+00	2.15E-04
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.77E-01	9.65E-01	9.72E-01	9.76E-01	9.79E-01	9.82E-01
Beta	1.13E-02	2.28E-02	3.46E-02	2.80E-02	2.36E-02	2.05E-02	1.82E-02
Gamma		0.00E+00	0.00E+00	3.28E-01	5.44E-01	6.84E-01	7.73E-01
Delta			0.00E+00	0.00E+00	2.00E-01	3.68E-01	5.06E-01
Epsilon				0.00E+00	0.00E+00	1.43E-01	2.73E-01
Mu					0.00E+00	0.00E+00	1.11E-01
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	14.00	21.00	28.00	35.00	42.00	49.00	56.00
N_1	0.7633	0.6400	0.1800	0.2175	0.2523	0.2845	0.3143
N_2	0.1683	0.5050	1.0100	0.6823	0.4668	0.3264	0.2361

N_3		0.0000	0.0000	0.3337	0.4453	0.4460	0.3976
N_4			0.0000	0.0000	0.1111	0.2223	0.2964
N_5				0.0000	0.0000	0.0370	0.0988
N_6					0.0000	0.0000	0.0123
N_7						0.0000	0.0000
N_8							0.0000

2.4.4 High Pressure Coolant Injection and Reactor Core Isolation Cooling Air Operated Valves

2.4.4.1 COMBINED HPCI AND RCIC AIR OPERATED VALVE FAIL TO OPEN/CLOSE

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 5.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8894201	0.9722892	0.9885281	0.9999447	1.0000000	1.525E+01	4.345E-01
α_2	5.13E-05	2.77E-02	1.15E-02	1.11E-01	0.00E+00	4.345E-01	1.525E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9119790	0.9691249	0.9773997	0.9979504	1.0000000	3.456E+01	1.101E+00
α_2	7.46E-04	2.34E-02	1.52E-02	7.38E-02	0.00E+00	8.337E-01	3.482E+01
α_3	2.64E-07	7.49E-03	1.52E-03	3.55E-02	0.00E+00	2.672E-01	3.539E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9162955	0.9649926	0.9706754	0.9942239	1.0000000	5.114E+01	1.855E+00
α_2	1.92E-03	2.32E-02	1.75E-02	6.39E-02	0.00E+00	1.228E+00	5.176E+01
α_3	8.61E-06	7.63E-03	2.84E-03	3.15E-02	0.00E+00	4.043E-01	5.259E+01
α_4	1.82E-08	4.20E-03	5.77E-04	2.11E-02	0.00E+00	2.227E-01	5.277E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9331208	0.9662056	0.9691381	0.9892696	1.0000000	1.012E+02	3.538E+00
α_2	3.89E-03	2.02E-02	1.72E-02	4.67E-02	0.00E+00	2.114E+00	1.026E+02
α_3	4.56E-04	9.34E-03	6.45E-03	2.81E-02	0.00E+00	9.774E-01	1.037E+02
α_4	2.35E-06	3.58E-03	1.20E-03	1.52E-02	0.00E+00	3.744E-01	1.043E+02
α_5	5.70E-21	6.90E-04	3.90E-07	4.00E-03	0.00E+00	7.228E-02	1.046E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9361793	0.9661012	0.9685394	0.9876934	1.0000000	1.219E+02	4.279E+00
α_2	3.65E-03	1.77E-02	1.53E-02	4.03E-02	0.00E+00	2.239E+00	1.240E+02
α_3	6.37E-04	9.05E-03	6.62E-03	2.58E-02	0.00E+00	1.142E+00	1.251E+02
α_4	4.20E-05	4.69E-03	2.46E-03	1.69E-02	0.00E+00	5.922E-01	1.256E+02

α_5	7.36E-09	1.76E-03	2.39E-04	8.82E-03	0.00E+00	2.222E-01	1.260E+02
α_6	1.12E-18	6.59E-04	1.15E-06	3.85E-03	0.00E+00	8.324E-02	1.261E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	5.00	5.00	5.00	5.00	5.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.4.4.2 COMBINED HPCI AND RCIC AIR OPERATED VALVE FAIL TO OPEN

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Air Operated Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 4.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8819913	0.9704016	0.9877119	0.9999408	1.0000000	1.425E+01	4.345E-01
α_2	5.49E-05	2.96E-02	1.23E-02	1.18E-01	0.00E+00	4.345E-01	1.425E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9094829	0.9682340	0.9767349	0.9978894	1.0000000	3.356E+01	1.101E+00
α_2	7.68E-04	2.41E-02	1.57E-02	7.59E-02	0.00E+00	8.337E-01	3.382E+01
α_3	2.71E-07	7.71E-03	1.56E-03	3.66E-02	0.00E+00	2.672E-01	3.439E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9147120	0.9643193	0.9701044	0.9941099	1.0000000	5.014E+01	1.855E+00
α_2	1.96E-03	2.36E-02	1.78E-02	6.51E-02	0.00E+00	1.228E+00	5.076E+01
α_3	8.78E-06	7.78E-03	2.89E-03	3.21E-02	0.00E+00	4.043E-01	5.159E+01
α_4	1.85E-08	4.28E-03	5.88E-04	2.15E-02	0.00E+00	2.227E-01	5.177E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9324841	0.9658797	0.9688381	0.9891644	1.0000000	1.002E+02	3.538E+00
α_2	3.93E-03	2.04E-02	1.74E-02	4.71E-02	0.00E+00	2.114E+00	1.016E+02
α_3	4.61E-04	9.43E-03	6.51E-03	2.83E-02	0.00E+00	9.774E-01	1.027E+02
α_4	2.37E-06	3.61E-03	1.22E-03	1.53E-02	0.00E+00	3.744E-01	1.033E+02
α_5	5.76E-21	6.97E-04	3.94E-07	4.04E-03	0.00E+00	7.228E-02	1.036E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9356756	0.9658305	0.9682864	0.9875936	1.0000000	1.209E+02	4.279E+00
α_2	3.68E-03	1.79E-02	1.54E-02	4.06E-02	0.00E+00	2.239E+00	1.230E+02
α_3	6.42E-04	9.12E-03	6.67E-03	2.60E-02	0.00E+00	1.142E+00	1.241E+02
α_4	4.23E-05	4.73E-03	2.48E-03	1.71E-02	0.00E+00	5.922E-01	1.246E+02
α_5	7.42E-09	1.77E-03	2.41E-04	8.89E-03	0.00E+00	2.222E-01	1.250E+02
α_6	1.13E-18	6.65E-04	1.16E-06	3.88E-03	0.00E+00	8.324E-02	1.251E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	4.00	4.00	4.00	4.00	4.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.4.4.3 COMBINED HPCI AND RCIC AIR OPERATED VALVE FAIL TO CLOSE

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Air Operated Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8522320	0.9627996	0.9843829	0.9999318	1.0000000	1.125E+01	4.345E-01
α_2	7.00E-05	3.72E-02	1.56E-02	1.48E-01	0.00E+00	4.345E-01	1.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9010678	0.9652235	0.9744833	0.9976825	1.0000000	3.056E+01	1.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	2.98E-07	8.44E-03	1.71E-03	4.00E-02	0.00E+00	2.672E-01	3.139E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9095821	0.9621343	0.9682529	0.9937392	1.0000000	4.714E+01	1.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	1.97E-08	4.55E-03	6.24E-04	2.28E-02	0.00E+00	2.227E-01	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9304992	0.9648632	0.9678976	0.9888359	1.0000000	9.716E+01	3.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	2.45E-06	3.72E-03	1.25E-03	1.58E-02	0.00E+00	3.744E-01	1.003E+02
α_5	5.93E-21	7.18E-04	4.06E-07	4.16E-03	0.00E+00	7.228E-02	1.006E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9341158	0.9649918	0.9674994	0.9872843	1.0000000	1.179E+02	4.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02
α_4	4.33E-05	4.85E-03	2.54E-03	1.75E-02	0.00E+00	5.922E-01	1.216E+02
α_5	7.60E-09	1.82E-03	2.47E-04	9.11E-03	0.00E+00	2.222E-01	1.220E+02
α_6	1.15E-18	6.81E-04	1.19E-06	3.98E-03	0.00E+00	8.324E-02	1.221E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.00	1.00	1.00	1.00	1.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.5 Check Valves

2.5.1 Pooled Check Valves

2.5.1.1 CHECK VALVE FAIL TO OPEN ALL SYSTEMS SPAR: CKV-CC

Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 10.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9159004	0.9789889	0.9913884	0.9999582	1.0000000	2.025E+01	4.345E-01
α_2	3.84E-05	2.10E-02	8.61E-03	8.41E-02	0.00E+00	4.345E-01	2.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9226541	0.9729220	0.9802249	0.9982128	1.0000000	3.956E+01	1.101E+00
α_2	6.52E-04	2.05E-02	1.33E-02	6.49E-02	0.00E+00	8.337E-01	3.982E+01
α_3	2.31E-07	6.57E-03	1.33E-03	3.12E-02	0.00E+00	2.672E-01	4.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9234088	0.9680109	0.9732366	0.9947336	1.0000000	5.614E+01	1.855E+00
α_2	1.76E-03	2.12E-02	1.60E-02	5.84E-02	0.00E+00	1.228E+00	5.676E+01
α_3	7.86E-06	6.97E-03	2.59E-03	2.88E-02	0.00E+00	4.043E-01	5.759E+01
α_4	1.66E-08	3.84E-03	5.26E-04	1.92E-02	0.00E+00	2.227E-01	5.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9361323	0.9677459	0.9705479	0.9897665	1.0000000	1.062E+02	3.538E+00
α_2	3.71E-03	1.93E-02	1.64E-02	4.45E-02	0.00E+00	2.114E+00	1.076E+02
α_3	4.35E-04	8.91E-03	6.16E-03	2.68E-02	0.00E+00	9.774E-01	1.087E+02
α_4	2.24E-06	3.41E-03	1.15E-03	1.45E-02	0.00E+00	3.744E-01	1.093E+02
α_5	5.44E-21	6.59E-04	3.73E-07	3.81E-03	0.00E+00	7.228E-02	1.096E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9385837	0.9673929	0.9697400	0.9881691	1.0000000	1.269E+02	4.279E+00
α_2	3.51E-03	1.71E-02	1.47E-02	3.88E-02	0.00E+00	2.239E+00	1.290E+02
α_3	6.13E-04	8.70E-03	6.37E-03	2.48E-02	0.00E+00	1.142E+00	1.301E+02
α_4	4.04E-05	4.51E-03	2.36E-03	1.63E-02	0.00E+00	5.922E-01	1.306E+02
α_5	7.08E-09	1.69E-03	2.30E-04	8.48E-03	0.00E+00	2.222E-01	1.310E+02
α_6	1.07E-18	6.34E-04	1.11E-06	3.70E-03	0.00E+00	8.324E-02	1.311E+02

CHECK VALVE FAIL TO OPEN ALL SYSTEMS SPAR: CKV-CC

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9451093	0.9678546	0.9693978	0.9853216	1.0000000	1.941E+02	6.445E+00
α_2	4.34E-03	1.54E-02	1.38E-02	3.19E-02	0.00E+00	3.088E+00	1.974E+02
α_3	1.10E-03	8.14E-03	6.57E-03	2.05E-02	0.00E+00	1.631E+00	1.989E+02
α_4	2.47E-04	4.93E-03	3.41E-03	1.48E-02	0.00E+00	9.889E-01	1.995E+02
α_5	1.28E-05	2.60E-03	1.23E-03	9.83E-03	0.00E+00	5.218E-01	2.000E+02
α_6	3.35E-10	9.29E-04	7.93E-05	4.88E-03	0.00E+00	1.863E-01	2.003E+02
α_7	5.07E-48	1.45E-04	1.27E-13	5.46E-04	0.00E+00	2.907E-02	2.005E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9477509	0.9684112	0.9697238	0.9845868	1.0000000	2.287E+02	7.461E+00
α_2	4.26E-03	1.42E-02	1.28E-02	2.87E-02	0.00E+00	3.345E+00	2.328E+02
α_3	1.09E-03	7.36E-03	6.02E-03	1.82E-02	0.00E+00	1.738E+00	2.345E+02
α_4	3.44E-04	4.85E-03	3.55E-03	1.38E-02	0.00E+00	1.147E+00	2.350E+02
α_5	5.46E-05	3.00E-03	1.76E-03	1.01E-02	0.00E+00	7.083E-01	2.355E+02
α_6	8.79E-07	1.55E-03	5.09E-04	6.65E-03	0.00E+00	3.670E-01	2.358E+02
α_7	6.89E-14	5.21E-04	9.36E-06	2.96E-03	0.00E+00	1.230E-01	2.361E+02
α_8	1.29E-42	1.40E-04	2.00E-12	5.93E-04	0.00E+00	3.312E-02	2.362E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	10.00	10.00	10.00	10.00	10.00	10.00	10.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.1.2 CHECK VALVE FAIL TO CLOSE ALL SYSTEMS SPAR: CKV-OO

Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 49.1
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8897130	0.9573077	0.9659977	0.9951343	0.9563811	3.239E+01	1.445E+00
α_2	4.86E-03	4.27E-02	3.40E-02	1.10E-01	4.36E-02	1.445E+00	3.239E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9247262	0.9671623	0.9718434	0.9935590	0.9699155	6.274E+01	2.130E+00
α_2	2.12E-03	2.10E-02	1.63E-02	5.59E-02	1.55E-02	1.363E+00	6.351E+01
α_3	2.87E-04	1.18E-02	7.33E-03	3.87E-02	1.46E-02	7.675E-01	6.411E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9347011	0.9687677	0.9720584	0.9915689	0.9766361	9.035E+01	2.913E+00
α_2	2.03E-03	1.65E-02	1.31E-02	4.22E-02	6.77E-03	1.535E+00	9.173E+01
α_3	3.87E-04	9.71E-03	6.50E-03	3.00E-02	1.11E-02	9.055E-01	9.236E+01
α_4	1.48E-05	5.07E-03	2.20E-03	1.98E-02	5.52E-03	4.727E-01	9.279E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9451325	0.9703071	0.9722979	0.9886841	0.9805687	1.514E+02	4.633E+00
α_2	3.21E-03	1.49E-02	1.29E-02	3.36E-02	3.84E-03	2.331E+00	1.537E+02
α_3	8.60E-04	8.69E-03	6.70E-03	2.33E-02	6.71E-03	1.355E+00	1.547E+02
α_4	1.07E-04	4.80E-03	2.92E-03	1.59E-02	6.66E-03	7.494E-01	1.553E+02
α_5	1.07E-09	1.26E-03	1.27E-04	6.54E-03	2.22E-03	1.973E-01	1.558E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9488806	0.9712720	0.9729254	0.9880163	0.9830949	1.832E+02	5.417E+00
α_2	2.90E-03	1.29E-02	1.12E-02	2.87E-02	2.90E-03	2.435E+00	1.861E+02
α_3	7.75E-04	7.41E-03	5.76E-03	1.97E-02	3.80E-03	1.398E+00	1.872E+02
α_4	2.43E-04	5.13E-03	3.52E-03	1.55E-02	5.57E-03	9.672E-01	1.876E+02
α_5	7.24E-06	2.50E-03	1.08E-03	9.81E-03	3.71E-03	4.722E-01	1.881E+02
α_6	3.95E-12	7.73E-04	2.89E-05	4.28E-03	9.28E-04	1.457E-01	1.884E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9532169	0.9716037	0.9727632	0.9860174	0.9848171	2.612E+02	7.635E+00
α_2	3.65E-03	1.23E-02	1.11E-02	2.50E-02	2.70E-03	3.299E+00	2.656E+02

α_3	1.04E-03	6.69E-03	5.51E-03	1.64E-02	2.12E-03	1.797E+00	2.671E+02
α_4	4.43E-04	4.84E-03	3.68E-03	1.32E-02	3.99E-03	1.301E+00	2.676E+02
α_5	9.70E-05	3.10E-03	1.99E-03	9.90E-03	3.99E-03	8.343E-01	2.680E+02
α_6	4.25E-07	1.27E-03	3.80E-04	5.58E-03	1.99E-03	3.425E-01	2.685E+02
α_7	5.93E-25	2.24E-04	2.24E-08	1.26E-03	3.99E-04	6.032E-02	2.688E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9557959	0.9724381	0.9734282	0.9856900	0.9861602	3.069E+02	8.698E+00
α_2	3.59E-03	1.13E-02	1.03E-02	2.25E-02	2.60E-03	3.577E+00	3.120E+02
α_3	9.47E-04	5.87E-03	4.86E-03	1.42E-02	1.27E-03	1.852E+00	3.137E+02
α_4	4.47E-04	4.38E-03	3.39E-03	1.17E-02	2.63E-03	1.381E+00	3.142E+02
α_5	1.75E-04	3.23E-03	2.27E-03	9.60E-03	3.50E-03	1.021E+00	3.146E+02
α_6	1.81E-05	1.91E-03	1.01E-03	6.84E-03	2.62E-03	6.013E-01	3.150E+02
α_7	2.08E-09	6.87E-04	8.75E-05	3.46E-03	1.05E-03	2.167E-01	3.154E+02
α_8	3.80E-30	1.54E-04	1.24E-09	8.15E-04	1.75E-04	4.875E-02	3.155E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.56E-01	9.70E-01	9.77E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01
α_2	4.36E-02	1.55E-02	6.77E-03	3.84E-03	2.90E-03	2.70E-03	2.60E-03
α_3		1.46E-02	1.11E-02	6.71E-03	3.80E-03	2.12E-03	1.27E-03
α_4			5.52E-03	6.66E-03	5.57E-03	3.99E-03	2.63E-03
α_5				2.22E-03	3.71E-03	3.99E-03	3.50E-03
α_6					9.28E-04	1.99E-03	2.62E-03
α_7						3.99E-04	1.05E-03
α_8							1.75E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.56E-01	9.70E-01	9.77E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01
Beta	4.36E-02	3.01E-02	2.34E-02	1.94E-02	1.69E-02	1.52E-02	1.38E-02
Gamma		4.86E-01	7.10E-01	8.02E-01	8.28E-01	8.22E-01	8.12E-01
Delta			3.33E-01	5.70E-01	7.29E-01	8.30E-01	8.87E-01
Epsilon				2.50E-01	4.55E-01	6.15E-01	7.36E-01
Mu					2.00E-01	3.75E-01	5.24E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	21.82	32.73	43.64	54.56	65.47	76.38	87.29
N_1	0.3229	0.4551	0.5691	0.6657	0.7457	0.8100	0.8717
N_2	1.0100	0.5291	0.3066	0.2164	0.1954	0.2113	0.2324
N_3		0.5003	0.5011	0.3779	0.2557	0.1663	0.1137
N_4			0.2500	0.3750	0.3750	0.3125	0.2350
N_5				0.1250	0.2500	0.3125	0.3125
N_6					0.0625	0.1563	0.2344
N_7						0.0313	0.0938
N_8							0.0156

2.5.1.3 CHECK VALVE FAIL TO REMAIN CLOSED ALL SYSTEMS SPAR: CKV-CO

Components/Valve/Check Valve
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8979023	0.9640891	0.9736327	0.9976042	0.0000000	2.956E+01	1.101E+00
α_2	8.71E-04	2.72E-02	1.78E-02	8.57E-02	0.00E+00	8.337E-01	2.982E+01
α_3	3.08E-07	8.72E-03	1.77E-03	4.13E-02	0.00E+00	2.672E-01	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9077328	0.9613453	0.9675777	0.9936050	0.0000000	4.614E+01	1.855E+00
α_2	2.13E-03	2.56E-02	1.93E-02	7.04E-02	0.00E+00	1.228E+00	4.676E+01
α_3	9.52E-06	8.42E-03	3.13E-03	3.48E-02	0.00E+00	4.043E-01	4.759E+01
α_4	2.01E-08	4.64E-03	6.37E-04	2.32E-02	0.00E+00	2.227E-01	4.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9298114	0.9645108	0.9675743	0.9887220	0.0000000	9.616E+01	3.538E+00
α_2	4.09E-03	2.12E-02	1.81E-02	4.90E-02	0.00E+00	2.114E+00	9.759E+01
α_3	4.79E-04	9.80E-03	6.78E-03	2.95E-02	0.00E+00	9.774E-01	9.872E+01
α_4	2.47E-06	3.76E-03	1.27E-03	1.59E-02	0.00E+00	3.744E-01	9.932E+01
α_5	5.99E-21	7.25E-04	4.10E-07	4.20E-03	0.00E+00	7.228E-02	9.963E+01

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9335790	0.9647030	0.9672350	0.9871778	0.0000000	1.169E+02	4.279E+00
α_2	3.80E-03	1.85E-02	1.59E-02	4.20E-02	0.00E+00	2.239E+00	1.190E+02
α_3	6.64E-04	9.42E-03	6.89E-03	2.68E-02	0.00E+00	1.142E+00	1.201E+02
α_4	4.37E-05	4.89E-03	2.56E-03	1.76E-02	0.00E+00	5.922E-01	1.206E+02
α_5	7.67E-09	1.83E-03	2.49E-04	9.18E-03	0.00E+00	2.222E-01	1.210E+02
α_6	1.16E-18	6.87E-04	1.20E-06	4.01E-03	0.00E+00	8.324E-02	1.211E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9422574	0.9661671	0.9677845	0.9845423	0.0000000	1.841E+02	6.445E+00
α_2	4.57E-03	1.62E-02	1.45E-02	3.35E-02	0.00E+00	3.088E+00	1.874E+02
α_3	1.15E-03	8.56E-03	6.91E-03	2.16E-02	0.00E+00	1.631E+00	1.889E+02
α_4	2.60E-04	5.19E-03	3.59E-03	1.56E-02	0.00E+00	9.889E-01	1.895E+02
α_5	1.35E-05	2.74E-03	1.30E-03	1.04E-02	0.00E+00	5.218E-01	1.900E+02
α_6	3.53E-10	9.78E-04	8.35E-05	5.13E-03	0.00E+00	1.863E-01	1.903E+02
α_7	5.34E-48	1.53E-04	1.34E-13	5.75E-04	0.00E+00	2.907E-02	1.905E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9454620	0.9670147	0.9683853	0.9838983	0.0000000	2.187E+02	7.461E+00
α_2	4.45E-03	1.48E-02	1.34E-02	2.99E-02	0.00E+00	3.345E+00	2.228E+02
α_3	1.14E-03	7.69E-03	6.29E-03	1.90E-02	0.00E+00	1.738E+00	2.245E+02
α_4	3.59E-04	5.07E-03	3.71E-03	1.44E-02	0.00E+00	1.147E+00	2.250E+02
α_5	5.70E-05	3.13E-03	1.84E-03	1.06E-02	0.00E+00	7.083E-01	2.255E+02
α_6	9.18E-07	1.62E-03	5.31E-04	6.94E-03	0.00E+00	3.670E-01	2.258E+02
α_7	7.20E-14	5.44E-04	9.78E-06	3.10E-03	0.00E+00	1.230E-01	2.261E+02
α_8	1.35E-42	1.46E-04	2.09E-12	6.19E-04	0.00E+00	3.312E-02	2.262E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.1.4 CKV FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS

Components/Valve/Check Valve
Failure Modes/Leak (Internal)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 53.1
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8073280	0.8957933	0.9023933	0.9616510	0.8725775	3.575E+01	4.158E+00
α_2	3.84E-02	1.04E-01	9.76E-02	1.93E-01	1.27E-01	4.158E+00	3.575E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8611780	0.9193848	0.9232470	0.9643820	0.8863453	6.632E+01	5.815E+00
α_2	1.40E-02	4.60E-02	4.19E-02	9.22E-02	5.99E-02	3.319E+00	6.882E+01
α_3	8.08E-03	3.46E-02	3.04E-02	7.56E-02	5.37E-02	2.496E+00	6.964E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8781620	0.9252009	0.9279876	0.9627104	0.8927150	9.380E+01	7.584E+00
α_2	1.23E-02	3.71E-02	3.40E-02	7.21E-02	4.74E-02	3.757E+00	9.763E+01
α_3	5.89E-03	2.50E-02	2.19E-02	5.45E-02	3.99E-02	2.533E+00	9.885E+01
α_4	1.16E-03	1.28E-02	9.73E-03	3.47E-02	2.01E-02	1.294E+00	1.001E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9045349	0.9380685	0.9398385	0.9655654	0.8975590	1.546E+02	1.020E+01
α_2	1.10E-02	2.86E-02	2.67E-02	5.26E-02	3.99E-02	4.709E+00	1.601E+02
α_3	5.05E-03	1.83E-02	1.64E-02	3.81E-02	3.13E-02	3.013E+00	1.618E+02
α_4	1.91E-03	1.15E-02	9.57E-03	2.76E-02	2.33E-02	1.892E+00	1.629E+02
α_5	3.15E-05	3.58E-03	1.87E-03	1.29E-02	7.96E-03	5.901E-01	1.642E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9136637	0.9430119	0.9444983	0.9672777	0.9087279	1.866E+02	1.128E+01
α_2	7.31E-03	2.08E-02	1.92E-02	3.97E-02	2.44E-02	4.114E+00	1.938E+02
α_3	5.17E-03	1.70E-02	1.54E-02	3.44E-02	2.91E-02	3.374E+00	1.945E+02
α_4	2.35E-03	1.14E-02	9.78E-03	2.59E-02	2.17E-02	2.253E+00	1.957E+02
α_5	4.78E-04	6.09E-03	4.52E-03	1.70E-02	1.28E-02	1.204E+00	1.967E+02
α_6	4.50E-07	1.68E-03	4.84E-04	7.44E-03	3.26E-03	3.332E-01	1.976E+02

CKV FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9290271	0.9517763	0.9528555	0.9708514	0.9207332	2.654E+02	1.344E+01
α_2	6.03E-03	1.62E-02	1.50E-02	3.02E-02	1.61E-02	4.513E+00	2.743E+02
α_3	3.29E-03	1.14E-02	1.03E-02	2.34E-02	1.76E-02	3.181E+00	2.756E+02
α_4	2.86E-03	1.06E-02	9.44E-03	2.22E-02	2.22E-02	2.951E+00	2.759E+02
α_5	1.13E-03	6.80E-03	5.67E-03	1.64E-02	1.56E-02	1.897E+00	2.769E+02
α_6	5.94E-05	2.69E-03	1.63E-03	8.91E-03	6.37E-03	7.488E-01	2.781E+02
α_7	8.16E-12	5.53E-04	2.54E-05	3.03E-03	1.42E-03	1.541E-01	2.787E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9354759	0.9556569	0.9565832	0.9726603	0.9299475	3.117E+02	1.446E+01
α_2	5.01E-03	1.36E-02	1.26E-02	2.56E-02	1.09E-02	4.438E+00	3.217E+02
α_3	2.61E-03	9.38E-03	8.40E-03	1.95E-02	1.32E-02	3.059E+00	3.231E+02
α_4	1.67E-03	7.46E-03	6.48E-03	1.66E-02	1.29E-02	2.432E+00	3.237E+02
α_5	2.24E-03	8.65E-03	7.67E-03	1.84E-02	2.11E-02	2.821E+00	3.233E+02
α_6	2.50E-04	3.52E-03	2.57E-03	1.00E-02	7.82E-03	1.148E+00	3.250E+02
α_7	3.87E-06	1.43E-03	6.12E-04	5.63E-03	3.44E-03	4.667E-01	3.256E+02
α_8	4.61E-17	2.93E-04	1.32E-06	1.71E-03	6.25E-04	9.562E-02	3.260E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	8.73E-01	8.86E-01	8.93E-01	8.98E-01	9.09E-01	9.21E-01	9.30E-01
α_2	1.27E-01	5.99E-02	4.74E-02	3.99E-02	2.44E-02	1.61E-02	1.09E-02
α_3		5.37E-02	3.99E-02	3.13E-02	2.91E-02	1.76E-02	1.32E-02
α_4			2.01E-02	2.33E-02	2.17E-02	2.22E-02	1.29E-02
α_5				7.96E-03	1.28E-02	1.56E-02	2.11E-02
α_6					3.26E-03	6.37E-03	7.82E-03
α_7						1.42E-03	3.44E-03
α_8							6.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	8.73E-01	8.86E-01	8.93E-01	8.98E-01	9.09E-01	9.21E-01	9.30E-01
Beta	1.27E-01	1.14E-01	1.07E-01	1.02E-01	9.13E-02	7.93E-02	7.01E-02
Gamma		4.73E-01	5.59E-01	6.11E-01	7.32E-01	7.96E-01	8.44E-01
Delta			3.35E-01	5.00E-01	5.64E-01	7.22E-01	7.76E-01
Epsilon				2.54E-01	4.26E-01	5.12E-01	7.20E-01
Mu					2.03E-01	3.33E-01	3.60E-01
Omega						1.82E-01	3.42E-01
Sigma							1.54E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	23.23	34.85	46.46	58.08	69.69	81.31	92.92
N_1	2.2690	1.9179	1.2048	0.3333	0.0000	0.0000	0.0000
N_2	3.7238	2.4857	2.5286	2.5952	1.8750	1.4250	1.0931
N_3		2.2286	2.1286	2.0357	2.2321	1.5500	1.3206

N_4			1.0714	1.5179	1.6607	1.9625	1.2856
N_5				0.5179	0.9821	1.3750	2.1131
N_6					0.2500	0.5625	0.7813
N_7						0.1250	0.3438
N_8							0.0625

2.5.2 BWR Residual Heat Removal Check Valves

2.5.2.1 BWR RHR CHECK VALVE FAIL TO OPEN

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8636859	0.9657333	0.9856734	0.9999376	1.0000000	1.225E+01	4.345E-01
α_2	6.41E-05	3.43E-02	1.43E-02	1.36E-01	0.00E+00	4.345E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9040424	0.9662885	0.9752807	0.9977558	1.0000000	3.156E+01	1.101E+00
α_2	8.16E-04	2.55E-02	1.67E-02	8.05E-02	0.00E+00	8.337E-01	3.182E+01
α_3	2.88E-07	8.18E-03	1.66E-03	3.88E-02	0.00E+00	2.672E-01	3.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113590	0.9628918	0.9688972	0.9938678	1.0000000	4.814E+01	1.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	1.93E-08	4.45E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.977E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9311737	0.9652087	0.9682205	0.9889476	1.0000000	9.816E+01	3.538E+00
α_2	4.01E-03	2.08E-02	1.77E-02	4.80E-02	0.00E+00	2.114E+00	9.959E+01
α_3	4.70E-04	9.61E-03	6.64E-03	2.89E-02	0.00E+00	9.774E-01	1.007E+02
α_4	2.42E-06	3.68E-03	1.24E-03	1.56E-02	0.00E+00	3.744E-01	1.013E+02
α_5	5.87E-21	7.11E-04	4.02E-07	4.12E-03	0.00E+00	7.228E-02	1.016E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9346441	0.9652759	0.9677639	0.9873891	1.0000000	1.189E+02	4.279E+00
α_2	3.74E-03	1.82E-02	1.56E-02	4.13E-02	0.00E+00	2.239E+00	1.210E+02
α_3	6.53E-04	9.27E-03	6.78E-03	2.64E-02	0.00E+00	1.142E+00	1.221E+02
α_4	4.30E-05	4.81E-03	2.52E-03	1.73E-02	0.00E+00	5.922E-01	1.226E+02
α_5	7.54E-09	1.80E-03	2.45E-04	9.04E-03	0.00E+00	2.222E-01	1.230E+02
α_6	1.14E-18	6.76E-04	1.18E-06	3.94E-03	0.00E+00	8.324E-02	1.231E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9428467	0.9665187	0.9681253	0.9847051	1.0000000	1.861E+02	6.445E+00
α_2	4.52E-03	1.60E-02	1.44E-02	3.32E-02	0.00E+00	3.088E+00	1.894E+02
α_3	1.14E-03	8.47E-03	6.84E-03	2.14E-02	0.00E+00	1.631E+00	1.909E+02
α_4	2.57E-04	5.14E-03	3.56E-03	1.54E-02	0.00E+00	9.889E-01	1.915E+02
α_5	1.33E-05	2.71E-03	1.28E-03	1.02E-02	0.00E+00	5.218E-01	1.920E+02
α_6	3.49E-10	9.68E-04	8.26E-05	5.08E-03	0.00E+00	1.863E-01	1.923E+02
α_7	5.28E-48	1.51E-04	1.32E-13	5.69E-04	0.00E+00	2.907E-02	1.925E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9459358	0.9673038	0.9686636	0.9840409	1.0000000	2.207E+02	7.461E+00
α_2	4.41E-03	1.47E-02	1.33E-02	2.97E-02	0.00E+00	3.345E+00	2.248E+02
α_3	1.13E-03	7.62E-03	6.24E-03	1.88E-02	0.00E+00	1.738E+00	2.265E+02
α_4	3.56E-04	5.02E-03	3.67E-03	1.43E-02	0.00E+00	1.147E+00	2.270E+02
α_5	5.65E-05	3.10E-03	1.82E-03	1.05E-02	0.00E+00	7.083E-01	2.275E+02
α_6	9.10E-07	1.61E-03	5.27E-04	6.88E-03	0.00E+00	3.670E-01	2.278E+02
α_7	7.14E-14	5.39E-04	9.69E-06	3.07E-03	0.00E+00	1.230E-01	2.281E+02
α_8	1.34E-42	1.45E-04	2.07E-12	6.14E-04	0.00E+00	3.312E-02	2.282E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	2.00	2.00	2.00	2.00	2.00	2.00	2.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.2.2 BWR RHR CHECK VALVE FAIL TO CLOSE

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8959649	0.9739505	0.9892426	0.9999481	1.0000000	1.625E+01	4.345E-01
α_2	4.81E-05	2.60E-02	1.08E-02	1.04E-01	0.00E+00	4.345E-01	1.625E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9143466	0.9699672	0.9780275	0.9980130	1.0000000	3.556E+01	1.101E+00
α_2	7.25E-04	2.27E-02	1.48E-02	7.18E-02	0.00E+00	8.337E-01	3.582E+01
α_3	2.56E-07	7.29E-03	1.48E-03	3.46E-02	0.00E+00	2.672E-01	3.639E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9178253	0.9656410	0.9712249	0.9943336	1.0000000	5.214E+01	1.855E+00
α_2	1.89E-03	2.27E-02	1.72E-02	6.27E-02	0.00E+00	1.228E+00	5.276E+01
α_3	8.45E-06	7.49E-03	2.78E-03	3.09E-02	0.00E+00	4.043E-01	5.359E+01
α_4	1.78E-08	4.12E-03	5.66E-04	2.07E-02	0.00E+00	2.227E-01	5.377E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9337456	0.9665253	0.9694271	0.9893728	1.0000000	1.022E+02	3.538E+00
α_2	3.85E-03	2.00E-02	1.71E-02	4.62E-02	0.00E+00	2.114E+00	1.036E+02
α_3	4.52E-04	9.25E-03	6.39E-03	2.78E-02	0.00E+00	9.774E-01	1.047E+02
α_4	2.33E-06	3.54E-03	1.19E-03	1.50E-02	0.00E+00	3.744E-01	1.053E+02
α_5	5.65E-21	6.84E-04	3.87E-07	3.96E-03	0.00E+00	7.228E-02	1.056E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9366751	0.9663677	0.9687883	0.9877915	1.0000000	1.229E+02	4.279E+00
α_2	3.62E-03	1.76E-02	1.51E-02	4.00E-02	0.00E+00	2.239E+00	1.250E+02
α_3	6.32E-04	8.98E-03	6.57E-03	2.55E-02	0.00E+00	1.142E+00	1.261E+02
α_4	4.16E-05	4.66E-03	2.44E-03	1.68E-02	0.00E+00	5.922E-01	1.266E+02
α_5	7.30E-09	1.75E-03	2.37E-04	8.75E-03	0.00E+00	2.222E-01	1.270E+02
α_6	1.11E-18	6.54E-04	1.14E-06	3.82E-03	0.00E+00	8.324E-02	1.271E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9439981	0.9672002	0.9687772	0.9850250	1.0000000	1.901E+02	6.445E+00
α_2	4.43E-03	1.57E-02	1.41E-02	3.25E-02	0.00E+00	3.088E+00	1.934E+02
α_3	1.12E-03	8.30E-03	6.70E-03	2.10E-02	0.00E+00	1.631E+00	1.949E+02
α_4	2.52E-04	5.03E-03	3.48E-03	1.51E-02	0.00E+00	9.889E-01	1.955E+02
α_5	1.31E-05	2.66E-03	1.26E-03	1.00E-02	0.00E+00	5.218E-01	1.960E+02
α_6	3.42E-10	9.48E-04	8.09E-05	4.98E-03	0.00E+00	1.863E-01	1.963E+02
α_7	5.17E-48	1.48E-04	1.30E-13	5.57E-04	0.00E+00	2.907E-02	1.965E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9468589	0.9678670	0.9692055	0.9843187	1.0000000	2.247E+02	7.461E+00
α_2	4.33E-03	1.44E-02	1.30E-02	2.92E-02	0.00E+00	3.345E+00	2.288E+02
α_3	1.11E-03	7.49E-03	6.13E-03	1.85E-02	0.00E+00	1.738E+00	2.305E+02
α_4	3.50E-04	4.94E-03	3.61E-03	1.41E-02	0.00E+00	1.147E+00	2.310E+02
α_5	5.55E-05	3.05E-03	1.79E-03	1.03E-02	0.00E+00	7.083E-01	2.315E+02
α_6	8.95E-07	1.58E-03	5.17E-04	6.76E-03	0.00E+00	3.670E-01	2.318E+02
α_7	7.01E-14	5.30E-04	9.53E-06	3.02E-03	0.00E+00	1.230E-01	2.321E+02
α_8	1.31E-42	1.43E-04	2.03E-12	6.03E-04	0.00E+00	3.312E-02	2.322E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	6.00	6.00	6.00	6.00	6.00	6.00	6.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.3 PWR Auxiliary Feedwater Check Valves

2.5.3.1 CHECK VALVE FAIL TO OPEN

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8636859	0.9657333	0.9856734	0.9999376	1.0000000	1.225E+01	4.345E-01
α_2	6.41E-05	3.43E-02	1.43E-02	1.36E-01	0.00E+00	4.345E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9040424	0.9662885	0.9752807	0.9977558	1.0000000	3.156E+01	1.101E+00
α_2	8.16E-04	2.55E-02	1.67E-02	8.05E-02	0.00E+00	8.337E-01	3.182E+01
α_3	2.88E-07	8.18E-03	1.66E-03	3.88E-02	0.00E+00	2.672E-01	3.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113590	0.9628918	0.9688972	0.9938678	1.0000000	4.814E+01	1.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	1.93E-08	4.45E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.977E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9311737	0.9652087	0.9682205	0.9889476	1.0000000	9.816E+01	3.538E+00
α_2	4.01E-03	2.08E-02	1.77E-02	4.80E-02	0.00E+00	2.114E+00	9.959E+01
α_3	4.70E-04	9.61E-03	6.64E-03	2.89E-02	0.00E+00	9.774E-01	1.007E+02
α_4	2.42E-06	3.68E-03	1.24E-03	1.56E-02	0.00E+00	3.744E-01	1.013E+02
α_5	5.87E-21	7.11E-04	4.02E-07	4.12E-03	0.00E+00	7.228E-02	1.016E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9346441	0.9652759	0.9677639	0.9873891	1.0000000	1.189E+02	4.279E+00
α_2	3.74E-03	1.82E-02	1.56E-02	4.13E-02	0.00E+00	2.239E+00	1.210E+02
α_3	6.53E-04	9.27E-03	6.78E-03	2.64E-02	0.00E+00	1.142E+00	1.221E+02
α_4	4.30E-05	4.81E-03	2.52E-03	1.73E-02	0.00E+00	5.922E-01	1.226E+02
α_5	7.54E-09	1.80E-03	2.45E-04	9.04E-03	0.00E+00	2.222E-01	1.230E+02
α_6	1.14E-18	6.76E-04	1.18E-06	3.94E-03	0.00E+00	8.324E-02	1.231E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9428467	0.9665187	0.9681253	0.9847051	1.0000000	1.861E+02	6.445E+00
α_2	4.52E-03	1.60E-02	1.44E-02	3.32E-02	0.00E+00	3.088E+00	1.894E+02
α_3	1.14E-03	8.47E-03	6.84E-03	2.14E-02	0.00E+00	1.631E+00	1.909E+02
α_4	2.57E-04	5.14E-03	3.56E-03	1.54E-02	0.00E+00	9.889E-01	1.915E+02
α_5	1.33E-05	2.71E-03	1.28E-03	1.02E-02	0.00E+00	5.218E-01	1.920E+02
α_6	3.49E-10	9.68E-04	8.26E-05	5.08E-03	0.00E+00	1.863E-01	1.923E+02
α_7	5.28E-48	1.51E-04	1.32E-13	5.69E-04	0.00E+00	2.907E-02	1.925E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9459358	0.9673038	0.9686636	0.9840409	1.0000000	2.207E+02	7.461E+00
α_2	4.41E-03	1.47E-02	1.33E-02	2.97E-02	0.00E+00	3.345E+00	2.248E+02
α_3	1.13E-03	7.62E-03	6.24E-03	1.88E-02	0.00E+00	1.738E+00	2.265E+02
α_4	3.56E-04	5.02E-03	3.67E-03	1.43E-02	0.00E+00	1.147E+00	2.270E+02
α_5	5.65E-05	3.10E-03	1.82E-03	1.05E-02	0.00E+00	7.083E-01	2.275E+02
α_6	9.10E-07	1.61E-03	5.27E-04	6.88E-03	0.00E+00	3.670E-01	2.278E+02
α_7	7.14E-14	5.39E-04	9.69E-06	3.07E-03	0.00E+00	1.230E-01	2.281E+02
α_8	1.34E-42	1.45E-04	2.07E-12	6.14E-04	0.00E+00	3.312E-02	2.282E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	2.00	2.00	2.00	2.00	2.00	2.00	2.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.3.2 CHECK VALVE FAIL TO CLOSE

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.6
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8640533	0.9655387	0.9852660	0.9999278	0.9954926	1.245E+01	4.445E-01
α_2	7.40E-05	3.45E-02	1.47E-02	1.36E-01	4.51E-03	4.445E-01	1.245E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9061231	0.9667253	0.9753936	0.9976527	0.9911176	3.284E+01	1.130E+00
α_2	8.99E-04	2.54E-02	1.68E-02	7.91E-02	8.80E-03	8.628E-01	3.311E+01
α_3	2.80E-07	7.87E-03	1.60E-03	3.73E-02	8.62E-05	2.675E-01	3.370E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9136003	0.9634889	0.9692324	0.9937207	0.9868780	5.048E+01	1.913E+00
α_2	2.23E-03	2.45E-02	1.88E-02	6.65E-02	1.29E-02	1.285E+00	5.110E+01
α_3	8.90E-06	7.74E-03	2.89E-03	3.19E-02	2.60E-04	4.055E-01	5.198E+01
α_4	1.84E-08	4.25E-03	5.83E-04	2.13E-02	0.00E+00	2.227E-01	5.217E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9321482	0.9654615	0.9683767	0.9888103	0.9827766	1.015E+02	3.633E+00
α_2	4.25E-03	2.10E-02	1.80E-02	4.78E-02	1.67E-02	2.206E+00	1.030E+02
α_3	4.59E-04	9.32E-03	6.45E-03	2.80E-02	5.22E-04	9.802E-01	1.042E+02
α_4	2.34E-06	3.56E-03	1.20E-03	1.51E-02	0.00E+00	3.744E-01	1.048E+02
α_5	5.68E-21	6.87E-04	3.89E-07	3.98E-03	0.00E+00	7.228E-02	1.051E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9354467	0.9654256	0.9678265	0.9871836	0.9788163	1.233E+02	4.417E+00
α_2	4.07E-03	1.86E-02	1.61E-02	4.14E-02	2.03E-02	2.372E+00	1.254E+02
α_3	6.39E-04	8.98E-03	6.58E-03	2.55E-02	8.74E-04	1.148E+00	1.266E+02
α_4	4.15E-05	4.64E-03	2.43E-03	1.67E-02	0.00E+00	5.922E-01	1.272E+02
α_5	7.27E-09	1.74E-03	2.36E-04	8.71E-03	0.00E+00	2.222E-01	1.275E+02
α_6	1.10E-18	6.52E-04	1.14E-06	3.80E-03	0.00E+00	8.324E-02	1.277E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9431936	0.9665060	0.9680675	0.9844855	0.9750000	1.915E+02	6.635E+00
α_2	4.88E-03	1.65E-02	1.49E-02	3.36E-02	2.37E-02	3.268E+00	1.948E+02
α_3	1.13E-03	8.28E-03	6.70E-03	2.09E-02	1.32E-03	1.641E+00	1.965E+02
α_4	2.50E-04	4.99E-03	3.46E-03	1.50E-02	0.00E+00	9.889E-01	1.971E+02
α_5	1.30E-05	2.63E-03	1.25E-03	9.95E-03	0.00E+00	5.218E-01	1.976E+02
α_6	3.39E-10	9.40E-04	8.03E-05	4.94E-03	0.00E+00	1.863E-01	1.979E+02
α_7	5.13E-48	1.47E-04	1.28E-13	5.52E-04	0.00E+00	2.907E-02	1.981E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9461562	0.9672196	0.9685408	0.9837836	0.9725780	2.271E+02	7.698E+00
α_2	4.79E-03	1.52E-02	1.38E-02	3.02E-02	2.51E-02	3.561E+00	2.313E+02
α_3	1.13E-03	7.49E-03	6.14E-03	1.84E-02	2.30E-03	1.758E+00	2.331E+02
α_4	3.46E-04	4.88E-03	3.57E-03	1.39E-02	6.74E-05	1.147E+00	2.337E+02
α_5	5.49E-05	3.02E-03	1.77E-03	1.02E-02	0.00E+00	7.083E-01	2.341E+02
α_6	8.84E-07	1.56E-03	5.12E-04	6.68E-03	0.00E+00	3.670E-01	2.345E+02
α_7	6.93E-14	5.24E-04	9.42E-06	2.98E-03	0.00E+00	1.230E-01	2.347E+02
α_8	1.30E-42	1.41E-04	2.01E-12	5.96E-04	0.00E+00	3.312E-02	2.348E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.95E-01	9.91E-01	9.87E-01	9.83E-01	9.79E-01	9.75E-01	9.73E-01
α_2	4.51E-03	8.80E-03	1.29E-02	1.67E-02	2.03E-02	2.37E-02	2.51E-02
α_3		8.62E-05	2.60E-04	5.22E-04	8.74E-04	1.32E-03	2.30E-03
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.74E-05
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.91E-01	9.87E-01	9.83E-01	9.79E-01	9.75E-01	9.73E-01
Beta	4.51E-03	8.88E-03	1.31E-02	1.72E-02	2.12E-02	2.50E-02	2.74E-02
Gamma		9.71E-03	1.98E-02	3.03E-02	4.12E-02	5.26E-02	8.64E-02
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-02
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	1.89	2.83	3.77	4.71	5.66	6.60	7.54
N_1	0.3229	0.4551	0.5691	0.6657	0.7457	0.8100	0.8717
N_2	0.0100	0.0291	0.0566	0.0914	0.1329	0.1800	0.2168

N_3		0.0003	0.0011	0.0029	0.0057	0.0100	0.0199
N_4			0.0000	0.0000	0.0000	0.0000	0.0006
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.4 PWR High Pressure Safety Injection Check Valves

2.5.4.1 HIGH PRESSURE INJECTION CHECK VALVE FAIL TO OPEN

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8734960	0.9682380	0.9867707	0.9999364	1.0000000	1.325E+01	4.345E-01
α_2	5.92E-05	3.18E-02	1.32E-02	1.27E-01	0.00E+00	4.345E-01	1.325E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9068394	0.9672901	0.9760299	0.9978247	1.0000000	3.256E+01	1.101E+00
α_2	7.91E-04	2.48E-02	1.62E-02	7.82E-02	0.00E+00	8.337E-01	3.282E+01
α_3	2.80E-07	7.94E-03	1.61E-03	3.77E-02	0.00E+00	2.672E-01	3.339E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9130677	0.9636195	0.9695108	0.9939913	1.0000000	4.914E+01	1.855E+00
α_2	2.00E-03	2.41E-02	1.82E-02	6.63E-02	0.00E+00	1.228E+00	4.976E+01
α_3	8.95E-06	7.93E-03	2.95E-03	3.27E-02	0.00E+00	4.043E-01	5.059E+01
α_4	1.89E-08	4.37E-03	5.99E-04	2.19E-02	0.00E+00	2.227E-01	5.077E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9318352	0.9655475	0.9685323	0.9890571	1.0000000	9.916E+01	3.538E+00
α_2	3.97E-03	2.06E-02	1.76E-02	4.76E-02	0.00E+00	2.114E+00	1.006E+02
α_3	4.65E-04	9.52E-03	6.58E-03	2.86E-02	0.00E+00	9.774E-01	1.017E+02
α_4	2.40E-06	3.65E-03	1.23E-03	1.55E-02	0.00E+00	3.744E-01	1.023E+02
α_5	5.81E-21	7.04E-04	3.98E-07	4.08E-03	0.00E+00	7.228E-02	1.026E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9351639	0.9655554	0.9680294	0.9874922	1.0000000	1.199E+02	4.279E+00
α_2	3.71E-03	1.80E-02	1.55E-02	4.10E-02	0.00E+00	2.239E+00	1.220E+02
α_3	6.48E-04	9.19E-03	6.73E-03	2.62E-02	0.00E+00	1.142E+00	1.231E+02
α_4	4.26E-05	4.77E-03	2.50E-03	1.72E-02	0.00E+00	5.922E-01	1.236E+02
α_5	7.48E-09	1.79E-03	2.43E-04	8.96E-03	0.00E+00	2.222E-01	1.240E+02
α_6	1.14E-18	6.70E-04	1.17E-06	3.91E-03	0.00E+00	8.324E-02	1.241E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	3.00	3.00	3.00	3.00	3.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.5.4.2 HIGH PRESSURE INJECTION CHECK VALVE FAIL TO CLOSE

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9093850	0.9773458	0.9906921	0.9999549	1.0000000	1.875E+01	4.345E-01
α_2	4.16E-05	2.27E-02	9.31E-03	9.06E-02	0.00E+00	4.345E-01	1.875E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9197348	0.9718847	0.9794544	0.9981428	1.0000000	3.806E+01	1.101E+00
α_2	6.78E-04	2.13E-02	1.39E-02	6.73E-02	0.00E+00	8.337E-01	3.832E+01
α_3	2.40E-07	6.82E-03	1.38E-03	3.24E-02	0.00E+00	2.672E-01	3.889E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9214018	0.9671615	0.9725127	0.9945904	1.0000000	5.464E+01	1.855E+00
α_2	1.80E-03	2.17E-02	1.64E-02	6.00E-02	0.00E+00	1.228E+00	5.526E+01
α_3	8.07E-06	7.16E-03	2.66E-03	2.96E-02	0.00E+00	4.043E-01	5.609E+01
α_4	1.70E-08	3.94E-03	5.40E-04	1.97E-02	0.00E+00	2.227E-01	5.627E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9352577	0.9672988	0.9701374	0.9896223	1.0000000	1.047E+02	3.538E+00
α_2	3.76E-03	1.95E-02	1.67E-02	4.52E-02	0.00E+00	2.114E+00	1.061E+02
α_3	4.41E-04	9.03E-03	6.24E-03	2.72E-02	0.00E+00	9.774E-01	1.072E+02
α_4	2.28E-06	3.46E-03	1.17E-03	1.47E-02	0.00E+00	3.744E-01	1.078E+02
α_5	5.52E-21	6.68E-04	3.78E-07	3.87E-03	0.00E+00	7.228E-02	1.081E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9378816	0.9670159	0.9693885	0.9880303	1.0000000	1.254E+02	4.279E+00
α_2	3.55E-03	1.73E-02	1.48E-02	3.92E-02	0.00E+00	2.239E+00	1.275E+02
α_3	6.20E-04	8.80E-03	6.44E-03	2.51E-02	0.00E+00	1.142E+00	1.286E+02
α_4	4.08E-05	4.57E-03	2.39E-03	1.65E-02	0.00E+00	5.922E-01	1.291E+02
α_5	7.16E-09	1.71E-03	2.32E-04	8.58E-03	0.00E+00	2.222E-01	1.295E+02
α_6	1.09E-18	6.42E-04	1.12E-06	3.75E-03	0.00E+00	8.324E-02	1.296E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	8.50	8.50	8.50	8.50	8.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.5.5 PWR Residual Heat Removal Check Valves

2.5.5.1 PWR RHR CHECK VALVE FAIL TO OPEN

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8979023	0.9640891	0.9736327	0.9976042	0.0000000	2.956E+01	1.101E+00
α_2	8.71E-04	2.72E-02	1.78E-02	8.57E-02	0.00E+00	8.337E-01	2.982E+01
α_3	3.08E-07	8.72E-03	1.77E-03	4.13E-02	0.00E+00	2.672E-01	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9077328	0.9613453	0.9675777	0.9936050	0.0000000	4.614E+01	1.855E+00
α_2	2.13E-03	2.56E-02	1.93E-02	7.04E-02	0.00E+00	1.228E+00	4.676E+01
α_3	9.52E-06	8.42E-03	3.13E-03	3.48E-02	0.00E+00	4.043E-01	4.759E+01
α_4	2.01E-08	4.64E-03	6.37E-04	2.32E-02	0.00E+00	2.227E-01	4.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9298114	0.9645108	0.9675743	0.9887220	0.0000000	9.616E+01	3.538E+00
α_2	4.09E-03	2.12E-02	1.81E-02	4.90E-02	0.00E+00	2.114E+00	9.759E+01
α_3	4.79E-04	9.80E-03	6.78E-03	2.95E-02	0.00E+00	9.774E-01	9.872E+01
α_4	2.47E-06	3.76E-03	1.27E-03	1.59E-02	0.00E+00	3.744E-01	9.932E+01
α_5	5.99E-21	7.25E-04	4.10E-07	4.20E-03	0.00E+00	7.228E-02	9.963E+01

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9335790	0.9647030	0.9672350	0.9871778	0.0000000	1.169E+02	4.279E+00
α_2	3.80E-03	1.85E-02	1.59E-02	4.20E-02	0.00E+00	2.239E+00	1.190E+02
α_3	6.64E-04	9.42E-03	6.89E-03	2.68E-02	0.00E+00	1.142E+00	1.201E+02
α_4	4.37E-05	4.89E-03	2.56E-03	1.76E-02	0.00E+00	5.922E-01	1.206E+02
α_5	7.67E-09	1.83E-03	2.49E-04	9.18E-03	0.00E+00	2.222E-01	1.210E+02
α_6	1.16E-18	6.87E-04	1.20E-06	4.01E-03	0.00E+00	8.324E-02	1.211E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9422574	0.9661671	0.9677845	0.9845423	0.0000000	1.841E+02	6.445E+00
α_2	4.57E-03	1.62E-02	1.45E-02	3.35E-02	0.00E+00	3.088E+00	1.874E+02
α_3	1.15E-03	8.56E-03	6.91E-03	2.16E-02	0.00E+00	1.631E+00	1.889E+02
α_4	2.60E-04	5.19E-03	3.59E-03	1.56E-02	0.00E+00	9.889E-01	1.895E+02
α_5	1.35E-05	2.74E-03	1.30E-03	1.04E-02	0.00E+00	5.218E-01	1.900E+02
α_6	3.53E-10	9.78E-04	8.35E-05	5.13E-03	0.00E+00	1.863E-01	1.903E+02
α_7	5.34E-48	1.53E-04	1.34E-13	5.75E-04	0.00E+00	2.907E-02	1.905E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9454620	0.9670147	0.9683853	0.9838983	0.0000000	2.187E+02	7.461E+00
α_2	4.45E-03	1.48E-02	1.34E-02	2.99E-02	0.00E+00	3.345E+00	2.228E+02
α_3	1.14E-03	7.69E-03	6.29E-03	1.90E-02	0.00E+00	1.738E+00	2.245E+02
α_4	3.59E-04	5.07E-03	3.71E-03	1.44E-02	0.00E+00	1.147E+00	2.250E+02
α_5	5.70E-05	3.13E-03	1.84E-03	1.06E-02	0.00E+00	7.083E-01	2.255E+02
α_6	9.18E-07	1.62E-03	5.31E-04	6.94E-03	0.00E+00	3.670E-01	2.258E+02
α_7	7.20E-14	5.44E-04	9.78E-06	3.10E-03	0.00E+00	1.230E-01	2.261E+02
α_8	1.35E-42	1.46E-04	2.09E-12	6.19E-04	0.00E+00	3.312E-02	2.262E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.5.2 PWR RHR CHECK VALVE FAIL TO CLOSE

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9093850	0.9773458	0.9906921	0.9999549	1.0000000	1.875E+01	4.345E-01
α_2	4.16E-05	2.27E-02	9.31E-03	9.06E-02	0.00E+00	4.345E-01	1.875E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9197348	0.9718847	0.9794544	0.9981428	1.0000000	3.806E+01	1.101E+00
α_2	6.78E-04	2.13E-02	1.39E-02	6.73E-02	0.00E+00	8.337E-01	3.832E+01
α_3	2.40E-07	6.82E-03	1.38E-03	3.24E-02	0.00E+00	2.672E-01	3.889E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9214018	0.9671615	0.9725127	0.9945904	1.0000000	5.464E+01	1.855E+00
α_2	1.80E-03	2.17E-02	1.64E-02	6.00E-02	0.00E+00	1.228E+00	5.526E+01
α_3	8.07E-06	7.16E-03	2.66E-03	2.96E-02	0.00E+00	4.043E-01	5.609E+01
α_4	1.70E-08	3.94E-03	5.40E-04	1.97E-02	0.00E+00	2.227E-01	5.627E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9352577	0.9672988	0.9701374	0.9896223	1.0000000	1.047E+02	3.538E+00
α_2	3.76E-03	1.95E-02	1.67E-02	4.52E-02	0.00E+00	2.114E+00	1.061E+02
α_3	4.41E-04	9.03E-03	6.24E-03	2.72E-02	0.00E+00	9.774E-01	1.072E+02
α_4	2.28E-06	3.46E-03	1.17E-03	1.47E-02	0.00E+00	3.744E-01	1.078E+02
α_5	5.52E-21	6.68E-04	3.78E-07	3.87E-03	0.00E+00	7.228E-02	1.081E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9378816	0.9670159	0.9693885	0.9880303	1.0000000	1.254E+02	4.279E+00
α_2	3.55E-03	1.73E-02	1.48E-02	3.92E-02	0.00E+00	2.239E+00	1.275E+02
α_3	6.20E-04	8.80E-03	6.44E-03	2.51E-02	0.00E+00	1.142E+00	1.286E+02
α_4	4.08E-05	4.57E-03	2.39E-03	1.65E-02	0.00E+00	5.922E-01	1.291E+02
α_5	7.16E-09	1.71E-03	2.32E-04	8.58E-03	0.00E+00	2.222E-01	1.295E+02
α_6	1.09E-18	6.42E-04	1.12E-06	3.75E-03	0.00E+00	8.324E-02	1.296E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9446994	0.9676123	0.9691712	0.9852144	1.0000000	1.926E+02	6.445E+00
α_2	4.37E-03	1.55E-02	1.39E-02	3.21E-02	0.00E+00	3.088E+00	1.959E+02
α_3	1.10E-03	8.20E-03	6.62E-03	2.07E-02	0.00E+00	1.631E+00	1.974E+02
α_4	2.49E-04	4.97E-03	3.44E-03	1.49E-02	0.00E+00	9.889E-01	1.980E+02
α_5	1.29E-05	2.62E-03	1.24E-03	9.91E-03	0.00E+00	5.218E-01	1.985E+02
α_6	3.38E-10	9.36E-04	7.99E-05	4.91E-03	0.00E+00	1.863E-01	1.988E+02
α_7	5.11E-48	1.46E-04	1.28E-13	5.50E-04	0.00E+00	2.907E-02	1.990E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474199	0.9682093	0.9695298	0.9844874	1.0000000	2.272E+02	7.461E+00
α_2	4.29E-03	1.43E-02	1.29E-02	2.88E-02	0.00E+00	3.345E+00	2.313E+02
α_3	1.10E-03	7.41E-03	6.06E-03	1.83E-02	0.00E+00	1.738E+00	2.330E+02
α_4	3.46E-04	4.89E-03	3.57E-03	1.39E-02	0.00E+00	1.147E+00	2.335E+02
α_5	5.49E-05	3.02E-03	1.77E-03	1.02E-02	0.00E+00	7.083E-01	2.340E+02
α_6	8.85E-07	1.56E-03	5.12E-04	6.69E-03	0.00E+00	3.670E-01	2.343E+02
α_7	6.94E-14	5.24E-04	9.42E-06	2.98E-03	0.00E+00	1.230E-01	2.346E+02
α_8	1.30E-42	1.41E-04	2.01E-12	5.97E-04	0.00E+00	3.312E-02	2.347E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	8.50	8.50	8.50	8.50	8.50	8.50	8.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.5.6 BWR High Pressure Coolant Injection/Reactor Core Isolation Cooling Check Valves

2.5.6.1 COMBINED HPCI AND RCIC CHECK VALVE FAIL TO OPEN

Systems/Clean Water/High pressure coolant injection
Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8522320	0.9627996	0.9843829	0.9999318	1.0000000	1.125E+01	4.345E-01
α_2	7.00E-05	3.72E-02	1.56E-02	1.48E-01	0.00E+00	4.345E-01	1.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9010678	0.9652235	0.9744833	0.9976825	1.0000000	3.056E+01	1.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	2.98E-07	8.44E-03	1.71E-03	4.00E-02	0.00E+00	2.672E-01	3.139E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9095821	0.9621343	0.9682529	0.9937392	1.0000000	4.714E+01	1.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	1.97E-08	4.55E-03	6.24E-04	2.28E-02	0.00E+00	2.227E-01	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9304992	0.9648632	0.9678976	0.9888359	1.0000000	9.716E+01	3.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	2.45E-06	3.72E-03	1.25E-03	1.58E-02	0.00E+00	3.744E-01	1.003E+02
α_5	5.93E-21	7.18E-04	4.06E-07	4.16E-03	0.00E+00	7.228E-02	1.006E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9341158	0.9649918	0.9674994	0.9872843	1.0000000	1.179E+02	4.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02
α_4	4.33E-05	4.85E-03	2.54E-03	1.75E-02	0.00E+00	5.922E-01	1.216E+02
α_5	7.60E-09	1.82E-03	2.47E-04	9.11E-03	0.00E+00	2.222E-01	1.220E+02
α_6	1.15E-18	6.81E-04	1.19E-06	3.98E-03	0.00E+00	8.324E-02	1.221E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.00	1.00	1.00	1.00	1.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.5.6.2 COMBINED HPCI AND RCIC CHECK VALVE FAIL TO CLOSE

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8959649	0.9739505	0.9892426	0.9999481	1.0000000	1.625E+01	4.345E-01
α_2	4.81E-05	2.60E-02	1.08E-02	1.04E-01	0.00E+00	4.345E-01	1.625E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9143466	0.9699672	0.9780275	0.9980130	1.0000000	3.556E+01	1.101E+00
α_2	7.25E-04	2.27E-02	1.48E-02	7.18E-02	0.00E+00	8.337E-01	3.582E+01
α_3	2.56E-07	7.29E-03	1.48E-03	3.46E-02	0.00E+00	2.672E-01	3.639E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9178253	0.9656410	0.9712249	0.9943336	1.0000000	5.214E+01	1.855E+00
α_2	1.89E-03	2.27E-02	1.72E-02	6.27E-02	0.00E+00	1.228E+00	5.276E+01
α_3	8.45E-06	7.49E-03	2.78E-03	3.09E-02	0.00E+00	4.043E-01	5.359E+01
α_4	1.78E-08	4.12E-03	5.66E-04	2.07E-02	0.00E+00	2.227E-01	5.377E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9337456	0.9665253	0.9694271	0.9893728	1.0000000	1.022E+02	3.538E+00
α_2	3.85E-03	2.00E-02	1.71E-02	4.62E-02	0.00E+00	2.114E+00	1.036E+02
α_3	4.52E-04	9.25E-03	6.39E-03	2.78E-02	0.00E+00	9.774E-01	1.047E+02
α_4	2.33E-06	3.54E-03	1.19E-03	1.50E-02	0.00E+00	3.744E-01	1.053E+02
α_5	5.65E-21	6.84E-04	3.87E-07	3.96E-03	0.00E+00	7.228E-02	1.056E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9366751	0.9663677	0.9687883	0.9877915	1.0000000	1.229E+02	4.279E+00
α_2	3.62E-03	1.76E-02	1.51E-02	4.00E-02	0.00E+00	2.239E+00	1.250E+02
α_3	6.32E-04	8.98E-03	6.57E-03	2.55E-02	0.00E+00	1.142E+00	1.261E+02
α_4	4.16E-05	4.66E-03	2.44E-03	1.68E-02	0.00E+00	5.922E-01	1.266E+02
α_5	7.30E-09	1.75E-03	2.37E-04	8.75E-03	0.00E+00	2.222E-01	1.270E+02
α_6	1.11E-18	6.54E-04	1.14E-06	3.82E-03	0.00E+00	8.324E-02	1.271E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	6.00	6.00	6.00	6.00	6.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6 Strainers, Trash Racks, and Filters

2.6.1 Pooled Strainers

2.6.1.1 TRAVELLING SCREEN PLUG

Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 40.0
Total Number of Common-Cause Failure Events: 18

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9116634	0.9779213	0.9909364	0.9999561	1.0000000	1.925E+01	4.345E-01
α_2	4.05E-05	2.21E-02	9.06E-03	8.83E-02	0.00E+00	4.345E-01	1.925E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9207321	0.9722392	0.9797178	0.9981667	1.0000000	3.856E+01	1.101E+00
α_2	6.69E-04	2.10E-02	1.37E-02	6.65E-02	0.00E+00	8.337E-01	3.882E+01
α_3	2.37E-07	6.74E-03	1.36E-03	3.20E-02	0.00E+00	2.672E-01	3.939E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9220799	0.9674496	0.9727565	0.9946390	1.0000000	5.514E+01	1.855E+00
α_2	1.79E-03	2.15E-02	1.63E-02	5.94E-02	0.00E+00	1.228E+00	5.576E+01
α_3	8.00E-06	7.09E-03	2.63E-03	2.93E-02	0.00E+00	4.043E-01	5.659E+01
α_4	1.69E-08	3.91E-03	5.36E-04	1.96E-02	0.00E+00	2.227E-01	5.677E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9355519	0.9674492	0.9702755	0.9896709	1.0000000	1.052E+02	3.538E+00
α_2	3.75E-03	1.94E-02	1.66E-02	4.50E-02	0.00E+00	2.114E+00	1.066E+02
α_3	4.39E-04	8.99E-03	6.21E-03	2.70E-02	0.00E+00	9.774E-01	1.077E+02
α_4	2.26E-06	3.44E-03	1.16E-03	1.46E-02	0.00E+00	3.744E-01	1.083E+02
α_5	5.49E-21	6.65E-04	3.76E-07	3.85E-03	0.00E+00	7.228E-02	1.086E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9381174	0.9671425	0.9695065	0.9880769	1.0000000	1.259E+02	4.279E+00
α_2	3.53E-03	1.72E-02	1.48E-02	3.91E-02	0.00E+00	2.239E+00	1.280E+02
α_3	6.17E-04	8.77E-03	6.41E-03	2.50E-02	0.00E+00	1.142E+00	1.291E+02
α_4	4.07E-05	4.55E-03	2.38E-03	1.64E-02	0.00E+00	5.922E-01	1.296E+02
α_5	7.13E-09	1.71E-03	2.31E-04	8.55E-03	0.00E+00	2.222E-01	1.300E+02

α_6	1.08E-18	6.39E-04	1.12E-06	3.73E-03	0.00E+00	8.324E-02	1.301E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	9.00	9.00	9.00	9.00	9.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.1.2 TSA PLUG EXTREME ENVIRONMENTAL

Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 31.0
Total Number of Common-Cause Failure Events: 18

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.6178497	0.7362674	0.7401517	0.8414003	0.6574253	3.011E+01	1.079E+01
α_2	1.59E-01	2.64E-01	2.60E-01	3.82E-01	3.43E-01	1.079E+01	3.011E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7070231	0.7913454	0.7941573	0.8660466	0.6543108	5.484E+01	1.446E+01
α_2	4.75E-02	9.88E-02	9.49E-02	1.63E-01	1.56E-01	6.845E+00	6.245E+01
α_3	5.55E-02	1.10E-01	1.06E-01	1.77E-01	1.90E-01	7.615E+00	6.169E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7394081	0.8092529	0.8114461	0.8715975	0.6511201	7.619E+01	1.796E+01
α_2	3.93E-02	7.93E-02	7.63E-02	1.29E-01	1.35E-01	7.467E+00	8.668E+01
α_3	3.03E-02	6.65E-02	6.34E-02	1.13E-01	1.27E-01	6.260E+00	8.789E+01
α_4	1.63E-02	4.49E-02	4.17E-02	8.45E-02	8.68E-02	4.231E+00	8.992E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8145159	0.8626916	0.8642758	0.9054721	0.6723392	1.320E+02	2.101E+01
α_2	2.01E-02	4.33E-02	4.13E-02	7.32E-02	8.45E-02	6.619E+00	1.464E+02
α_3	2.38E-02	4.86E-02	4.66E-02	8.00E-02	1.21E-01	7.430E+00	1.456E+02
α_4	1.28E-02	3.23E-02	3.03E-02	5.87E-02	8.56E-02	4.941E+00	1.481E+02
α_5	2.40E-03	1.32E-02	1.12E-02	3.11E-02	3.66E-02	2.022E+00	1.510E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8352332	0.8773997	0.8787831	0.9148341	0.7021801	1.593E+02	2.227E+01
α_2	9.01E-03	2.44E-02	2.27E-02	4.56E-02	3.62E-02	4.427E+00	1.772E+02
α_3	2.10E-02	4.24E-02	4.07E-02	6.94E-02	1.08E-01	7.693E+00	1.739E+02
α_4	1.42E-02	3.26E-02	3.09E-02	5.67E-02	8.81E-02	5.913E+00	1.757E+02
α_5	5.03E-03	1.74E-02	1.57E-02	3.58E-02	4.88E-02	3.167E+00	1.784E+02
α_6	3.53E-04	5.87E-03	4.18E-03	1.71E-02	1.63E-02	1.066E+00	1.806E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	6.57E-01	6.54E-01	6.51E-01	6.72E-01	7.02E-01
α_2	3.43E-01	1.56E-01	1.35E-01	8.45E-02	3.62E-02
α_3		1.90E-01	1.27E-01	1.21E-01	1.08E-01
α_4			8.68E-02	8.56E-02	8.81E-02
α_5				3.66E-02	4.88E-02
α_6					1.63E-02

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	6.57E-01	6.54E-01	6.51E-01	6.72E-01	7.02E-01
Beta	3.43E-01	3.46E-01	3.49E-01	3.28E-01	2.98E-01
Gamma		5.50E-01	6.13E-01	7.42E-01	8.78E-01
Delta			4.06E-01	5.02E-01	5.85E-01
Epsilon				2.99E-01	4.25E-01
Mu					2.50E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	14.13	21.19	28.25	35.32	42.38
N_1	5.7381	4.0955	1.8012	0.5387	0.0300
N_2	10.3512	6.0116	6.2393	4.5048	2.1880
N_3		7.3473	5.8560	6.4524	6.5509
N_4			4.0083	4.5667	5.3211
N_5				1.9500	2.9450
N_6					0.9825

2.6.1.3 TSA PLUG NON ENVIRONMENTAL

Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 9.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9116634	0.9779213	0.9909364	0.9999561	1.0000000	1.925E+01	4.345E-01
α_2	4.05E-05	2.21E-02	9.06E-03	8.83E-02	0.00E+00	4.345E-01	1.925E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9207321	0.9722392	0.9797178	0.9981667	1.0000000	3.856E+01	1.101E+00
α_2	6.69E-04	2.10E-02	1.37E-02	6.65E-02	0.00E+00	8.337E-01	3.882E+01
α_3	2.37E-07	6.74E-03	1.36E-03	3.20E-02	0.00E+00	2.672E-01	3.939E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9220799	0.9674496	0.9727565	0.9946390	1.0000000	5.514E+01	1.855E+00
α_2	1.79E-03	2.15E-02	1.63E-02	5.94E-02	0.00E+00	1.228E+00	5.576E+01
α_3	8.00E-06	7.09E-03	2.63E-03	2.93E-02	0.00E+00	4.043E-01	5.659E+01
α_4	1.69E-08	3.91E-03	5.36E-04	1.96E-02	0.00E+00	2.227E-01	5.677E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9355519	0.9674492	0.9702755	0.9896709	1.0000000	1.052E+02	3.538E+00
α_2	3.75E-03	1.94E-02	1.66E-02	4.50E-02	0.00E+00	2.114E+00	1.066E+02
α_3	4.39E-04	8.99E-03	6.21E-03	2.70E-02	0.00E+00	9.774E-01	1.077E+02
α_4	2.26E-06	3.44E-03	1.16E-03	1.46E-02	0.00E+00	3.744E-01	1.083E+02
α_5	5.49E-21	6.65E-04	3.76E-07	3.85E-03	0.00E+00	7.228E-02	1.086E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9381174	0.9671425	0.9695065	0.9880769	1.0000000	1.259E+02	4.279E+00
α_2	3.53E-03	1.72E-02	1.48E-02	3.91E-02	0.00E+00	2.239E+00	1.280E+02
α_3	6.17E-04	8.77E-03	6.41E-03	2.50E-02	0.00E+00	1.142E+00	1.291E+02
α_4	4.07E-05	4.55E-03	2.38E-03	1.64E-02	0.00E+00	5.922E-01	1.296E+02
α_5	7.13E-09	1.71E-03	2.31E-04	8.55E-03	0.00E+00	2.222E-01	1.300E+02

α_6	1.08E-18	6.39E-04	1.12E-06	3.73E-03	0.00E+00	8.324E-02	1.301E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	9.00	9.00	9.00	9.00	9.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.1.4 TSA FTO NON ENVIRONMENTAL

Components/Filter/Strainer/Traveling Screen
Failure Modes/Fail to Operate
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 79.0
Total Number of Common-Cause Failure Events: 13

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7749362	0.8588850	0.8633038	0.9277253	0.8342882	4.663E+01	7.661E+00
α_2	7.23E-02	1.41E-01	1.37E-01	2.25E-01	1.66E-01	7.661E+00	4.663E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8502529	0.9047943	0.9077150	0.9493488	0.8752736	8.345E+01	8.781E+00
α_2	6.38E-03	2.73E-02	2.39E-02	5.96E-02	2.73E-02	2.514E+00	8.972E+01
α_3	3.10E-02	6.80E-02	6.48E-02	1.16E-01	9.74E-02	6.267E+00	8.596E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8768863	0.9197588	0.9219511	0.9551291	0.8945954	1.171E+02	1.022E+01
α_2	6.87E-03	2.43E-02	2.18E-02	5.00E-02	2.35E-02	3.088E+00	1.242E+02
α_3	1.17E-03	1.10E-02	8.60E-03	2.92E-02	1.26E-02	1.404E+00	1.259E+02
α_4	1.94E-02	4.50E-02	4.26E-02	7.86E-02	6.93E-02	5.723E+00	1.216E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9042156	0.9353090	0.9367856	0.9613756	0.9052473	1.838E+02	1.271E+01
α_2	8.53E-03	2.29E-02	2.13E-02	4.27E-02	2.46E-02	4.496E+00	1.921E+02
α_3	1.37E-03	9.02E-03	7.42E-03	2.21E-02	8.21E-03	1.772E+00	1.948E+02
α_4	3.88E-04	5.72E-03	4.16E-03	1.64E-02	7.74E-03	1.124E+00	1.954E+02
α_5	1.12E-02	2.71E-02	2.55E-02	4.84E-02	5.42E-02	5.322E+00	1.912E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9109512	0.9385895	0.9398314	0.9619901	0.9108666	2.209E+02	1.446E+01
α_2	9.65E-03	2.31E-02	2.18E-02	4.12E-02	2.81E-02	5.443E+00	2.300E+02
α_3	1.09E-03	7.37E-03	6.02E-03	1.82E-02	5.18E-03	1.734E+00	2.337E+02
α_4	5.62E-04	5.73E-03	4.41E-03	1.54E-02	6.63E-03	1.349E+00	2.341E+02
α_5	5.99E-05	3.07E-03	1.82E-03	1.03E-02	4.38E-03	7.222E-01	2.347E+02

α_6	9.00E-03	2.21E-02	2.08E-02	3.98E-02	4.49E-02	5.208E+00	2.302E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	8.34E-01	8.75E-01	8.95E-01	9.05E-01	9.11E-01
α_2	1.66E-01	2.73E-02	2.35E-02	2.46E-02	2.81E-02
α_3		9.74E-02	1.26E-02	8.21E-03	5.18E-03
α_4			6.93E-02	7.74E-03	6.63E-03
α_5				5.42E-02	4.38E-03
α_6					4.49E-02

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	8.34E-01	8.75E-01	8.95E-01	9.05E-01	9.11E-01
Beta	1.66E-01	1.25E-01	1.05E-01	9.48E-02	8.91E-02
Gamma		7.81E-01	7.78E-01	7.40E-01	6.85E-01
Delta			8.46E-01	8.83E-01	9.15E-01
Epsilon				8.75E-01	8.81E-01
Mu					9.11E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	32.60	48.90	65.21	81.51	97.81
N_1	3.7800	4.9900	5.7467	6.1627	6.1942
N_2	7.2267	1.6800	1.8599	2.3815	3.2034
N_3		6.0000	1.0000	0.7951	0.5919
N_4			5.5000	0.7500	0.7571
N_5				5.2500	0.5000
N_6					5.1250

2.6.1.5 GENERIC CLEAN DISCHARGE STRAINER PLUGS

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/Component cooling water
Systems/Clean Water/High pressure injection
Systems/Clean Water/Standby liquid control
Systems/Reactor/Control rod drive
Components/Filter/Strainer/Passive filter
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8979023	0.9640891	0.9736327	0.9976042	0.0000000	2.956E+01	1.101E+00
α_2	8.71E-04	2.72E-02	1.78E-02	8.57E-02	0.00E+00	8.337E-01	2.982E+01
α_3	3.08E-07	8.72E-03	1.77E-03	4.13E-02	0.00E+00	2.672E-01	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9077328	0.9613453	0.9675777	0.9936050	0.0000000	4.614E+01	1.855E+00
α_2	2.13E-03	2.56E-02	1.93E-02	7.04E-02	0.00E+00	1.228E+00	4.676E+01
α_3	9.52E-06	8.42E-03	3.13E-03	3.48E-02	0.00E+00	4.043E-01	4.759E+01
α_4	2.01E-08	4.64E-03	6.37E-04	2.32E-02	0.00E+00	2.227E-01	4.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9298114	0.9645108	0.9675743	0.9887220	0.0000000	9.616E+01	3.538E+00
α_2	4.09E-03	2.12E-02	1.81E-02	4.90E-02	0.00E+00	2.114E+00	9.759E+01
α_3	4.79E-04	9.80E-03	6.78E-03	2.95E-02	0.00E+00	9.774E-01	9.872E+01
α_4	2.47E-06	3.76E-03	1.27E-03	1.59E-02	0.00E+00	3.744E-01	9.932E+01
α_5	5.99E-21	7.25E-04	4.10E-07	4.20E-03	0.00E+00	7.228E-02	9.963E+01

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9335790	0.9647030	0.9672350	0.9871778	0.0000000	1.169E+02	4.279E+00
α_2	3.80E-03	1.85E-02	1.59E-02	4.20E-02	0.00E+00	2.239E+00	1.190E+02
α_3	6.64E-04	9.42E-03	6.89E-03	2.68E-02	0.00E+00	1.142E+00	1.201E+02
α_4	4.37E-05	4.89E-03	2.56E-03	1.76E-02	0.00E+00	5.922E-01	1.206E+02
α_5	7.67E-09	1.83E-03	2.49E-04	9.18E-03	0.00E+00	2.222E-01	1.210E+02
α_6	1.16E-18	6.87E-04	1.20E-06	4.01E-03	0.00E+00	8.324E-02	1.211E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	0.00	0.00	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.2 Service Water Strainers

2.6.2.1 SERVICE WATER TSA FTO NON ENVIRONMENTAL

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Traveling Screen
Failure Modes/Fail to Operate
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.0
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8708046	0.9493289	0.9592315	0.9939160	0.9435989	2.781E+01	1.485E+00
α_2	6.08E-03	5.07E-02	4.08E-02	1.29E-01	5.64E-02	1.485E+00	2.781E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9127637	0.9611957	0.9663858	0.9918689	0.9579525	5.576E+01	2.251E+00
α_2	3.01E-03	2.56E-02	2.03E-02	6.61E-02	2.38E-02	1.484E+00	5.652E+01
α_3	3.21E-04	1.32E-02	8.20E-03	4.33E-02	1.83E-02	7.672E-01	5.724E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9234345	0.9624504	0.9660636	0.9890963	0.9639223	8.087E+01	3.155E+00
α_2	3.26E-03	2.12E-02	1.75E-02	5.16E-02	1.53E-02	1.778E+00	8.225E+01
α_3	4.28E-04	1.08E-02	7.21E-03	3.32E-02	1.39E-02	9.043E-01	8.312E+01
α_4	1.64E-05	5.63E-03	2.45E-03	2.20E-02	6.94E-03	4.727E-01	8.355E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9369974	0.9651474	0.9672750	0.9860181	0.9665684	1.393E+02	5.032E+00
α_2	4.77E-03	1.89E-02	1.67E-02	4.05E-02	1.38E-02	2.729E+00	1.416E+02
α_3	9.31E-04	9.39E-03	7.24E-03	2.52E-02	8.47E-03	1.356E+00	1.430E+02
α_4	1.15E-04	5.19E-03	3.16E-03	1.72E-02	8.40E-03	7.494E-01	1.436E+02
α_5	1.15E-09	1.37E-03	1.37E-04	7.07E-03	2.80E-03	1.973E-01	1.442E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9402695	0.9655470	0.9673112	0.9847869	0.9674681	1.685E+02	6.011E+00

α_2	4.81E-03	1.73E-02	1.55E-02	3.61E-02	1.48E-02	3.026E+00	1.714E+02
α_3	8.42E-04	8.03E-03	6.24E-03	2.13E-02	4.85E-03	1.400E+00	1.731E+02
α_4	2.63E-04	5.54E-03	3.81E-03	1.68E-02	7.04E-03	9.673E-01	1.735E+02
α_5	7.83E-06	2.71E-03	1.17E-03	1.06E-02	4.69E-03	4.722E-01	1.740E+02
α_6	4.27E-12	8.35E-04	3.12E-05	4.63E-03	1.17E-03	1.457E-01	1.743E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.44E-01	9.58E-01	9.64E-01	9.67E-01	9.67E-01
α_2	5.64E-02	2.38E-02	1.53E-02	1.38E-02	1.48E-02
α_3		1.83E-02	1.39E-02	8.47E-03	4.85E-03
α_4			6.94E-03	8.40E-03	7.04E-03
α_5				2.80E-03	4.69E-03
α_6					1.17E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.44E-01	9.58E-01	9.64E-01	9.67E-01	9.67E-01
Beta	5.64E-02	4.20E-02	3.61E-02	3.34E-02	3.25E-02
Gamma		4.35E-01	5.77E-01	5.88E-01	5.46E-01
Delta			3.33E-01	5.69E-01	7.27E-01
Epsilon				2.50E-01	4.54E-01
Mu					2.00E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	16.00	24.00	32.00	40.00	48.00
N_1	1.5667	2.2000	2.7333	3.1750	3.5230
N_2	1.0500	0.6500	0.5500	0.6150	0.7864
N_3		0.5000	0.5000	0.3783	0.2584
N_4			0.2500	0.3750	0.3751
N_5				0.1250	0.2500
N_6					0.0625

2.6.2.2 SERVICE WATER TSA PLUG SPAR: TSA-PG-SWS

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 4.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8133034	0.9402812	0.9604615	0.9981810	0.8695652	1.275E+01	8.095E-01
α_2	1.82E-03	5.97E-02	3.95E-02	1.87E-01	1.30E-01	8.095E-01	1.275E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8760519	0.9483495	0.9567683	0.9917909	0.8267717	3.284E+01	1.788E+00
α_2	3.55E-03	3.76E-02	2.91E-02	1.01E-01	1.18E-01	1.302E+00	3.332E+01
α_3	4.84E-05	1.40E-02	6.34E-03	5.41E-02	5.51E-02	4.860E-01	3.414E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8911809	0.9484804	0.9540449	0.9867355	0.8250000	5.026E+01	2.730E+00
α_2	4.04E-03	3.03E-02	2.46E-02	7.60E-02	7.50E-02	1.603E+00	5.139E+01
α_3	3.76E-04	1.47E-02	9.20E-03	4.78E-02	7.50E-02	7.793E-01	5.221E+01
α_4	2.49E-06	6.56E-03	2.02E-03	2.85E-02	2.50E-02	3.477E-01	5.264E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9212626	0.9575426	0.9604002	0.9840474	0.8419958	1.012E+02	4.488E+00
α_2	4.79E-03	2.21E-02	1.92E-02	4.95E-02	3.74E-02	2.339E+00	1.034E+02
α_3	1.27E-03	1.28E-02	9.88E-03	3.43E-02	6.24E-02	1.352E+00	1.044E+02
α_4	8.08E-05	6.14E-03	3.43E-03	2.14E-02	4.57E-02	6.494E-01	1.051E+02
α_5	8.77E-12	1.39E-03	5.43E-05	7.71E-03	1.25E-02	1.473E-01	1.056E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9267206	0.9589339	0.9613045	0.9830524	0.8592804	1.230E+02	5.266E+00
α_2	4.04E-03	1.85E-02	1.60E-02	4.12E-02	1.82E-02	2.367E+00	1.259E+02
α_3	1.21E-03	1.11E-02	8.71E-03	2.93E-02	4.06E-02	1.427E+00	1.268E+02
α_4	3.07E-04	7.23E-03	4.88E-03	2.22E-02	4.77E-02	9.272E-01	1.273E+02
α_5	4.47E-06	3.25E-03	1.24E-03	1.33E-02	2.78E-02	4.172E-01	1.278E+02
α_6	3.47E-13	1.00E-03	2.19E-05	5.66E-03	6.41E-03	1.282E-01	1.281E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	8.70E-01	8.27E-01	8.25E-01	8.42E-01	8.59E-01
α_2	1.30E-01	1.18E-01	7.50E-02	3.74E-02	1.82E-02
α_3		5.51E-02	7.50E-02	6.24E-02	4.06E-02
α_4			2.50E-02	4.57E-02	4.77E-02
α_5				1.25E-02	2.78E-02
α_6					6.41E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	8.70E-01	8.27E-01	8.25E-01	8.42E-01	8.59E-01
Beta	1.30E-01	1.73E-01	1.75E-01	1.58E-01	1.41E-01
Gamma		3.18E-01	5.71E-01	7.63E-01	8.71E-01
Delta			2.50E-01	4.83E-01	6.69E-01
Epsilon				2.14E-01	4.17E-01
Mu					1.88E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	2.00	3.00	4.00	5.00	6.00
N_1	0.5000	0.2813	0.1250	0.0625	0.0300
N_2	0.3750	0.4688	0.3750	0.2250	0.1275
N_3		0.2188	0.3750	0.3750	0.2850
N_4			0.1250	0.2750	0.3350
N_5				0.0750	0.1950
N_6					0.0450

2.6.2.3 SERVICE WATER TSA PLUG ENVIRONMENTAL SPAR: TSA-PE-SWS

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8064196	0.9379940	0.9588728	0.9981064	0.8421053	1.225E+01	8.095E-01
α_2	1.89E-03	6.20E-02	4.11E-02	1.94E-01	1.58E-01	8.095E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8733780	0.9472059	0.9557921	0.9916020	0.7864078	3.209E+01	1.788E+00
α_2	3.63E-03	3.84E-02	2.98E-02	1.03E-01	1.46E-01	1.302E+00	3.257E+01
α_3	4.95E-05	1.43E-02	6.48E-03	5.53E-02	6.80E-02	4.860E-01	3.339E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8891332	0.9474895	0.9531449	0.9864727	0.7812500	4.926E+01	2.730E+00
α_2	4.12E-03	3.08E-02	2.50E-02	7.74E-02	9.38E-02	1.603E+00	5.039E+01
α_3	3.84E-04	1.50E-02	9.38E-03	4.87E-02	9.38E-02	7.793E-01	5.121E+01
α_4	2.54E-06	6.69E-03	2.06E-03	2.91E-02	3.13E-02	3.477E-01	5.164E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9203340	0.9570345	0.9599271	0.9838529	0.8005249	9.997E+01	4.488E+00
α_2	4.85E-03	2.24E-02	1.94E-02	5.01E-02	4.72E-02	2.339E+00	1.021E+02
α_3	1.28E-03	1.29E-02	9.99E-03	3.47E-02	7.87E-02	1.352E+00	1.031E+02
α_4	8.18E-05	6.22E-03	3.47E-03	2.17E-02	5.77E-02	6.494E-01	1.038E+02
α_5	8.87E-12	1.41E-03	5.50E-05	7.80E-03	1.57E-02	1.473E-01	1.043E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9258649	0.9584479	0.9608384	0.9828487	0.8210240	1.215E+02	5.266E+00
α_2	4.08E-03	1.87E-02	1.62E-02	4.17E-02	2.31E-02	2.367E+00	1.244E+02
α_3	1.22E-03	1.13E-02	8.81E-03	2.97E-02	5.17E-02	1.427E+00	1.253E+02
α_4	3.11E-04	7.32E-03	4.94E-03	2.24E-02	6.07E-02	9.272E-01	1.258E+02
α_5	4.53E-06	3.29E-03	1.26E-03	1.35E-02	3.53E-02	4.172E-01	1.263E+02
α_6	3.52E-13	1.01E-03	2.21E-05	5.73E-03	8.16E-03	1.282E-01	1.266E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	8.42E-01	7.86E-01	7.81E-01	8.01E-01	8.21E-01
α_2	1.58E-01	1.46E-01	9.38E-02	4.72E-02	2.31E-02
α_3		6.80E-02	9.38E-02	7.87E-02	5.17E-02
α_4			3.13E-02	5.77E-02	6.07E-02
α_5				1.57E-02	3.53E-02
α_6					8.16E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	8.42E-01	7.86E-01	7.81E-01	8.01E-01	8.21E-01
Beta	1.58E-01	2.14E-01	2.19E-01	1.99E-01	1.79E-01
Gamma		3.18E-01	5.71E-01	7.63E-01	8.71E-01
Delta			2.50E-01	4.83E-01	6.69E-01
Epsilon				2.14E-01	4.17E-01
Mu					1.88E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.50	2.25	3.00	3.75	4.50
N_1	0.5000	0.2813	0.1250	0.0625	0.0300
N_2	0.3750	0.4688	0.3750	0.2250	0.1275
N_3		0.2188	0.3750	0.3750	0.2850
N_4			0.1250	0.2750	0.3350
N_5				0.0750	0.1950
N_6					0.0450

2.6.2.4 SERVICE WATER TSA PLUG NON ENVIRONMENTAL

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8522320	0.9627996	0.9843829	0.9999318	1.0000000	1.125E+01	4.345E-01
α_2	7.00E-05	3.72E-02	1.56E-02	1.48E-01	0.00E+00	4.345E-01	1.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9010678	0.9652235	0.9744833	0.9976825	1.0000000	3.056E+01	1.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	2.98E-07	8.44E-03	1.71E-03	4.00E-02	0.00E+00	2.672E-01	3.139E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9095821	0.9621343	0.9682529	0.9937392	1.0000000	4.714E+01	1.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	1.97E-08	4.55E-03	6.24E-04	2.28E-02	0.00E+00	2.227E-01	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9304992	0.9648632	0.9678976	0.9888359	1.0000000	9.716E+01	3.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	2.45E-06	3.72E-03	1.25E-03	1.58E-02	0.00E+00	3.744E-01	1.003E+02
α_5	5.93E-21	7.18E-04	4.06E-07	4.16E-03	0.00E+00	7.228E-02	1.006E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9341158	0.9649918	0.9674994	0.9872843	1.0000000	1.179E+02	4.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02

α_4	4.33E-05	4.85E-03	2.54E-03	1.75E-02	0.00E+00	5.922E-01	1.216E+02
α_5	7.60E-09	1.82E-03	2.47E-04	9.11E-03	0.00E+00	2.222E-01	1.220E+02
α_6	1.15E-18	6.81E-04	1.19E-06	3.98E-03	0.00E+00	8.324E-02	1.221E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.00	1.00	1.00	1.00	1.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.2.5 SERVICE WATER STRAINER PLUG POOLED CAUSES SPAR: STR-PG-SWS

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
Failure Modes/High dP
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 47.0
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8469251	0.9197886	0.9256607	0.9725438	0.9082879	4.359E+01	3.801E+00
α_2	2.75E-02	8.02E-02	7.43E-02	1.53E-01	9.17E-02	3.801E+00	4.359E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8694220	0.9225287	0.9259084	0.9640742	0.8982129	7.662E+01	6.434E+00
α_2	2.26E-02	5.76E-02	5.41E-02	1.05E-01	7.54E-02	4.784E+00	7.827E+01
α_3	2.75E-03	1.99E-02	1.62E-02	4.97E-02	2.64E-02	1.651E+00	8.140E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8840246	0.9273359	0.9297912	0.9622565	0.9032200	1.073E+02	8.405E+00
α_2	1.62E-02	4.14E-02	3.88E-02	7.56E-02	5.26E-02	4.786E+00	1.109E+02
α_3	5.74E-03	2.31E-02	2.04E-02	4.97E-02	3.35E-02	2.674E+00	1.130E+02
α_4	3.65E-04	8.17E-03	5.56E-03	2.49E-02	1.07E-02	9.449E-01	1.147E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9109482	0.9418598	0.9434677	0.9672696	0.9145959	1.719E+02	1.061E+01
α_2	9.83E-03	2.57E-02	2.40E-02	4.74E-02	3.10E-02	4.685E+00	1.778E+02
α_3	6.55E-03	2.02E-02	1.84E-02	3.97E-02	3.26E-02	3.681E+00	1.788E+02
α_4	1.49E-03	9.73E-03	8.01E-03	2.39E-02	1.69E-02	1.776E+00	1.808E+02
α_5	7.30E-06	2.58E-03	1.11E-03	1.01E-02	4.81E-03	4.704E-01	1.821E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9200391	0.9469856	0.9483389	0.9693019	0.9250546	2.075E+02	1.162E+01
α_2	5.76E-03	1.73E-02	1.59E-02	3.39E-02	1.59E-02	3.800E+00	2.153E+02
α_3	6.49E-03	1.86E-02	1.72E-02	3.56E-02	3.00E-02	4.075E+00	2.151E+02
α_4	2.18E-03	1.04E-02	8.98E-03	2.36E-02	1.73E-02	2.285E+00	2.169E+02
α_5	3.75E-04	5.25E-03	3.85E-03	1.49E-02	9.49E-03	1.151E+00	2.180E+02
α_6	1.85E-07	1.40E-03	3.55E-04	6.36E-03	2.28E-03	3.070E-01	2.188E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.08E-01	8.98E-01	9.03E-01	9.15E-01	9.25E-01
α_2	9.17E-02	7.54E-02	5.26E-02	3.10E-02	1.59E-02
α_3		2.64E-02	3.35E-02	3.26E-02	3.00E-02
α_4			1.07E-02	1.69E-02	1.73E-02
α_5				4.81E-03	9.49E-03
α_6					2.28E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.08E-01	8.98E-01	9.03E-01	9.15E-01	9.25E-01
Beta	9.17E-02	1.02E-01	9.68E-02	8.54E-02	7.49E-02
Gamma		2.59E-01	4.57E-01	6.37E-01	7.87E-01
Delta			2.41E-01	4.00E-01	4.92E-01
Epsilon				2.21E-01	4.05E-01
Mu					1.94E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	29.91	44.86	59.82	74.77	89.73
N_1	3.4333	2.2000	1.3111	0.9838	0.8623
N_2	3.3667	3.9500	3.5583	2.5706	1.5605
N_3		1.3833	2.2694	2.7037	2.9335
N_4			0.7222	1.4016	1.6924
N_5				0.3981	0.9291
N_6					0.2238

2.6.2.6 SERVICE WATER STRAINER PLUG ENVIRONMENTAL SPAR: STR-PE-SWS

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
Failure Modes/High dP
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 16.0
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7613192	0.8744379	0.8831502	0.9576845	0.8240741	2.508E+01	3.601E+00
α_2	4.23E-02	1.26E-01	1.17E-01	2.39E-01	1.76E-01	3.601E+00	2.508E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8174042	0.8925725	0.8973061	0.9515386	0.8033898	4.931E+01	5.934E+00
α_2	2.93E-02	7.85E-02	7.34E-02	1.45E-01	1.42E-01	4.334E+00	5.091E+01
α_3	3.85E-03	2.90E-02	2.35E-02	7.29E-02	5.42E-02	1.601E+00	5.364E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8439517	0.9035527	0.9069586	0.9515017	0.8136814	7.125E+01	7.605E+00
α_2	1.92E-02	5.31E-02	4.93E-02	9.98E-02	9.59E-02	4.186E+00	7.467E+01
α_3	7.24E-03	3.14E-02	2.75E-02	6.88E-02	6.71E-02	2.474E+00	7.638E+01
α_4	5.38E-04	1.20E-02	8.18E-03	3.64E-02	2.34E-02	9.449E-01	7.791E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8906477	0.9297125	0.9318053	0.9616328	0.8360922	1.271E+02	9.612E+00
α_2	1.09E-02	3.06E-02	2.83E-02	5.80E-02	5.59E-02	4.185E+00	1.326E+02
α_3	6.75E-03	2.33E-02	2.10E-02	4.76E-02	5.95E-02	3.181E+00	1.336E+02
α_4	1.99E-03	1.30E-02	1.07E-02	3.18E-02	3.78E-02	1.776E+00	1.350E+02
α_5	9.75E-06	3.44E-03	1.49E-03	1.35E-02	1.07E-02	4.704E-01	1.363E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9012501	0.9354218	0.9371816	0.9635783	0.8532620	1.538E+02	1.062E+01
α_2	7.69E-03	2.31E-02	2.12E-02	4.50E-02	3.61E-02	3.800E+00	1.606E+02
α_3	5.26E-03	1.87E-02	1.68E-02	3.87E-02	4.48E-02	3.075E+00	1.613E+02
α_4	2.92E-03	1.39E-02	1.20E-02	3.14E-02	3.92E-02	2.285E+00	1.621E+02
α_5	5.01E-04	7.00E-03	5.13E-03	1.99E-02	2.15E-02	1.151E+00	1.633E+02
α_6	2.47E-07	1.87E-03	4.74E-04	8.48E-03	5.18E-03	3.070E-01	1.641E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	8.24E-01	8.03E-01	8.14E-01	8.36E-01	8.53E-01
α_2	1.76E-01	1.42E-01	9.59E-02	5.59E-02	3.61E-02
α_3		5.42E-02	6.71E-02	5.95E-02	4.48E-02
α_4			2.34E-02	3.78E-02	3.92E-02
α_5				1.07E-02	2.15E-02
α_6					5.18E-03

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	8.24E-01	8.03E-01	8.14E-01	8.36E-01	8.53E-01
Beta	1.76E-01	1.97E-01	1.86E-01	1.64E-01	1.47E-01
Gamma		2.76E-01	4.86E-01	6.59E-01	7.54E-01
Delta			2.59E-01	4.50E-01	5.95E-01
Epsilon				2.21E-01	4.05E-01
Mu					1.94E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	12.00	18.00	24.00	30.00	36.00
N_1	2.8333	1.7500	1.1111	0.9838	0.8623
N_2	3.1667	3.5000	2.9583	2.0706	1.5605
N_3		1.3333	2.0694	2.2037	1.9335
N_4			0.7222	1.4016	1.6924
N_5				0.3981	0.9291
N_6					0.2238

2.6.2.7 SERVICE WATER STRAINER PLUG NON ENVIRONMENTAL

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
Failure Modes/High dP
Failure Modes/Plug
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 31.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8989261	0.9709121	0.9836099	0.9996388	0.9820359	2.118E+01	6.345E-01
α_2	3.59E-04	2.91E-02	1.64E-02	1.01E-01	1.80E-02	6.345E-01	2.118E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9147530	0.9660153	0.9723817	0.9954592	0.9696049	4.551E+01	1.601E+00
α_2	2.48E-03	2.73E-02	2.09E-02	7.38E-02	2.74E-02	1.284E+00	4.582E+01
α_3	1.20E-06	6.73E-03	1.82E-03	3.02E-02	3.04E-03	3.172E-01	4.679E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9183858	0.9618839	0.9662245	0.9905220	0.9630769	6.700E+01	2.655E+00
α_2	4.22E-03	2.62E-02	2.19E-02	6.33E-02	2.77E-02	1.828E+00	6.783E+01
α_3	8.52E-05	8.68E-03	4.63E-03	3.10E-02	9.23E-03	6.043E-01	6.905E+01
α_4	1.38E-08	3.20E-03	4.37E-04	1.60E-02	0.00E+00	2.227E-01	6.944E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9335175	0.9641338	0.9665530	0.9864688	0.9627329	1.220E+02	4.538E+00
α_2	5.01E-03	2.07E-02	1.82E-02	4.48E-02	1.86E-02	2.614E+00	1.239E+02
α_3	1.35E-03	1.17E-02	9.22E-03	3.04E-02	1.86E-02	1.477E+00	1.251E+02
α_4	1.94E-06	2.96E-03	9.96E-04	1.26E-02	0.00E+00	3.744E-01	1.262E+02
α_5	4.71E-21	5.71E-04	3.23E-07	3.31E-03	0.00E+00	7.228E-02	1.265E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9384330	0.9655482	0.9675546	0.9858056	0.9687500	1.479E+02	5.279E+00
α_2	3.00E-03	1.46E-02	1.26E-02	3.33E-02	0.00E+00	2.239E+00	1.510E+02

α_3	2.72E-03	1.40E-02	1.19E-02	3.23E-02	3.13E-02	2.142E+00	1.511E+02
α_4	3.45E-05	3.87E-03	2.02E-03	1.39E-02	0.00E+00	5.922E-01	1.526E+02
α_5	6.06E-09	1.45E-03	1.97E-04	7.27E-03	0.00E+00	2.222E-01	1.530E+02
α_6	9.20E-19	5.43E-04	9.50E-07	3.17E-03	0.00E+00	8.324E-02	1.531E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.82E-01	9.70E-01	9.63E-01	9.63E-01	9.69E-01
α_2	1.80E-02	2.74E-02	2.77E-02	1.86E-02	0.00E+00
α_3		3.04E-03	9.23E-03	1.86E-02	3.13E-02
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.82E-01	9.70E-01	9.63E-01	9.63E-01	9.69E-01
Beta	1.80E-02	3.04E-02	3.69E-02	3.73E-02	3.13E-02
Gamma		1.00E-01	2.50E-01	5.00E-01	1.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	10.33	15.50	20.67	25.83	31.00
N_1	0.6000	0.4500	0.2000	0.0000	0.0000
N_2	0.2000	0.4500	0.6000	0.5000	0.0000
N_3		0.0500	0.2000	0.5000	1.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.3 Pooled Sump Strainers

2.6.3.1 SUMP SUCTION PLUGGED

Systems/Clean Water/Containment spray recirculation
Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/High pressure core spray
Systems/Clean Water/Low pressure core spray
Systems/Clean Water/Reactor core isolation
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Filter/Strainer/Sump Strainer Filter
Failure Modes/High dP
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8581893	0.9643266	0.9850586	0.9999348	1.0000000	1.175E+01	4.345E-01
α_2	6.69E-05	3.57E-02	1.49E-02	1.42E-01	0.00E+00	4.345E-01	1.175E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9025784	0.9657643	0.9748883	0.9977197	1.0000000	3.106E+01	1.101E+00
α_2	8.29E-04	2.59E-02	1.69E-02	8.18E-02	0.00E+00	8.337E-01	3.132E+01
α_3	2.93E-07	8.31E-03	1.69E-03	3.94E-02	0.00E+00	2.672E-01	3.189E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9104794	0.9625169	0.9685784	0.9938042	1.0000000	4.764E+01	1.855E+00
α_2	2.06E-03	2.48E-02	1.87E-02	6.83E-02	0.00E+00	1.228E+00	4.826E+01
α_3	9.23E-06	8.17E-03	3.04E-03	3.37E-02	0.00E+00	4.043E-01	4.909E+01
α_4	1.95E-08	4.50E-03	6.18E-04	2.25E-02	0.00E+00	2.227E-01	4.927E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9308381	0.9650368	0.9680622	0.9888921	1.0000000	9.766E+01	3.538E+00
α_2	4.03E-03	2.09E-02	1.78E-02	4.83E-02	0.00E+00	2.114E+00	9.909E+01
α_3	4.72E-04	9.66E-03	6.68E-03	2.90E-02	0.00E+00	9.774E-01	1.002E+02
α_4	2.43E-06	3.70E-03	1.25E-03	1.57E-02	0.00E+00	3.744E-01	1.008E+02
α_5	5.90E-21	7.14E-04	4.04E-07	4.14E-03	0.00E+00	7.228E-02	1.011E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9343810	0.9651344	0.9676322	0.9873369	1.0000000	1.184E+02	4.279E+00
α_2	3.75E-03	1.82E-02	1.57E-02	4.15E-02	0.00E+00	2.239E+00	1.205E+02
α_3	6.56E-04	9.30E-03	6.81E-03	2.65E-02	0.00E+00	1.142E+00	1.216E+02

α_4	4.32E-05	4.83E-03	2.53E-03	1.74E-02	0.00E+00	5.922E-01	1.221E+02
α_5	7.57E-09	1.81E-03	2.46E-04	9.07E-03	0.00E+00	2.222E-01	1.225E+02
α_6	1.15E-18	6.78E-04	1.19E-06	3.96E-03	0.00E+00	8.324E-02	1.226E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	1.50	1.50	1.50	1.50	1.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.4 PWR Containment Sump Strainers

2.6.4.1 CONTAINMENT SPRAY SUMP STRAINER PLUG

Systems/Clean Water/Containment spray recirculation
Components/Filter/Strainer/Sump Strainer Filter
Failure Modes/High dP
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	0.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	0.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	0.00
N_1	0.0000
N_2	0.0000

2.6.5 BWR Suppression Pool Strainers

2.6.5.1 BWR RHR SUMP STRAINER PLUG

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Filter/Strainer/Sump Strainer Filter
Failure Modes/High dP
Failure Modes/Plug
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8979023	0.9640891	0.9736327	0.9976042	0.0000000	2.956E+01	1.101E+00
α_2	8.71E-04	2.72E-02	1.78E-02	8.57E-02	0.00E+00	8.337E-01	2.982E+01
α_3	3.08E-07	8.72E-03	1.77E-03	4.13E-02	0.00E+00	2.672E-01	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9077328	0.9613453	0.9675777	0.9936050	0.0000000	4.614E+01	1.855E+00
α_2	2.13E-03	2.56E-02	1.93E-02	7.04E-02	0.00E+00	1.228E+00	4.676E+01
α_3	9.52E-06	8.42E-03	3.13E-03	3.48E-02	0.00E+00	4.043E-01	4.759E+01
α_4	2.01E-08	4.64E-03	6.37E-04	2.32E-02	0.00E+00	2.227E-01	4.777E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9298114	0.9645108	0.9675743	0.9887220	0.0000000	9.616E+01	3.538E+00
α_2	4.09E-03	2.12E-02	1.81E-02	4.90E-02	0.00E+00	2.114E+00	9.759E+01
α_3	4.79E-04	9.80E-03	6.78E-03	2.95E-02	0.00E+00	9.774E-01	9.872E+01
α_4	2.47E-06	3.76E-03	1.27E-03	1.59E-02	0.00E+00	3.744E-01	9.932E+01
α_5	5.99E-21	7.25E-04	4.10E-07	4.20E-03	0.00E+00	7.228E-02	9.963E+01

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9335790	0.9647030	0.9672350	0.9871778	0.0000000	1.169E+02	4.279E+00
α_2	3.80E-03	1.85E-02	1.59E-02	4.20E-02	0.00E+00	2.239E+00	1.190E+02
α_3	6.64E-04	9.42E-03	6.89E-03	2.68E-02	0.00E+00	1.142E+00	1.201E+02
α_4	4.37E-05	4.89E-03	2.56E-03	1.76E-02	0.00E+00	5.922E-01	1.206E+02
α_5	7.67E-09	1.83E-03	2.49E-04	9.18E-03	0.00E+00	2.222E-01	1.210E+02
α_6	1.16E-18	6.87E-04	1.20E-06	4.01E-03	0.00E+00	8.324E-02	1.211E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	0.00	0.00	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.6.6 Circulating Water Strainers

2.6.6.1 CIRCULATING WATER TSA EXTREME ENVIRONMENTAL PLUG

Systems/Raw Water/Circulating water system
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 28.0
Total Number of Common-Cause Failure Events: 17

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.6075115	0.7302096	0.7342191	0.8391782	0.6425281	2.818E+01	1.041E+01
α_2	1.61E-01	2.70E-01	2.66E-01	3.92E-01	3.57E-01	1.041E+01	2.818E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7056086	0.7919012	0.7948522	0.8680988	0.6433167	5.241E+01	1.377E+01
α_2	4.48E-02	9.63E-02	9.23E-02	1.62E-01	1.56E-01	6.377E+00	5.981E+01
α_3	5.58E-02	1.12E-01	1.08E-01	1.81E-01	2.01E-01	7.396E+00	5.879E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7395823	0.8107756	0.8130749	0.8741082	0.6399135	7.320E+01	1.708E+01
α_2	3.81E-02	7.86E-02	7.55E-02	1.30E-01	1.39E-01	7.092E+00	8.319E+01
α_3	2.88E-02	6.52E-02	6.20E-02	1.12E-01	1.30E-01	5.885E+00	8.440E+01
α_4	1.61E-02	4.55E-02	4.22E-02	8.62E-02	9.18E-02	4.106E+00	8.618E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8161799	0.8648406	0.8664831	0.9079008	0.6609341	1.284E+02	2.006E+01
α_2	1.97E-02	4.31E-02	4.10E-02	7.35E-02	8.78E-02	6.394E+00	1.420E+02
α_3	2.28E-02	4.75E-02	4.55E-02	7.92E-02	1.25E-01	7.055E+00	1.414E+02
α_4	1.20E-02	3.14E-02	2.94E-02	5.80E-02	8.81E-02	4.666E+00	1.438E+02
α_5	2.27E-03	1.31E-02	1.10E-02	3.12E-02	3.85E-02	1.947E+00	1.465E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8367402	0.8793034	0.8807399	0.9169677	0.6913580	1.550E+02	2.128E+01
α_2	8.84E-03	2.44E-02	2.26E-02	4.60E-02	3.74E-02	4.300E+00	1.720E+02
α_3	2.05E-02	4.20E-02	4.03E-02	6.94E-02	1.14E-01	7.408E+00	1.689E+02
α_4	1.34E-02	3.16E-02	2.99E-02	5.59E-02	9.05E-02	5.578E+00	1.707E+02
α_5	4.60E-03	1.69E-02	1.51E-02	3.52E-02	4.99E-02	2.972E+00	1.733E+02
α_6	3.14E-04	5.79E-03	4.06E-03	1.72E-02	1.70E-02	1.021E+00	1.753E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	6.43E-01	6.43E-01	6.40E-01	6.61E-01	6.91E-01
α_2	3.57E-01	1.56E-01	1.39E-01	8.78E-02	3.74E-02
α_3		2.01E-01	1.30E-01	1.25E-01	1.14E-01
α_4			9.18E-02	8.81E-02	9.05E-02
α_5				3.85E-02	4.99E-02
α_6					1.70E-02

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	6.43E-01	6.43E-01	6.40E-01	6.61E-01	6.91E-01
Beta	3.57E-01	3.57E-01	3.60E-01	3.39E-01	3.09E-01
Gamma		5.63E-01	6.15E-01	7.41E-01	8.79E-01
Delta			4.15E-01	5.04E-01	5.81E-01
Epsilon				3.04E-01	4.25E-01
Mu					2.54E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	12.69	19.04	25.39	31.73	38.08
N_1	5.2381	3.8143	1.6762	0.4762	0.0000
N_2	9.9762	5.5429	5.8643	4.2798	2.0605
N_3		7.1286	5.4810	6.0774	6.2659
N_4			3.8833	4.2917	4.9861
N_5				1.8750	2.7500
N_6					0.9375

2.6.6.2 CIRCULATING WATER TSA NON ENVIRONMENTAL PLUG

Systems/Raw Water/Circulating water system
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9069843	0.9767394	0.9904343	0.9999537	1.0000000	1.825E+01	4.345E-01
α_2	4.27E-05	2.33E-02	9.56E-03	9.30E-02	0.00E+00	4.345E-01	1.825E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9187121	0.9715210	0.9791840	0.9981182	1.0000000	3.756E+01	1.101E+00
α_2	6.87E-04	2.16E-02	1.40E-02	6.82E-02	0.00E+00	8.337E-01	3.782E+01
α_3	2.43E-07	6.91E-03	1.40E-03	3.28E-02	0.00E+00	2.672E-01	3.839E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9207146	0.9668683	0.9722644	0.9945409	1.0000000	5.414E+01	1.855E+00
α_2	1.82E-03	2.19E-02	1.65E-02	6.05E-02	0.00E+00	1.228E+00	5.476E+01
α_3	8.14E-06	7.22E-03	2.68E-03	2.98E-02	0.00E+00	4.043E-01	5.559E+01
α_4	1.72E-08	3.98E-03	5.45E-04	1.99E-02	0.00E+00	2.227E-01	5.577E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9349608	0.9671470	0.9699979	0.9895734	1.0000000	1.042E+02	3.538E+00
α_2	3.78E-03	1.96E-02	1.67E-02	4.54E-02	0.00E+00	2.114E+00	1.056E+02
α_3	4.43E-04	9.08E-03	6.27E-03	2.73E-02	0.00E+00	9.774E-01	1.067E+02
α_4	2.29E-06	3.48E-03	1.17E-03	1.48E-02	0.00E+00	3.744E-01	1.073E+02
α_5	5.54E-21	6.71E-04	3.80E-07	3.89E-03	0.00E+00	7.228E-02	1.076E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9376440	0.9668882	0.9692695	0.9879833	1.0000000	1.249E+02	4.279E+00
α_2	3.56E-03	1.73E-02	1.49E-02	3.94E-02	0.00E+00	2.239E+00	1.270E+02
α_3	6.22E-04	8.84E-03	6.46E-03	2.52E-02	0.00E+00	1.142E+00	1.281E+02
α_4	4.10E-05	4.58E-03	2.40E-03	1.65E-02	0.00E+00	5.922E-01	1.286E+02

α_5	7.19E-09	1.72E-03	2.33E-04	8.62E-03	0.00E+00	2.222E-01	1.290E+02
α_6	1.09E-18	6.44E-04	1.13E-06	3.76E-03	0.00E+00	8.324E-02	1.291E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	8.00	8.00	8.00	8.00	8.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000
N_5				0.0000	0.0000
N_6					0.0000

2.7 Heat Exchangers

2.7.1 Pooled Heat Exchanger Plugged or Failure to Transfer Heat

2.7.1.1 HEAT EXCHANGER LOSS OF HEAT TRANSFER ALL SYSTEMS

Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 26.2
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9036632	0.9727832	0.9851713	0.9997273	0.9852436	2.162E+01	6.049E-01
α_2	2.75E-04	2.72E-02	1.48E-02	9.63E-02	1.48E-02	6.049E-01	2.162E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9154524	0.9662238	0.9725131	0.9954413	0.9700600	4.610E+01	1.612E+00
α_2	2.79E-03	2.82E-02	2.19E-02	7.51E-02	2.99E-02	1.344E+00	4.637E+01
α_3	1.97E-07	5.60E-03	1.13E-03	2.66E-02	7.33E-06	2.673E-01	4.745E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9146042	0.9591444	0.9634270	0.9890317	0.9544302	6.752E+01	2.876E+00
α_2	6.66E-03	3.19E-02	2.76E-02	7.20E-02	4.55E-02	2.249E+00	6.815E+01
α_3	6.52E-06	5.75E-03	2.13E-03	2.37E-02	2.23E-05	4.048E-01	6.999E+01
α_4	1.36E-08	3.16E-03	4.33E-04	1.58E-02	0.00E+00	2.227E-01	7.017E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.85E-01	9.70E-01	9.54E-01
α_2	1.48E-02	2.99E-02	4.55E-02
α_3		7.33E-06	2.23E-05
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.85E-01	9.70E-01	9.54E-01
Beta	1.48E-02	2.99E-02	4.56E-02
Gamma		2.45E-04	4.90E-04
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. IEs	10.48	15.72	20.96
N_1	0.8927	0.8284	0.4242
N_2	0.1703	0.5106	1.0205

N_3		0.0001	0.0005
N_4			0.0000

2.7.1.2 HEAT EXCHANGER LOSS OF HEAT TRANSFER ALL SYSTEMS ENVIRONMENTAL

Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.5
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8566121	0.9592798	0.9775748	0.9995898	0.9591837	1.416E+01	6.012E-01
α_2	4.08E-04	4.07E-02	2.24E-02	1.43E-01	4.08E-02	6.012E-01	1.416E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8906121	0.9561773	0.9642417	0.9941005	0.9148936	3.493E+01	1.601E+00
α_2	3.59E-03	3.65E-02	2.84E-02	9.72E-02	8.51E-02	1.334E+00	3.520E+01
α_3	2.57E-07	7.31E-03	1.48E-03	3.47E-02	0.00E+00	2.672E-01	3.626E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8927039	0.9485488	0.9538675	0.9861963	0.8666667	5.264E+01	2.855E+00
α_2	8.33E-03	4.02E-02	3.47E-02	9.05E-02	1.33E-01	2.228E+00	5.326E+01
α_3	8.22E-06	7.29E-03	2.71E-03	3.01E-02	0.00E+00	4.043E-01	5.509E+01
α_4	1.73E-08	4.01E-03	5.50E-04	2.01E-02	0.00E+00	2.227E-01	5.527E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.59E-01	9.15E-01	8.67E-01
α_2	4.08E-02	8.51E-02	1.33E-01
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.59E-01	9.15E-01	8.67E-01
Beta	4.08E-02	8.51E-02	1.33E-01
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. IEs	3.25	4.88	6.50

N_1	0.6667	0.5000	0.0000
N_2	0.1667	0.5000	1.0000
N_3		0.0000	0.0000
N_4			0.0000

2.7.1.3 HEAT EXCHANGER PLUGGED ALL SYSTEMS NON ENVIRO

Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 19.7
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9001299	0.9749276	0.9895734	0.9999475	0.9994605	1.704E+01	4.382E-01
α_2	4.86E-05	2.51E-02	1.04E-02	9.99E-02	5.40E-04	4.382E-01	1.704E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9225282	0.9727842	0.9800572	0.9981644	0.9989450	3.973E+01	1.112E+00
α_2	6.83E-04	2.07E-02	1.35E-02	6.51E-02	1.04E-03	8.443E-01	4.000E+01
α_3	2.31E-07	6.55E-03	1.32E-03	3.10E-02	1.23E-05	2.673E-01	4.058E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9272471	0.9695291	0.9744672	0.9949135	0.9984534	5.969E+01	1.876E+00
α_2	1.74E-03	2.03E-02	1.54E-02	5.57E-02	1.51E-03	1.249E+00	6.032E+01
α_3	7.47E-06	6.57E-03	2.44E-03	2.71E-02	3.68E-05	4.048E-01	6.116E+01
α_4	1.56E-08	3.62E-03	4.95E-04	1.81E-02	0.00E+00	2.227E-01	6.135E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.99E-01	9.99E-01	9.98E-01
α_2	5.40E-04	1.04E-03	1.51E-03
α_3		1.23E-05	3.68E-05
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.99E-01	9.99E-01	9.98E-01
Beta	5.40E-04	1.06E-03	1.55E-03
Gamma		1.16E-02	2.38E-02
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	6.57	9.85	13.13
N_1	0.2260	0.3284	0.4242

N_2	0.0037	0.0106	0.0205
N_3		0.0001	0.0005
N_4			0.0000

2.7.2 PWR HEAT EXCHANGER LOSS OF HEAT TRANSFER

2.7.2.1 PWR RHR HEAT EXCHANGER PLUG/LOSS OF HEAT TRANSFER

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.1
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8534631	0.9631154	0.9845229	0.9999324	1.0000000	1.135E+01	4.345E-01
α_2	6.93E-05	3.69E-02	1.55E-02	1.47E-01	0.00E+00	4.345E-01	1.135E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9013737	0.9653330	0.9745653	0.9976900	1.0000000	3.066E+01	1.101E+00
α_2	8.40E-04	2.63E-02	1.71E-02	8.28E-02	0.00E+00	8.337E-01	3.092E+01
α_3	2.97E-07	8.41E-03	1.71E-03	3.99E-02	0.00E+00	2.672E-01	3.149E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9097630	0.9622115	0.9683186	0.9937523	1.0000000	4.724E+01	1.855E+00
α_2	2.08E-03	2.50E-02	1.89E-02	6.89E-02	0.00E+00	1.228E+00	4.786E+01
α_3	9.31E-06	8.24E-03	3.06E-03	3.40E-02	0.00E+00	4.043E-01	4.869E+01
α_4	1.96E-08	4.54E-03	6.23E-04	2.27E-02	0.00E+00	2.227E-01	4.887E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	1.10	1.10	1.10
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.7.3 Containment Spray Heat Exchanger

2.7.3.1 CONTAINMENT SPRAY HTX LOSS OF HEAT TRANSFER

Systems/Clean Water/Containment spray recirculation
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8778913	0.9693580	0.9872586	0.9999387	1.0000000	1.375E+01	4.345E-01
α_2	5.70E-05	3.06E-02	1.27E-02	1.22E-01	0.00E+00	4.345E-01	1.375E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2
α_1	1.00E+00
α_2	0.00E+00

MGL	CCCG=2
1-Beta	1.00E+00
Beta	0.00E+00

Avg. Impact Vector	CCCG=2
Adj. Ind. Events	3.50
N_1	0.0000
N_2	0.0000

2.7.4 BWR Residual Heat Removal Heat Exchanger

2.7.4.1 BWR RHR HEAT EXCHANGER LOSS OF HEAT TRANSFER CAPABILITIES

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8636859	0.9657333	0.9856734	0.9999376	1.0000000	1.225E+01	4.345E-01
α_2	6.41E-05	3.43E-02	1.43E-02	1.36E-01	0.00E+00	4.345E-01	1.225E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9040424	0.9662885	0.9752807	0.9977558	1.0000000	3.156E+01	1.101E+00
α_2	8.16E-04	2.55E-02	1.67E-02	8.05E-02	0.00E+00	8.337E-01	3.182E+01
α_3	2.88E-07	8.18E-03	1.66E-03	3.88E-02	0.00E+00	2.672E-01	3.239E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113590	0.9628918	0.9688972	0.9938678	1.0000000	4.814E+01	1.855E+00
α_2	2.04E-03	2.46E-02	1.86E-02	6.77E-02	0.00E+00	1.228E+00	4.876E+01
α_3	9.14E-06	8.09E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.959E+01
α_4	1.93E-08	4.45E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.977E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	2.00	2.00	2.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000

N_4			0.0000

2.7.5 BWR Isolation Condenser Heat Exchanger

2.7.5.1 ISO CONDENSER HEAT EXCHANGER PLUG/LOSS OF HEAT TRANSFER

Systems/Clean Water/Isolation condenser
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: .0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8386831	0.9593166	0.9828300	0.9999249	0.0000000	1.025E+01	4.345E-01
α_2	7.70E-05	4.07E-02	1.72E-02	1.61E-01	0.00E+00	4.345E-01	1.025E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8979023	0.9640891	0.9736327	0.9976042	0.0000000	2.956E+01	1.101E+00
α_2	8.71E-04	2.72E-02	1.78E-02	8.57E-02	0.00E+00	8.337E-01	2.982E+01
α_3	3.08E-07	8.72E-03	1.77E-03	4.13E-02	0.00E+00	2.672E-01	3.039E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9077328	0.9613453	0.9675777	0.9936050	0.0000000	4.614E+01	1.855E+00
α_2	2.13E-03	2.56E-02	1.93E-02	7.04E-02	0.00E+00	1.228E+00	4.676E+01
α_3	9.52E-06	8.42E-03	3.13E-03	3.48E-02	0.00E+00	4.043E-01	4.759E+01
α_4	2.01E-08	4.64E-03	6.37E-04	2.32E-02	0.00E+00	2.227E-01	4.777E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	0.00E+00	0.00E+00	0.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	0.00E+00	0.00E+00	0.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**
Adj. Ind. Events	0.00	0.00	0.00
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.7.6 Component Cooling Heat Exchanger

2.7.6.1 CCW HEAT EXCHANGER LOSS OF HEAT TRANSFER SPAR: HTX-PG-CCW

Systems/Clean Water/Component cooling water
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 19.1
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8897885	0.9687955	0.9829245	0.9996857	0.9804282	1.878E+01	6.049E-01
α_2	3.17E-04	3.12E-02	1.71E-02	1.10E-01	1.96E-02	6.049E-01	1.878E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9073155	0.9629127	0.9697786	0.9949818	0.9600949	4.184E+01	1.612E+00
α_2	3.07E-03	3.09E-02	2.41E-02	8.24E-02	3.99E-02	1.344E+00	4.211E+01
α_3	2.17E-07	6.15E-03	1.24E-03	2.92E-02	9.77E-06	2.673E-01	4.319E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9072451	0.9555586	0.9601844	0.9880451	0.9389543	6.184E+01	2.876E+00
α_2	7.26E-03	3.47E-02	3.01E-02	7.83E-02	6.10E-02	2.249E+00	6.247E+01
α_3	7.10E-06	6.26E-03	2.32E-03	2.58E-02	2.99E-05	4.048E-01	6.431E+01
α_4	1.48E-08	3.44E-03	4.71E-04	1.72E-02	0.00E+00	2.227E-01	6.449E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.80E-01	9.60E-01	9.39E-01
α_2	1.96E-02	3.99E-02	6.10E-02
α_3		9.77E-06	2.99E-05
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.80E-01	9.60E-01	9.39E-01
Beta	1.96E-02	3.99E-02	6.10E-02
Gamma		2.45E-04	4.90E-04
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. IEs	7.64	11.46	15.28
N_1	0.8927	0.8284	0.4242

N_2	0.1703	0.5106	1.0205
N_3		0.0001	0.0005
N_4			0.0000

2.7.6.2 CCW HEAT EXCHANGER LHT ENVIRONMENTAL

Systems/Clean Water/Component cooling water
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8542001	0.9585784	0.9771708	0.9995823	0.9565217	1.391E+01	6.012E-01
α_2	4.16E-04	4.14E-02	2.28E-02	1.46E-01	4.35E-02	6.012E-01	1.391E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8895031	0.9557228	0.9638636	0.9940372	0.9090909	3.456E+01	1.601E+00
α_2	3.63E-03	3.69E-02	2.87E-02	9.82E-02	9.09E-02	1.334E+00	3.482E+01
α_3	2.60E-07	7.39E-03	1.50E-03	3.51E-02	0.00E+00	2.672E-01	3.589E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8917498	0.9480810	0.9534430	0.9860671	0.8571429	5.214E+01	2.855E+00
α_2	8.41E-03	4.05E-02	3.51E-02	9.13E-02	1.43E-01	2.228E+00	5.276E+01
α_3	8.29E-06	7.35E-03	2.73E-03	3.04E-02	0.00E+00	4.043E-01	5.459E+01
α_4	1.75E-08	4.05E-03	5.55E-04	2.03E-02	0.00E+00	2.227E-01	5.477E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.57E-01	9.09E-01	8.57E-01
α_2	4.35E-02	9.09E-02	1.43E-01
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.57E-01	9.09E-01	8.57E-01
Beta	4.35E-02	9.09E-02	1.43E-01
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4

Adj. IEs	3.00	4.50	6.00
N_1	0.6667	0.5000	0.0000
N_2	0.1667	0.5000	1.0000
N_3		0.0000	0.0000
N_4			0.0000

2.7.6.3 CCW HEAT EXCHANGER LOSS OF HEAT TRANSFER

Systems/Clean Water/Component cooling water
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
CCF Categories/Cause/Design
CCF Categories/Cause/Environment/Ambient environmental stress
CCF Categories/Cause/Environment/Internal environment
CCF Categories/Cause/Other
CCF Categories/Cause/Human
CCF Categories/Cause/Component
CCF Categories/Cause/Unknown
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 13.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8859391	0.9713170	0.9880077	0.9999398	0.9992023	1.484E+01	4.382E-01
α_2	5.60E-05	2.87E-02	1.20E-02	1.14E-01	7.98E-04	4.382E-01	1.484E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9158244	0.9703921	0.9782731	0.9979939	0.9984396	3.643E+01	1.112E+00
α_2	7.44E-04	2.25E-02	1.47E-02	7.07E-02	1.54E-03	8.443E-01	3.670E+01
α_3	2.52E-07	7.12E-03	1.44E-03	3.38E-02	1.81E-05	2.673E-01	3.728E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9217333	0.9671839	0.9724739	0.9945126	0.9977120	5.529E+01	1.876E+00
α_2	1.87E-03	2.18E-02	1.66E-02	5.99E-02	2.23E-03	1.249E+00	5.592E+01
α_3	8.05E-06	7.08E-03	2.63E-03	2.92E-02	5.45E-05	4.048E-01	5.676E+01
α_4	1.68E-08	3.89E-03	5.34E-04	1.95E-02	0.00E+00	2.227E-01	5.695E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.99E-01	9.98E-01	9.98E-01
α_2	7.98E-04	1.54E-03	2.23E-03
α_3		1.81E-05	5.45E-05
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.99E-01	9.98E-01	9.98E-01
Beta	7.98E-04	1.56E-03	2.29E-03
Gamma		1.16E-02	2.38E-02
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	4.37	6.55	8.73

N_1	0.2260	0.3284	0.4242
N_2	0.0037	0.0106	0.0205
N_3		0.0001	0.0005
N_4			0.0000

2.8 Safety and Relief Valves

2.8.1 Pooled Safety Valves

2.8.1.1 SAFETY VALVES (DIRECT ACTING) FAIL TO OPEN ALL SYS

Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3.5
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8423612	0.9583479	0.9802367	0.9998358	0.9493826	1.134E+01	4.929E-01
α_2	1.62E-04	4.17E-02	1.98E-02	1.58E-01	5.06E-02	4.929E-01	1.134E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8942165	0.9609415	0.9700294	0.9965325	0.9024839	3.104E+01	1.262E+00
α_2	1.57E-03	3.06E-02	2.15E-02	9.05E-02	9.32E-02	9.875E-01	3.132E+01
α_3	3.92E-07	8.49E-03	1.81E-03	3.99E-02	4.33E-03	2.744E-01	3.203E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9023389	0.9570786	0.9630327	0.9914396	0.8596897	4.794E+01	2.150E+00
α_2	3.57E-03	2.99E-02	2.39E-02	7.68E-02	1.28E-01	1.496E+00	4.860E+01
α_3	1.46E-05	8.60E-03	3.43E-03	3.47E-02	1.25E-02	4.307E-01	4.966E+01
α_4	1.99E-08	4.46E-03	6.15E-04	2.23E-02	2.61E-04	2.232E-01	4.987E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9253455	0.9609862	0.9639578	0.9864583	0.8213063	9.823E+01	3.988E+00
α_2	5.69E-03	2.45E-02	2.14E-02	5.36E-02	1.54E-01	2.501E+00	9.971E+01
α_3	5.76E-04	1.02E-02	7.19E-03	2.99E-02	2.40E-02	1.038E+00	1.012E+02
α_4	2.56E-06	3.69E-03	1.25E-03	1.56E-02	1.09E-03	3.771E-01	1.018E+02
α_5	5.84E-21	7.07E-04	4.00E-07	4.09E-03	0.00E+00	7.228E-02	1.021E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9283462	0.9605693	0.9630204	0.9844107	0.7875381	1.192E+02	4.894E+00
α_2	5.59E-03	2.20E-02	1.95E-02	4.71E-02	1.72E-01	2.736E+00	1.214E+02
α_3	8.60E-04	1.01E-02	7.60E-03	2.78E-02	3.79E-02	1.252E+00	1.229E+02
α_4	4.60E-05	4.84E-03	2.56E-03	1.74E-02	2.85E-03	6.005E-01	1.235E+02
α_5	7.49E-09	1.79E-03	2.43E-04	8.97E-03	0.00E+00	2.222E-01	1.239E+02
α_6	1.14E-18	6.71E-04	1.17E-06	3.91E-03	0.00E+00	8.324E-02	1.240E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379559	0.9626854	0.9642656	0.9820090	0.7584674	1.865E+02	7.229E+00
α_2	6.17E-03	1.90E-02	1.74E-02	3.74E-02	1.82E-01	3.680E+00	1.901E+02
α_3	1.45E-03	9.31E-03	7.69E-03	2.27E-02	5.33E-02	1.804E+00	1.919E+02
α_4	2.74E-04	5.20E-03	3.63E-03	1.55E-02	5.92E-03	1.008E+00	1.927E+02
α_5	1.32E-05	2.69E-03	1.28E-03	1.02E-02	0.00E+00	5.218E-01	1.932E+02
α_6	3.47E-10	9.61E-04	8.21E-05	5.05E-03	0.00E+00	1.863E-01	1.936E+02
α_7	5.25E-48	1.50E-04	1.31E-13	5.65E-04	0.00E+00	2.907E-02	1.937E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9410190	0.9633888	0.9647243	0.9811939	0.7340365	2.214E+02	8.412E+00
α_2	6.02E-03	1.75E-02	1.61E-02	3.36E-02	1.86E-01	4.011E+00	2.258E+02
α_3	1.53E-03	8.64E-03	7.26E-03	2.05E-02	6.88E-02	1.985E+00	2.278E+02
α_4	3.92E-04	5.16E-03	3.81E-03	1.45E-02	1.08E-02	1.185E+00	2.286E+02
α_5	5.61E-05	3.08E-03	1.81E-03	1.04E-02	0.00E+00	7.083E-01	2.291E+02
α_6	9.04E-07	1.60E-03	5.23E-04	6.83E-03	0.00E+00	3.670E-01	2.294E+02
α_7	7.09E-14	5.35E-04	9.63E-06	3.05E-03	0.00E+00	1.230E-01	2.296E+02
α_8	1.33E-42	1.44E-04	2.05E-12	6.09E-04	0.00E+00	3.312E-02	2.297E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.49E-01	9.02E-01	8.60E-01	8.21E-01	7.88E-01	7.58E-01	7.34E-01
α_2	5.06E-02	9.32E-02	1.28E-01	1.54E-01	1.72E-01	1.82E-01	1.86E-01
α_3		4.33E-03	1.25E-02	2.40E-02	3.79E-02	5.33E-02	6.88E-02
α_4			2.61E-04	1.09E-03	2.85E-03	5.92E-03	1.08E-02
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.49E-01	9.02E-01	8.60E-01	8.21E-01	7.88E-01	7.58E-01	7.34E-01
Beta	5.06E-02	9.75E-02	1.40E-01	1.79E-01	2.12E-01	2.42E-01	2.66E-01
Gamma		4.44E-02	9.13E-02	1.41E-01	1.92E-01	2.45E-01	2.99E-01
Delta			2.04E-02	4.35E-02	6.98E-02	1.00E-01	1.35E-01
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	0.44	0.66	0.88	1.09	1.31	1.53	1.75
N_1	0.6582	0.8334	0.9325	0.9725	0.9681	0.9321	0.8748
N_2	0.0584	0.1538	0.2681	0.3864	0.4971	0.5921	0.6664

N_3		0.0071	0.0264	0.0604	0.1099	0.1731	0.2462
N_4			0.0005	0.0027	0.0082	0.0192	0.0385
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.1.2 SAFETY VALVES (DIRECT ACTING) FAIL TO CLOSE ALL SYS

Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 7.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8519405	0.9624611	0.9839354	0.9999227	0.9925373	1.135E+01	4.429E-01
α_2	7.92E-05	3.75E-02	1.61E-02	1.48E-01	7.46E-03	4.429E-01	1.135E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9016672	0.9651629	0.9742472	0.9975598	0.9849624	3.119E+01	1.126E+00
α_2	9.28E-04	2.66E-02	1.76E-02	8.29E-02	1.50E-02	8.587E-01	3.146E+01
α_3	2.91E-07	8.27E-03	1.68E-03	3.92E-02	0.00E+00	2.672E-01	3.205E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9101260	0.9620435	0.9680200	0.9934995	0.9772727	4.829E+01	1.905E+00
α_2	2.29E-03	2.55E-02	1.95E-02	6.92E-02	2.27E-02	1.278E+00	4.891E+01
α_3	9.10E-06	8.06E-03	3.00E-03	3.33E-02	0.00E+00	4.043E-01	4.979E+01
α_4	1.92E-08	4.44E-03	6.09E-04	2.22E-02	0.00E+00	2.227E-01	4.997E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9305048	0.9646428	0.9676263	0.9885662	0.9694656	9.881E+01	3.622E+00
α_2	4.33E-03	2.15E-02	1.84E-02	4.90E-02	3.05E-02	2.198E+00	1.002E+02
α_3	4.66E-04	9.54E-03	6.60E-03	2.87E-02	0.00E+00	9.774E-01	1.015E+02
α_4	2.40E-06	3.66E-03	1.23E-03	1.55E-02	0.00E+00	3.744E-01	1.021E+02
α_5	5.83E-21	7.06E-04	3.99E-07	4.09E-03	0.00E+00	7.228E-02	1.024E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9339101	0.9646204	0.9670860	0.9869062	0.9615385	1.201E+02	4.404E+00
α_2	4.15E-03	1.90E-02	1.65E-02	4.24E-02	3.85E-02	2.364E+00	1.221E+02
α_3	6.46E-04	9.17E-03	6.71E-03	2.61E-02	0.00E+00	1.142E+00	1.233E+02
α_4	4.26E-05	4.76E-03	2.49E-03	1.72E-02	0.00E+00	5.922E-01	1.239E+02
α_5	7.47E-09	1.79E-03	2.42E-04	8.94E-03	0.00E+00	2.222E-01	1.242E+02
α_6	1.13E-18	6.69E-04	1.17E-06	3.90E-03	0.00E+00	8.324E-02	1.244E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9421839	0.9659216	0.9675078	0.9842331	0.9534884	1.876E+02	6.620E+00
α_2	4.96E-03	1.68E-02	1.52E-02	3.42E-02	4.65E-02	3.263E+00	1.910E+02

α_3	1.13E-03	8.40E-03	6.78E-03	2.12E-02	0.00E+00	1.631E+00	1.926E+02
α_4	2.55E-04	5.09E-03	3.52E-03	1.53E-02	0.00E+00	9.889E-01	1.933E+02
α_5	1.32E-05	2.69E-03	1.27E-03	1.02E-02	0.00E+00	5.218E-01	1.937E+02
α_6	3.46E-10	9.59E-04	8.19E-05	5.03E-03	0.00E+00	1.863E-01	1.941E+02
α_7	5.23E-48	1.50E-04	1.31E-13	5.63E-04	0.00E+00	2.907E-02	1.942E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9451628	0.9666129	0.9679568	0.9834838	0.9453125	2.228E+02	7.694E+00
α_2	4.93E-03	1.55E-02	1.41E-02	3.08E-02	5.47E-02	3.578E+00	2.269E+02
α_3	1.12E-03	7.54E-03	6.17E-03	1.87E-02	0.00E+00	1.738E+00	2.287E+02
α_4	3.52E-04	4.97E-03	3.64E-03	1.42E-02	0.00E+00	1.147E+00	2.293E+02
α_5	5.60E-05	3.07E-03	1.81E-03	1.04E-02	0.00E+00	7.083E-01	2.297E+02
α_6	9.01E-07	1.59E-03	5.21E-04	6.81E-03	0.00E+00	3.670E-01	2.301E+02
α_7	7.07E-14	5.34E-04	9.60E-06	3.04E-03	0.00E+00	1.230E-01	2.303E+02
α_8	1.32E-42	1.44E-04	2.05E-12	6.07E-04	0.00E+00	3.312E-02	2.304E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.93E-01	9.85E-01	9.77E-01	9.69E-01	9.62E-01	9.53E-01	9.45E-01
α_2	7.46E-03	1.50E-02	2.27E-02	3.05E-02	3.85E-02	4.65E-02	5.47E-02
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.93E-01	9.85E-01	9.77E-01	9.69E-01	9.62E-01	9.53E-01	9.45E-01
Beta	7.46E-03	1.50E-02	2.27E-02	3.05E-02	3.85E-02	4.65E-02	5.47E-02
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	0.88	1.31	1.75	2.19	2.63	3.06	3.50
N_1	0.2333	0.3250	0.4000	0.4583	0.5000	0.5250	0.5333
N_2	0.0083	0.0250	0.0500	0.0833	0.1250	0.1750	0.2333
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.2 PWR Steam Generator Safety Valves

2.8.2.1 PWR MAIN STEAM CODE SAFETIES FAIL TO OPEN

Plants/PWR
Systems/Steam
Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8381861	0.9572182	0.9796698	0.9998312	0.9305872	1.103E+01	4.929E-01
α_2	1.67E-04	4.28E-02	2.03E-02	1.62E-01	6.94E-02	4.929E-01	1.103E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8926914	0.9603664	0.9695791	0.9964796	0.8638081	3.058E+01	1.262E+00
α_2	1.59E-03	3.10E-02	2.18E-02	9.18E-02	1.30E-01	9.875E-01	3.085E+01
α_3	3.98E-07	8.62E-03	1.84E-03	4.05E-02	6.04E-03	2.744E-01	3.156E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9011283	0.9565364	0.9625594	0.9913285	0.8003377	4.732E+01	2.150E+00
α_2	3.62E-03	3.02E-02	2.42E-02	7.77E-02	1.81E-01	1.496E+00	4.797E+01
α_3	1.48E-05	8.71E-03	3.47E-03	3.51E-02	1.78E-02	4.307E-01	4.904E+01
α_4	2.01E-08	4.51E-03	6.23E-04	2.26E-02	3.72E-04	2.232E-01	4.925E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.31E-01	8.64E-01	8.00E-01
α_2	6.94E-02	1.30E-01	1.81E-01
α_3		6.04E-03	1.78E-02
α_4			3.72E-04

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.31E-01	8.64E-01	8.00E-01
Beta	6.94E-02	1.36E-01	2.00E-01
Gamma		4.44E-02	9.13E-02
Delta			2.04E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	0.13	0.19	0.25
N_1	0.6582	0.8334	0.9325
N_2	0.0584	0.1538	0.2681
N_3		0.0071	0.0264
N_4			0.0005

2.8.2.2 PWR MAIN STEAM CODE SAFETIES FAIL TO CLOSE

Plants/PWR
Systems/Steam
Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 6.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8503856	0.9620591	0.9837537	0.9999218	0.9915966	1.123E+01	4.429E-01
α_2	8.01E-05	3.79E-02	1.62E-02	1.50E-01	8.40E-03	4.429E-01	1.123E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9011038	0.9649596	0.9740938	0.9975450	0.9830508	3.100E+01	1.126E+00
α_2	9.34E-04	2.67E-02	1.77E-02	8.34E-02	1.69E-02	8.587E-01	3.127E+01
α_3	2.93E-07	8.32E-03	1.69E-03	3.94E-02	0.00E+00	2.672E-01	3.186E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9096842	0.9618534	0.9678529	0.9934661	0.9743590	4.804E+01	1.905E+00
α_2	2.30E-03	2.56E-02	1.96E-02	6.95E-02	2.56E-02	1.278E+00	4.866E+01
α_3	9.14E-06	8.10E-03	3.01E-03	3.34E-02	0.00E+00	4.043E-01	4.954E+01
α_4	1.93E-08	4.46E-03	6.12E-04	2.23E-02	0.00E+00	2.227E-01	4.972E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9302950	0.9645346	0.9675269	0.9885306	0.9655172	9.849E+01	3.622E+00
α_2	4.34E-03	2.15E-02	1.85E-02	4.91E-02	3.45E-02	2.198E+00	9.992E+01
α_3	4.68E-04	9.57E-03	6.62E-03	2.88E-02	0.00E+00	9.774E-01	1.011E+02
α_4	2.41E-06	3.67E-03	1.24E-03	1.56E-02	0.00E+00	3.744E-01	1.017E+02
α_5	5.85E-21	7.08E-04	4.00E-07	4.10E-03	0.00E+00	7.228E-02	1.020E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9337128	0.9645134	0.9669855	0.9868660	0.9565217	1.197E+02	4.404E+00
α_2	4.16E-03	1.91E-02	1.65E-02	4.26E-02	4.35E-02	2.364E+00	1.217E+02
α_3	6.48E-04	9.20E-03	6.73E-03	2.62E-02	0.00E+00	1.142E+00	1.230E+02
α_4	4.27E-05	4.77E-03	2.50E-03	1.72E-02	0.00E+00	5.922E-01	1.235E+02
α_5	7.49E-09	1.79E-03	2.43E-04	8.97E-03	0.00E+00	2.222E-01	1.239E+02
α_6	1.14E-18	6.71E-04	1.17E-06	3.92E-03	0.00E+00	8.324E-02	1.240E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9420548	0.9658446	0.9674344	0.9841971	0.9473684	1.872E+02	6.620E+00
α_2	4.97E-03	1.68E-02	1.52E-02	3.43E-02	5.26E-02	3.263E+00	1.906E+02
α_3	1.13E-03	8.42E-03	6.80E-03	2.12E-02	0.00E+00	1.631E+00	1.922E+02
α_4	2.56E-04	5.10E-03	3.53E-03	1.53E-02	0.00E+00	9.889E-01	1.928E+02
α_5	1.32E-05	2.69E-03	1.27E-03	1.02E-02	0.00E+00	5.218E-01	1.933E+02
α_6	3.47E-10	9.61E-04	8.21E-05	5.04E-03	0.00E+00	1.863E-01	1.936E+02
α_7	5.25E-48	1.50E-04	1.31E-13	5.65E-04	0.00E+00	2.907E-02	1.938E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9450446	0.9665403	0.9678869	0.9834475	0.9380531	2.223E+02	7.694E+00
α_2	4.94E-03	1.56E-02	1.42E-02	3.09E-02	6.19E-02	3.578E+00	2.264E+02
α_3	1.12E-03	7.56E-03	6.19E-03	1.87E-02	0.00E+00	1.738E+00	2.282E+02
α_4	3.53E-04	4.99E-03	3.64E-03	1.42E-02	0.00E+00	1.147E+00	2.288E+02
α_5	5.61E-05	3.08E-03	1.81E-03	1.04E-02	0.00E+00	7.083E-01	2.292E+02
α_6	9.03E-07	1.60E-03	5.22E-04	6.83E-03	0.00E+00	3.670E-01	2.296E+02
α_7	7.08E-14	5.35E-04	9.62E-06	3.04E-03	0.00E+00	1.230E-01	2.298E+02
α_8	1.33E-42	1.44E-04	2.05E-12	6.09E-04	0.00E+00	3.312E-02	2.299E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.92E-01	9.83E-01	9.74E-01	9.66E-01	9.57E-01	9.47E-01	9.38E-01
α_2	8.40E-03	1.69E-02	2.56E-02	3.45E-02	4.35E-02	5.26E-02	6.19E-02
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.83E-01	9.74E-01	9.66E-01	9.57E-01	9.47E-01	9.38E-01
Beta	8.40E-03	1.69E-02	2.56E-02	3.45E-02	4.35E-02	5.26E-02	6.19E-02
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	0.75	1.13	1.50	1.88	2.25	2.63	3.00
N_1	0.2333	0.3250	0.4000	0.4583	0.5000	0.5250	0.5333
N_2	0.0083	0.0250	0.0500	0.0833	0.1250	0.1750	0.2333

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.3 BWR Safety Relief Valves

2.8.3.1 BWR SAFETY RELIEF VALVE FAIL TO OPEN SPAR: SRV-CC-BWR

Plants/BWR
Systems/Steam
Components/Valve/Safety Relief Valve (Dual Actuation)
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 29.6
Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8754094	0.9583991	0.9710434	0.9980945	0.9575779	2.167E+01	9.407E-01
α_2	1.90E-03	4.16E-02	2.90E-02	1.25E-01	4.24E-02	9.407E-01	2.167E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8929478	0.9517987	0.9579676	0.9895370	0.9300123	4.564E+01	2.311E+00
α_2	6.69E-03	3.94E-02	3.32E-02	9.35E-02	6.11E-02	1.890E+00	4.606E+01
α_3	1.30E-05	8.79E-03	3.42E-03	3.57E-02	8.91E-03	4.214E-01	4.753E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8948479	0.9452196	0.9494006	0.9812931	0.9106580	6.653E+01	3.856E+00
α_2	1.05E-02	3.99E-02	3.56E-02	8.40E-02	7.06E-02	2.808E+00	6.757E+01
α_3	2.52E-04	1.08E-02	6.64E-03	3.55E-02	1.58E-02	7.591E-01	6.962E+01
α_4	3.03E-07	4.09E-03	9.41E-04	1.90E-02	2.92E-03	2.881E-01	7.009E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9157130	0.9507161	0.9530712	0.9776800	0.9003554	1.207E+02	6.259E+00
α_2	1.11E-02	3.18E-02	2.93E-02	6.07E-02	7.03E-02	4.033E+00	1.230E+02
α_3	1.59E-03	1.24E-02	9.96E-03	3.16E-02	2.19E-02	1.577E+00	1.254E+02
α_4	2.64E-05	4.30E-03	2.12E-03	1.60E-02	6.28E-03	5.458E-01	1.265E+02
α_5	1.46E-15	8.18E-04	6.12E-06	4.75E-03	1.16E-03	1.039E-01	1.269E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9179088	0.9497860	0.9517315	0.9750107	0.8934332	1.456E+02	7.698E+00
α_2	1.07E-02	2.89E-02	2.69E-02	5.40E-02	6.83E-02	4.431E+00	1.489E+02
α_3	2.27E-03	1.29E-02	1.08E-02	3.05E-02	2.59E-02	1.973E+00	1.513E+02
α_4	2.07E-04	5.72E-03	3.76E-03	1.79E-02	8.85E-03	8.762E-01	1.524E+02
α_5	3.80E-07	2.08E-03	5.59E-04	9.32E-03	3.00E-03	3.185E-01	1.530E+02

α_6	2.80E-16	6.45E-04	3.60E-06	3.75E-03	4.89E-04	9.892E-02	1.532E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9287552	0.9536876	0.9550116	0.9740915	0.8890090	2.167E+02	1.052E+01
α_2	1.01E-02	2.41E-02	2.27E-02	4.28E-02	6.51E-02	5.479E+00	2.218E+02
α_3	2.96E-03	1.19E-02	1.05E-02	2.56E-02	2.91E-02	2.702E+00	2.245E+02
α_4	6.07E-04	6.03E-03	4.65E-03	1.61E-02	1.04E-02	1.370E+00	2.259E+02
α_5	5.21E-05	3.06E-03	1.78E-03	1.04E-02	4.72E-03	6.953E-01	2.266E+02
α_6	1.21E-08	1.06E-03	1.73E-04	5.20E-03	1.50E-03	2.414E-01	2.270E+02
α_7	1.39E-38	1.62E-04	1.77E-11	7.42E-04	2.13E-04	3.689E-02	2.272E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9319306	0.9545883	0.9557152	0.9733857	0.8865919	2.554E+02	1.215E+01
α_2	9.47E-03	2.19E-02	2.07E-02	3.83E-02	6.05E-02	5.846E+00	2.617E+02
α_3	3.22E-03	1.15E-02	1.03E-02	2.38E-02	3.23E-02	3.074E+00	2.645E+02
α_4	7.92E-04	6.01E-03	4.84E-03	1.53E-02	1.12E-02	1.609E+00	2.659E+02
α_5	1.61E-04	3.56E-03	2.42E-03	1.08E-02	5.88E-03	9.513E-01	2.666E+02
α_6	5.53E-06	1.79E-03	7.82E-04	6.97E-03	2.69E-03	4.780E-01	2.670E+02
α_7	8.75E-12	5.77E-04	2.67E-05	3.16E-03	7.58E-04	1.543E-01	2.674E+02
α_8	1.60E-38	1.38E-04	1.61E-11	6.34E-04	9.45E-05	3.703E-02	2.675E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.58E-01	9.30E-01	9.11E-01	9.00E-01	8.93E-01	8.89E-01	8.87E-01
α_2	4.24E-02	6.11E-02	7.06E-02	7.03E-02	6.83E-02	6.51E-02	6.05E-02
α_3		8.91E-03	1.58E-02	2.19E-02	2.59E-02	2.91E-02	3.23E-02
α_4			2.92E-03	6.28E-03	8.85E-03	1.04E-02	1.12E-02
α_5				1.16E-03	3.00E-03	4.72E-03	5.88E-03
α_6					4.89E-04	1.50E-03	2.69E-03
α_7						2.13E-04	7.58E-04
α_8							9.45E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.58E-01	9.30E-01	9.11E-01	9.00E-01	8.93E-01	8.89E-01	8.87E-01
Beta	4.24E-02	7.00E-02	8.93E-02	9.96E-02	1.07E-01	1.11E-01	1.13E-01
Gamma		1.27E-01	2.10E-01	2.95E-01	3.59E-01	4.14E-01	4.66E-01
Delta			1.56E-01	2.53E-01	3.23E-01	3.66E-01	3.89E-01
Epsilon				1.56E-01	2.83E-01	3.83E-01	4.57E-01
Mu					1.40E-01	2.66E-01	3.76E-01
Omega						1.24E-01	2.41E-01
Sigma							1.11E-01

BWR SAFETY RELIEF VALVE FAIL TO OPEN SPAR: SRV-CC-BWR

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	8.46	12.69	16.91	21.14	25.37	29.60	33.83
N_1	2.9694	3.3979	3.4769	3.4453	3.2965	3.0758	2.8199
N_2	0.5062	1.0562	1.5803	1.9188	2.1920	2.3913	2.5010
N_3		0.1541	0.3548	0.5994	0.8315	1.0708	1.3352
N_4			0.0654	0.1714	0.2840	0.3810	0.4624
N_5				0.0317	0.0963	0.1736	0.2430
N_6					0.0157	0.0551	0.1111
N_7						0.0078	0.0313
N_8							0.0039

2.8.3.2 BWR SAFETY RELIEF VALVE FAIL TO CLOSE SPAR: SRV-OO-BWR

Plants/BWR
Systems/Steam
Components/Valve/Safety Relief Valve (Dual Actuation)
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 7.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9049707	0.9762304	0.9902176	0.9999527	1.0000000	1.785E+01	4.345E-01
α_2	4.37E-05	2.38E-02	9.78E-03	9.50E-02	0.00E+00	4.345E-01	1.785E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9178750	0.9712232	0.9789625	0.9980981	1.0000000	3.715E+01	1.101E+00
α_2	6.94E-04	2.18E-02	1.42E-02	6.89E-02	0.00E+00	8.337E-01	3.742E+01
α_3	2.45E-07	6.99E-03	1.41E-03	3.31E-02	0.00E+00	2.672E-01	3.799E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9201484	0.9666299	0.9720626	0.9945007	1.0000000	5.374E+01	1.855E+00
α_2	1.83E-03	2.21E-02	1.67E-02	6.09E-02	0.00E+00	1.228E+00	5.436E+01
α_3	8.20E-06	7.27E-03	2.70E-03	3.00E-02	0.00E+00	4.043E-01	5.519E+01
α_4	1.73E-08	4.01E-03	5.49E-04	2.01E-02	0.00E+00	2.227E-01	5.537E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9347214	0.9670245	0.9698855	0.9895339	1.0000000	1.038E+02	3.538E+00
α_2	3.80E-03	1.97E-02	1.68E-02	4.55E-02	0.00E+00	2.114E+00	1.052E+02
α_3	4.45E-04	9.11E-03	6.29E-03	2.74E-02	0.00E+00	9.774E-01	1.063E+02
α_4	2.29E-06	3.49E-03	1.18E-03	1.48E-02	0.00E+00	3.744E-01	1.069E+02
α_5	5.56E-21	6.74E-04	3.81E-07	3.90E-03	0.00E+00	7.228E-02	1.072E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9374526	0.9667854	0.9691785	0.9879454	1.0000000	1.245E+02	4.279E+00
α_2	3.57E-03	1.74E-02	1.50E-02	3.95E-02	0.00E+00	2.239E+00	1.266E+02
α_3	6.24E-04	8.86E-03	6.48E-03	2.52E-02	0.00E+00	1.142E+00	1.277E+02
α_4	4.11E-05	4.60E-03	2.41E-03	1.66E-02	0.00E+00	5.922E-01	1.282E+02
α_5	7.21E-09	1.72E-03	2.34E-04	8.64E-03	0.00E+00	2.222E-01	1.286E+02
α_6	1.09E-18	6.46E-04	1.13E-06	3.77E-03	0.00E+00	8.324E-02	1.287E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444459	0.9674651	0.9690305	0.9851468	1.0000000	1.916E+02	6.445E+00
α_2	4.39E-03	1.56E-02	1.40E-02	3.23E-02	0.00E+00	3.088E+00	1.950E+02
α_3	1.11E-03	8.23E-03	6.65E-03	2.08E-02	0.00E+00	1.631E+00	1.965E+02
α_4	2.50E-04	4.99E-03	3.46E-03	1.50E-02	0.00E+00	9.889E-01	1.971E+02
α_5	1.30E-05	2.63E-03	1.25E-03	9.95E-03	0.00E+00	5.218E-01	1.976E+02
α_6	3.39E-10	9.40E-04	8.03E-05	4.94E-03	0.00E+00	1.863E-01	1.979E+02
α_7	5.13E-48	1.47E-04	1.28E-13	5.52E-04	0.00E+00	2.907E-02	1.981E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9472193	0.9680869	0.9694122	0.9844270	1.0000000	2.263E+02	7.461E+00
α_2	4.30E-03	1.43E-02	1.29E-02	2.90E-02	0.00E+00	3.345E+00	2.304E+02
α_3	1.10E-03	7.44E-03	6.09E-03	1.84E-02	0.00E+00	1.738E+00	2.321E+02
α_4	3.47E-04	4.90E-03	3.58E-03	1.40E-02	0.00E+00	1.147E+00	2.326E+02
α_5	5.52E-05	3.03E-03	1.78E-03	1.03E-02	0.00E+00	7.083E-01	2.331E+02
α_6	8.88E-07	1.57E-03	5.14E-04	6.71E-03	0.00E+00	3.670E-01	2.334E+02
α_7	6.97E-14	5.26E-04	9.46E-06	2.99E-03	0.00E+00	1.230E-01	2.337E+02
α_8	1.30E-42	1.42E-04	2.02E-12	5.99E-04	0.00E+00	3.312E-02	2.338E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	7.60	7.60	7.60	7.60	7.60	7.60	7.60
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.3.3 BWR SAFETY RELIEF VALVE SPURIOUS OPERATION

Plants/BWR
Systems/Steam
Components/Valve/Safety Relief Valve (Dual Actuation)
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 11.0
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8766519	0.9689178	0.9869257	0.9999398	0.9986207	1.369E+01	4.393E-01
α_2	6.18E-05	3.11E-02	1.31E-02	1.23E-01	1.38E-03	4.393E-01	1.369E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9116717	0.9688739	0.9771138	0.9978729	0.9972376	3.471E+01	1.115E+00
α_2	7.95E-04	2.37E-02	1.55E-02	7.43E-02	2.76E-03	8.479E-01	3.498E+01
α_3	2.62E-07	7.46E-03	1.51E-03	3.54E-02	0.00E+00	2.672E-01	3.556E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9183002	0.9656749	0.9711720	0.9942233	0.9958506	5.299E+01	1.884E+00
α_2	1.99E-03	2.29E-02	1.74E-02	6.26E-02	4.15E-03	1.257E+00	5.362E+01
α_3	8.31E-06	7.37E-03	2.74E-03	3.04E-02	0.00E+00	4.043E-01	5.447E+01
α_4	1.75E-08	4.06E-03	5.56E-04	2.03E-02	0.00E+00	2.227E-01	5.465E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9346897	0.9668878	0.9697224	0.9893830	0.9944598	1.047E+02	3.586E+00
α_2	3.95E-03	2.00E-02	1.71E-02	4.58E-02	5.54E-03	2.162E+00	1.061E+02
α_3	4.41E-04	9.03E-03	6.24E-03	2.71E-02	0.00E+00	9.774E-01	1.073E+02
α_4	2.27E-06	3.46E-03	1.16E-03	1.47E-02	0.00E+00	3.744E-01	1.079E+02
α_5	5.51E-21	6.67E-04	3.77E-07	3.86E-03	0.00E+00	7.228E-02	1.082E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379729	0.9669242	0.9692644	0.9878668	0.9930652	1.272E+02	4.350E+00
α_2	3.74E-03	1.76E-02	1.52E-02	3.95E-02	6.93E-03	2.311E+00	1.292E+02
α_3	6.11E-04	8.68E-03	6.35E-03	2.47E-02	0.00E+00	1.142E+00	1.304E+02
α_4	4.03E-05	4.50E-03	2.36E-03	1.62E-02	0.00E+00	5.922E-01	1.309E+02
α_5	7.06E-09	1.69E-03	2.29E-04	8.46E-03	0.00E+00	2.222E-01	1.313E+02

α_6	1.07E-18	6.33E-04	1.11E-06	3.69E-03	0.00E+00	8.324E-02	1.314E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9450007	0.9676783	0.9692107	0.9851367	0.9916667	1.960E+02	6.545E+00
α_2	4.56E-03	1.57E-02	1.42E-02	3.23E-02	8.33E-03	3.188E+00	1.993E+02
α_3	1.09E-03	8.06E-03	6.50E-03	2.03E-02	0.00E+00	1.631E+00	2.009E+02
α_4	2.45E-04	4.88E-03	3.38E-03	1.47E-02	0.00E+00	9.889E-01	2.015E+02
α_5	1.27E-05	2.58E-03	1.22E-03	9.74E-03	0.00E+00	5.218E-01	2.020E+02
α_6	3.32E-10	9.20E-04	7.85E-05	4.83E-03	0.00E+00	1.863E-01	2.023E+02
α_7	5.02E-48	1.44E-04	1.26E-13	5.40E-04	0.00E+00	2.907E-02	2.025E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9478620	0.9683674	0.9696597	0.9844525	0.9907074	2.323E+02	7.588E+00
α_2	4.48E-03	1.45E-02	1.31E-02	2.90E-02	9.07E-03	3.469E+00	2.364E+02
α_3	1.08E-03	7.26E-03	5.94E-03	1.79E-02	2.21E-04	1.741E+00	2.381E+02
α_4	3.38E-04	4.78E-03	3.49E-03	1.36E-02	0.00E+00	1.147E+00	2.387E+02
α_5	5.37E-05	2.95E-03	1.74E-03	9.99E-03	0.00E+00	7.083E-01	2.392E+02
α_6	8.66E-07	1.53E-03	5.01E-04	6.54E-03	0.00E+00	3.670E-01	2.395E+02
α_7	6.79E-14	5.13E-04	9.22E-06	2.92E-03	0.00E+00	1.230E-01	2.398E+02
α_8	1.27E-42	1.38E-04	1.97E-12	5.84E-04	0.00E+00	3.312E-02	2.399E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.99E-01	9.97E-01	9.96E-01	9.94E-01	9.93E-01	9.92E-01	9.91E-01
α_2	1.38E-03	2.76E-03	4.15E-03	5.54E-03	6.93E-03	8.33E-03	9.07E-03
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E-04
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.99E-01	9.97E-01	9.96E-01	9.94E-01	9.93E-01	9.92E-01	9.91E-01
Beta	1.38E-03	2.76E-03	4.15E-03	5.54E-03	6.93E-03	8.33E-03	9.29E-03
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-02
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	3.14	4.71	6.29	7.86	9.43	11.00	12.57
N_1	0.3048	0.4429	0.5714	0.6905	0.8000	0.9000	0.9974
N_2	0.0048	0.0143	0.0286	0.0476	0.0714	0.1000	0.1242
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0030
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.4 PWR Pressurizer Safety Valve

2.8.4.1 PWR PRESSURIZER CODE SAFETIES FAIL TO OPEN

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 2.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8687697	0.9670332	0.9862439	0.9999401	1.0000000	1.275E+01	4.345E-01
α_2	6.16E-05	3.30E-02	1.38E-02	1.31E-01	0.00E+00	4.345E-01	1.275E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9054638	0.9667968	0.9756611	0.9977908	1.0000000	3.206E+01	1.101E+00
α_2	8.04E-04	2.51E-02	1.64E-02	7.93E-02	0.00E+00	8.337E-01	3.232E+01
α_3	2.84E-07	8.06E-03	1.63E-03	3.82E-02	0.00E+00	2.672E-01	3.289E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9122217	0.9632593	0.9692097	0.9939302	1.0000000	4.864E+01	1.855E+00
α_2	2.02E-03	2.43E-02	1.84E-02	6.70E-02	0.00E+00	1.228E+00	4.926E+01
α_3	9.04E-06	8.01E-03	2.98E-03	3.31E-02	0.00E+00	4.043E-01	5.009E+01
α_4	1.91E-08	4.41E-03	6.05E-04	2.21E-02	0.00E+00	2.227E-01	5.027E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9315060	0.9653789	0.9683772	0.9890026	1.0000000	9.866E+01	3.538E+00
α_2	3.99E-03	2.07E-02	1.76E-02	4.78E-02	0.00E+00	2.114E+00	1.001E+02
α_3	4.67E-04	9.56E-03	6.61E-03	2.87E-02	0.00E+00	9.774E-01	1.012E+02
α_4	2.41E-06	3.66E-03	1.23E-03	1.56E-02	0.00E+00	3.744E-01	1.018E+02
α_5	5.84E-21	7.07E-04	4.00E-07	4.10E-03	0.00E+00	7.228E-02	1.021E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9349051	0.9654162	0.9678994	0.9874408	1.0000000	1.194E+02	4.279E+00
α_2	3.72E-03	1.81E-02	1.56E-02	4.11E-02	0.00E+00	2.239E+00	1.215E+02
α_3	6.50E-04	9.23E-03	6.75E-03	2.63E-02	0.00E+00	1.142E+00	1.226E+02
α_4	4.28E-05	4.79E-03	2.51E-03	1.73E-02	0.00E+00	5.922E-01	1.231E+02
α_5	7.51E-09	1.80E-03	2.44E-04	9.00E-03	0.00E+00	2.222E-01	1.235E+02
α_6	1.14E-18	6.73E-04	1.18E-06	3.93E-03	0.00E+00	8.324E-02	1.236E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9429932	0.9666054	0.9682083	0.9847453	1.0000000	1.866E+02	6.445E+00
α_2	4.51E-03	1.60E-02	1.44E-02	3.31E-02	0.00E+00	3.088E+00	1.899E+02
α_3	1.14E-03	8.45E-03	6.82E-03	2.13E-02	0.00E+00	1.631E+00	1.914E+02
α_4	2.57E-04	5.12E-03	3.55E-03	1.54E-02	0.00E+00	9.889E-01	1.920E+02
α_5	1.33E-05	2.70E-03	1.28E-03	1.02E-02	0.00E+00	5.218E-01	1.925E+02
α_6	3.48E-10	9.65E-04	8.24E-05	5.07E-03	0.00E+00	1.863E-01	1.928E+02
α_7	5.27E-48	1.51E-04	1.32E-13	5.67E-04	0.00E+00	2.907E-02	1.930E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9460529	0.9673753	0.9687323	0.9840762	1.0000000	2.212E+02	7.461E+00
α_2	4.40E-03	1.46E-02	1.32E-02	2.96E-02	0.00E+00	3.345E+00	2.253E+02
α_3	1.12E-03	7.60E-03	6.22E-03	1.88E-02	0.00E+00	1.738E+00	2.270E+02
α_4	3.55E-04	5.01E-03	3.66E-03	1.43E-02	0.00E+00	1.147E+00	2.275E+02
α_5	5.64E-05	3.10E-03	1.82E-03	1.05E-02	0.00E+00	7.083E-01	2.280E+02
α_6	9.08E-07	1.60E-03	5.25E-04	6.86E-03	0.00E+00	3.670E-01	2.283E+02
α_7	7.12E-14	5.38E-04	9.67E-06	3.06E-03	0.00E+00	1.230E-01	2.286E+02
α_8	1.33E-42	1.45E-04	2.06E-12	6.12E-04	0.00E+00	3.312E-02	2.287E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	2.50	2.50	2.50	2.50	2.50	2.50	2.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.8.4.2 PWR PRESSURIZER CODE SAFETIES FAIL TO CLOSE

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8522320	0.9627996	0.9843829	0.9999318	1.0000000	1.125E+01	4.345E-01
α_2	7.00E-05	3.72E-02	1.56E-02	1.48E-01	0.00E+00	4.345E-01	1.125E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9010678	0.9652235	0.9744833	0.9976825	1.0000000	3.056E+01	1.101E+00
α_2	8.43E-04	2.63E-02	1.72E-02	8.30E-02	0.00E+00	8.337E-01	3.082E+01
α_3	2.98E-07	8.44E-03	1.71E-03	4.00E-02	0.00E+00	2.672E-01	3.139E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9095821	0.9621343	0.9682529	0.9937392	1.0000000	4.714E+01	1.855E+00
α_2	2.09E-03	2.51E-02	1.89E-02	6.90E-02	0.00E+00	1.228E+00	4.776E+01
α_3	9.32E-06	8.25E-03	3.07E-03	3.41E-02	0.00E+00	4.043E-01	4.859E+01
α_4	1.97E-08	4.55E-03	6.24E-04	2.28E-02	0.00E+00	2.227E-01	4.877E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9304992	0.9648632	0.9678976	0.9888359	1.0000000	9.716E+01	3.538E+00
α_2	4.05E-03	2.10E-02	1.79E-02	4.85E-02	0.00E+00	2.114E+00	9.859E+01
α_3	4.74E-04	9.71E-03	6.71E-03	2.92E-02	0.00E+00	9.774E-01	9.972E+01
α_4	2.45E-06	3.72E-03	1.25E-03	1.58E-02	0.00E+00	3.744E-01	1.003E+02
α_5	5.93E-21	7.18E-04	4.06E-07	4.16E-03	0.00E+00	7.228E-02	1.006E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9341158	0.9649918	0.9674994	0.9872843	1.0000000	1.179E+02	4.279E+00
α_2	3.77E-03	1.83E-02	1.58E-02	4.16E-02	0.00E+00	2.239E+00	1.200E+02
α_3	6.58E-04	9.34E-03	6.84E-03	2.66E-02	0.00E+00	1.142E+00	1.211E+02
α_4	4.33E-05	4.85E-03	2.54E-03	1.75E-02	0.00E+00	5.922E-01	1.216E+02
α_5	7.60E-09	1.82E-03	2.47E-04	9.11E-03	0.00E+00	2.222E-01	1.220E+02
α_6	1.15E-18	6.81E-04	1.19E-06	3.98E-03	0.00E+00	8.324E-02	1.221E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9425514	0.9663438	0.9679581	0.9846241	1.0000000	1.851E+02	6.445E+00
α_2	4.55E-03	1.61E-02	1.45E-02	3.34E-02	0.00E+00	3.088E+00	1.884E+02
α_3	1.15E-03	8.52E-03	6.88E-03	2.15E-02	0.00E+00	1.631E+00	1.899E+02
α_4	2.59E-04	5.16E-03	3.58E-03	1.55E-02	0.00E+00	9.889E-01	1.905E+02
α_5	1.34E-05	2.72E-03	1.29E-03	1.03E-02	0.00E+00	5.218E-01	1.910E+02
α_6	3.51E-10	9.73E-04	8.31E-05	5.11E-03	0.00E+00	1.863E-01	1.913E+02
α_7	5.31E-48	1.52E-04	1.33E-13	5.72E-04	0.00E+00	2.907E-02	1.915E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9456999	0.9671599	0.9685251	0.9839700	1.0000000	2.197E+02	7.461E+00
α_2	4.43E-03	1.47E-02	1.33E-02	2.98E-02	0.00E+00	3.345E+00	2.238E+02
α_3	1.13E-03	7.65E-03	6.26E-03	1.89E-02	0.00E+00	1.738E+00	2.255E+02
α_4	3.57E-04	5.05E-03	3.69E-03	1.44E-02	0.00E+00	1.147E+00	2.260E+02
α_5	5.68E-05	3.12E-03	1.83E-03	1.06E-02	0.00E+00	7.083E-01	2.265E+02
α_6	9.14E-07	1.62E-03	5.29E-04	6.91E-03	0.00E+00	3.670E-01	2.268E+02
α_7	7.17E-14	5.41E-04	9.74E-06	3.08E-03	0.00E+00	1.230E-01	2.271E+02
α_8	1.34E-42	1.46E-04	2.08E-12	6.16E-04	0.00E+00	3.312E-02	2.272E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	1.00	1.00	1.00	1.00	1.00	1.00	1.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.9 PORVs

2.9.1 Pooled PORVs

2.9.1.1 POWER OPERATED RELIEF VALVES FAIL TO OPEN ALL SYSTEMS

Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Open
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 109.4
Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9333168	0.9722656	0.9768632	0.9954856	0.9747467	6.458E+01	1.842E+00
α_2	4.51E-03	2.77E-02	2.31E-02	6.67E-02	2.53E-02	1.842E+00	6.458E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9408240	0.9706621	0.9733954	0.9911567	0.9731044	1.098E+02	3.320E+00
α_2	3.36E-03	1.81E-02	1.54E-02	4.23E-02	1.48E-02	2.051E+00	1.111E+02
α_3	9.84E-04	1.12E-02	8.50E-03	3.08E-02	1.21E-02	1.269E+00	1.119E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9485764	0.9727353	0.9747196	0.9901206	0.9777412	1.529E+02	4.286E+00
α_2	2.68E-03	1.37E-02	1.17E-02	3.15E-02	8.45E-03	2.151E+00	1.550E+02
α_3	9.56E-04	8.98E-03	7.00E-03	2.38E-02	9.22E-03	1.412E+00	1.558E+02
α_4	9.02E-05	4.60E-03	2.74E-03	1.54E-02	4.58E-03	7.229E-01	1.565E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9544810	0.9736067	0.9749391	0.9881886	0.9802835	2.293E+02	6.216E+00
α_2	3.52E-03	1.28E-02	1.14E-02	2.67E-02	6.60E-03	3.011E+00	2.325E+02
α_3	1.12E-03	7.46E-03	6.12E-03	1.84E-02	5.74E-03	1.758E+00	2.338E+02
α_4	3.25E-04	4.78E-03	3.47E-03	1.37E-02	5.53E-03	1.125E+00	2.344E+02
α_5	2.77E-07	1.37E-03	3.74E-04	6.11E-03	1.84E-03	3.223E-01	2.352E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9573856	0.9744392	0.9755492	0.9877100	0.9817069	2.764E+02	7.249E+00
α_2	3.40E-03	1.15E-02	1.04E-02	2.35E-02	6.34E-03	3.269E+00	2.803E+02

α_3	8.64E-04	6.01E-03	4.90E-03	1.50E-02	3.47E-03	1.705E+00	2.819E+02
α_4	4.62E-04	4.74E-03	3.64E-03	1.28E-02	4.64E-03	1.346E+00	2.823E+02
α_5	4.97E-05	2.55E-03	1.51E-03	8.56E-03	3.08E-03	7.223E-01	2.829E+02
α_6	1.31E-09	7.34E-04	8.48E-05	3.74E-03	7.70E-04	2.082E-01	2.834E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9596950	0.9743051	0.9751315	0.9860885	0.9825114	3.697E+02	9.749E+00
α_2	4.15E-03	1.14E-02	1.06E-02	2.16E-02	6.63E-03	4.340E+00	3.751E+02
α_3	9.92E-04	5.40E-03	4.56E-03	1.27E-02	2.21E-03	2.049E+00	3.774E+02
α_4	5.70E-04	4.28E-03	3.44E-03	1.08E-02	3.35E-03	1.622E+00	3.778E+02
α_5	2.14E-04	3.02E-03	2.21E-03	8.62E-03	3.31E-03	1.147E+00	3.783E+02
α_6	5.11E-06	1.31E-03	5.98E-04	5.05E-03	1.65E-03	4.988E-01	3.789E+02
α_7	9.87E-18	2.41E-04	8.22E-07	1.41E-03	3.31E-04	9.157E-02	3.793E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9614305	0.9747854	0.9754965	0.9857042	0.9829467	4.304E+02	1.113E+01
α_2	4.30E-03	1.10E-02	1.03E-02	2.03E-02	7.10E-03	4.875E+00	4.367E+02
α_3	8.83E-04	4.72E-03	3.99E-03	1.10E-02	1.60E-03	2.082E+00	4.395E+02
α_4	4.96E-04	3.69E-03	2.98E-03	9.34E-03	2.25E-03	1.631E+00	4.399E+02
α_5	2.90E-04	3.02E-03	2.31E-03	8.18E-03	2.91E-03	1.334E+00	4.402E+02
α_6	5.94E-05	1.89E-03	1.21E-03	6.04E-03	2.18E-03	8.358E-01	4.407E+02
α_7	1.03E-07	7.03E-04	1.81E-04	3.18E-03	8.71E-04	3.105E-01	4.412E+02
α_8	8.25E-24	1.46E-04	2.82E-08	8.29E-04	1.45E-04	6.437E-02	4.415E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.75E-01	9.73E-01	9.78E-01	9.80E-01	9.82E-01	9.83E-01	9.83E-01
α_2	2.53E-02	1.48E-02	8.45E-03	6.60E-03	6.34E-03	6.63E-03	7.10E-03
α_3		1.21E-02	9.22E-03	5.74E-03	3.47E-03	2.21E-03	1.60E-03
α_4			4.58E-03	5.53E-03	4.64E-03	3.35E-03	2.25E-03
α_5				1.84E-03	3.08E-03	3.31E-03	2.91E-03
α_6					7.70E-04	1.65E-03	2.18E-03
α_7						3.31E-04	8.71E-04
α_8							1.45E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.75E-01	9.73E-01	9.78E-01	9.80E-01	9.82E-01	9.83E-01	9.83E-01
Beta	2.53E-02	2.69E-02	2.23E-02	1.97E-02	1.83E-02	1.75E-02	1.71E-02
Gamma		4.52E-01	6.20E-01	6.65E-01	6.53E-01	6.21E-01	5.83E-01
Delta			3.32E-01	5.62E-01	7.10E-01	7.97E-01	8.39E-01
Epsilon				2.50E-01	4.53E-01	6.12E-01	7.30E-01
Mu					2.00E-01	3.75E-01	5.23E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind. Events	51.48	77.22	102.96	128.71	154.45	180.19	205.93
N_1	2.8514	3.0601	3.7980	4.4383	4.9747	5.4152	5.7670
N_2	1.4077	1.2170	0.9231	0.8967	1.0294	1.2525	1.5301
N_3		1.0020	1.0072	0.7803	0.5628	0.4174	0.3440
N_4			0.5002	0.7509	0.7534	0.6334	0.4850
N_5				0.2500	0.5001	0.6254	0.6261
N_6					0.1250	0.3125	0.4688
N_7						0.0625	0.1875
N_8							0.0313

2.9.1.2 POWER OPERATED RELIEF VALVES FAIL TO CLOSE ALL SYSTEMS

Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Close
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 40.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432745	0.9858513	0.9942402	0.9999713	0.9999173	3.039E+01	4.362E-01
α_2	2.62E-05	1.41E-02	5.76E-03	5.67E-02	8.27E-05	4.362E-01	3.039E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9479474	0.9818339	0.9867838	0.9987999	0.9998345	5.977E+01	1.106E+00
α_2	4.43E-04	1.38E-02	8.93E-03	4.36E-02	1.65E-04	8.387E-01	6.004E+01
α_3	1.53E-07	4.39E-03	8.82E-04	2.08E-02	0.00E+00	2.672E-01	6.061E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9492453	0.9788734	0.9823767	0.9965244	0.9997518	8.642E+01	1.865E+00
α_2	1.17E-03	1.40E-02	1.06E-02	3.87E-02	2.48E-04	1.238E+00	8.704E+01
α_3	5.14E-06	4.58E-03	1.69E-03	1.89E-02	0.00E+00	4.043E-01	8.788E+01
α_4	1.09E-08	2.52E-03	3.44E-04	1.26E-02	0.00E+00	2.227E-01	8.806E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9530070	0.9763141	0.9784022	0.9924951	0.9996823	1.465E+02	3.554E+00
α_2	2.75E-03	1.42E-02	1.21E-02	3.28E-02	3.11E-04	2.130E+00	1.479E+02
α_3	3.18E-04	6.52E-03	4.50E-03	1.96E-02	6.62E-06	9.777E-01	1.491E+02
α_4	1.64E-06	2.49E-03	8.39E-04	1.06E-02	0.00E+00	3.744E-01	1.497E+02
α_5	3.97E-21	4.82E-04	2.72E-07	2.79E-03	0.00E+00	7.228E-02	1.500E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553160	0.9763169	0.9780474	0.9914155	0.9996154	1.773E+02	4.302E+00
α_2	2.58E-03	1.25E-02	1.07E-02	2.83E-02	3.71E-04	2.262E+00	1.794E+02
α_3	4.43E-04	6.29E-03	4.60E-03	1.79E-02	1.40E-05	1.143E+00	1.805E+02
α_4	2.91E-05	3.26E-03	1.71E-03	1.18E-02	0.00E+00	5.922E-01	1.811E+02
α_5	5.11E-09	1.22E-03	1.66E-04	6.13E-03	0.00E+00	2.222E-01	1.814E+02
α_6	7.75E-19	4.58E-04	8.01E-07	2.67E-03	0.00E+00	8.324E-02	1.816E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9575780	0.9751841	0.9763913	0.9886757	0.9995514	2.545E+02	6.477E+00
α_2	3.39E-03	1.19E-02	1.07E-02	2.47E-02	4.26E-04	3.118E+00	2.579E+02
α_3	8.43E-04	6.26E-03	5.05E-03	1.58E-02	2.22E-05	1.633E+00	2.594E+02
α_4	1.90E-04	3.79E-03	2.62E-03	1.14E-02	0.00E+00	9.889E-01	2.600E+02
α_5	9.82E-06	2.00E-03	9.46E-04	7.56E-03	0.00E+00	5.218E-01	2.605E+02
α_6	2.57E-10	7.14E-04	6.09E-05	3.75E-03	0.00E+00	1.863E-01	2.608E+02
α_7	3.89E-48	1.11E-04	9.75E-14	4.19E-04	0.00E+00	2.907E-02	2.610E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9595165	0.9755429	0.9765722	0.9880666	0.9994893	2.992E+02	7.502E+00
α_2	3.34E-03	1.10E-02	9.99E-03	2.23E-02	4.78E-04	3.383E+00	3.034E+02
α_3	8.40E-04	5.68E-03	4.64E-03	1.40E-02	3.12E-05	1.741E+00	3.050E+02
α_4	2.64E-04	3.74E-03	2.73E-03	1.07E-02	1.11E-06	1.147E+00	3.056E+02
α_5	4.20E-05	2.31E-03	1.36E-03	7.82E-03	0.00E+00	7.083E-01	3.060E+02
α_6	6.77E-07	1.20E-03	3.91E-04	5.12E-03	0.00E+00	3.670E-01	3.064E+02
α_7	5.31E-14	4.01E-04	7.21E-06	2.28E-03	0.00E+00	1.230E-01	3.066E+02
α_8	9.94E-43	1.08E-04	1.54E-12	4.56E-04	0.00E+00	3.312E-02	3.067E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01
α_2	8.27E-05	1.65E-04	2.48E-04	3.11E-04	3.71E-04	4.26E-04	4.78E-04
α_3		0.00E+00	0.00E+00	6.62E-06	1.40E-05	2.22E-05	3.12E-05
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-06
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01
Beta	8.27E-05	1.65E-04	2.48E-04	3.18E-04	3.85E-04	4.49E-04	5.11E-04
Gamma		0.00E+00	0.00E+00	2.08E-02	3.63E-02	4.94E-02	6.33E-02
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8

POWER OPERATED RELIEF VALVES FAIL TO CLOSE ALL SYSTEMS

Adj. IEs	20.05	30.07	40.10	50.12	60.15	70.17	80.20
N_1	0.0967	0.1400	0.1800	0.2175	0.2523	0.2845	0.3143
N_2	0.0017	0.0050	0.0100	0.0157	0.0224	0.0301	0.0385
N_3		0.0000	0.0000	0.0003	0.0008	0.0016	0.0025
N_4			0.0000	0.0000	0.0000	0.0000	0.0001
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.9.2 PWR Steam Generator PORV

2.9.2.1 PWR MAIN STEAM PORV FAIL TO OPEN

Plants/PWR
Systems/Steam
Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 86.7
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9110952	0.9629937	0.9690882	0.9940309	0.9640123	4.742E+01	1.822E+00
α_2	5.97E-03	3.70E-02	3.09E-02	8.89E-02	3.60E-02	1.822E+00	4.742E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9245702	0.9626619	0.9661386	0.9888525	0.9618910	8.415E+01	3.264E+00
α_2	4.11E-03	2.28E-02	1.93E-02	5.37E-02	2.05E-02	1.997E+00	8.542E+01
α_3	1.27E-03	1.45E-02	1.10E-02	3.97E-02	1.76E-02	1.267E+00	8.615E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9355709	0.9659783	0.9684810	0.9878346	0.9689468	1.187E+02	4.181E+00
α_2	3.10E-03	1.67E-02	1.42E-02	3.90E-02	1.10E-02	2.054E+00	1.208E+02
α_3	1.21E-03	1.14E-02	8.91E-03	3.03E-02	1.34E-02	1.404E+00	1.215E+02
α_4	1.15E-04	5.88E-03	3.51E-03	1.97E-02	6.68E-03	7.227E-01	1.222E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9455756	0.9685865	0.9701935	0.9860999	0.9729560	1.866E+02	6.053E+00
α_2	3.92E-03	1.49E-02	1.32E-02	3.14E-02	8.07E-03	2.865E+00	1.898E+02
α_3	1.34E-03	9.04E-03	7.40E-03	2.23E-02	8.22E-03	1.741E+00	1.910E+02
α_4	3.96E-04	5.84E-03	4.24E-03	1.67E-02	8.06E-03	1.124E+00	1.916E+02
α_5	3.38E-07	1.67E-03	4.58E-04	7.47E-03	2.69E-03	3.223E-01	1.924E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9493240	0.9697727	0.9711100	0.9856496	0.9753068	2.252E+02	7.021E+00
α_2	3.71E-03	1.32E-02	1.19E-02	2.74E-02	7.50E-03	3.072E+00	2.292E+02
α_3	1.01E-03	7.21E-03	5.86E-03	1.81E-02	4.81E-03	1.675E+00	2.306E+02
α_4	5.62E-04	5.78E-03	4.44E-03	1.56E-02	6.76E-03	1.343E+00	2.309E+02
α_5	6.07E-05	3.11E-03	1.85E-03	1.04E-02	4.50E-03	7.222E-01	2.315E+02

α_6	1.60E-09	8.97E-04	1.04E-04	4.57E-03	1.13E-03	2.082E-01	2.321E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9533750	0.9704293	0.9714045	0.9841474	0.9767206	3.101E+02	9.449E+00
α_2	4.47E-03	1.28E-02	1.18E-02	2.46E-02	7.78E-03	4.092E+00	3.155E+02
α_3	1.12E-03	6.27E-03	5.27E-03	1.48E-02	2.88E-03	2.003E+00	3.175E+02
α_4	6.72E-04	5.06E-03	4.07E-03	1.28E-02	4.87E-03	1.617E+00	3.179E+02
α_5	2.54E-04	3.59E-03	2.62E-03	1.02E-02	4.84E-03	1.147E+00	3.184E+02
α_6	6.07E-06	1.56E-03	7.10E-04	6.00E-03	2.42E-03	4.988E-01	3.191E+02
α_7	1.17E-17	2.87E-04	9.76E-07	1.67E-03	4.84E-04	9.157E-02	3.195E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9556539	0.9711693	0.9720100	0.9838237	0.9775612	3.625E+02	1.076E+01
α_2	4.60E-03	1.23E-02	1.14E-02	2.29E-02	8.38E-03	4.577E+00	3.686E+02
α_3	9.73E-04	5.40E-03	4.55E-03	1.28E-02	1.89E-03	2.016E+00	3.712E+02
α_4	5.79E-04	4.35E-03	3.50E-03	1.10E-02	3.24E-03	1.622E+00	3.716E+02
α_5	3.42E-04	3.57E-03	2.74E-03	9.67E-03	4.25E-03	1.334E+00	3.719E+02
α_6	7.03E-05	2.24E-03	1.44E-03	7.14E-03	3.19E-03	8.357E-01	3.724E+02
α_7	1.22E-07	8.32E-04	2.15E-04	3.76E-03	1.28E-03	3.105E-01	3.729E+02
α_8	9.77E-24	1.72E-04	3.34E-08	9.81E-04	2.13E-04	6.437E-02	3.731E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.64E-01	9.62E-01	9.69E-01	9.73E-01	9.75E-01	9.77E-01	9.78E-01
α_2	3.60E-02	2.05E-02	1.10E-02	8.07E-03	7.50E-03	7.78E-03	8.38E-03
α_3		1.76E-02	1.34E-02	8.22E-03	4.81E-03	2.88E-03	1.89E-03
α_4			6.68E-03	8.06E-03	6.76E-03	4.87E-03	3.24E-03
α_5				2.69E-03	4.50E-03	4.84E-03	4.25E-03
α_6					1.13E-03	2.42E-03	3.19E-03
α_7						4.84E-04	1.28E-03
α_8							2.13E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.64E-01	9.62E-01	9.69E-01	9.73E-01	9.75E-01	9.77E-01	9.78E-01
Beta	3.60E-02	3.81E-02	3.11E-02	2.70E-02	2.47E-02	2.33E-02	2.24E-02
Gamma		4.62E-01	6.45E-01	7.01E-01	6.96E-01	6.66E-01	6.26E-01
Delta			3.33E-01	5.67E-01	7.21E-01	8.14E-01	8.66E-01
Epsilon				2.50E-01	4.54E-01	6.14E-01	7.34E-01
Mu					2.00E-01	3.75E-01	5.24E-01
Omega						1.67E-01	3.18E-01
Sigma							1.43E-01

PWR MAIN STEAM PORV FAIL TO OPEN

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind. Events	34.68	52.02	69.36	86.70	104.04	121.38	138.72
N_1	2.4914	2.5741	3.2148	3.7822	4.2661	4.6712	5.0018
N_2	1.3877	1.1630	0.8259	0.7509	0.8326	1.0045	1.2325
N_3		1.0000	1.0000	0.7641	0.5336	0.3715	0.2779
N_4			0.5000	0.7500	0.7510	0.6282	0.4758
N_5				0.2500	0.5000	0.6251	0.6253
N_6					0.1250	0.3125	0.4688
N_7						0.0625	0.1875
N_8							0.0313

2.9.2.2 PWR MAIN STEAM PORV FAIL TO CLOSE

Plants/PWR
Systems/Steam
Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.6
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9354729	0.9838920	0.9934240	0.9999673	0.9998984	2.664E+01	4.362E-01
α_2	2.99E-05	1.61E-02	6.58E-03	6.45E-02	1.02E-04	4.362E-01	2.664E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9427037	0.9799844	0.9854222	0.9986705	0.9997967	5.414E+01	1.106E+00
α_2	4.89E-04	1.52E-02	9.85E-03	4.80E-02	2.03E-04	8.387E-01	5.441E+01
α_3	1.69E-07	4.84E-03	9.73E-04	2.29E-02	0.00E+00	2.672E-01	5.498E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9445832	0.9769119	0.9807268	0.9961964	0.9996950	7.892E+01	1.865E+00
α_2	1.28E-03	1.53E-02	1.15E-02	4.23E-02	3.05E-04	1.238E+00	7.954E+01
α_3	5.62E-06	5.01E-03	1.85E-03	2.07E-02	0.00E+00	4.043E-01	8.038E+01
α_4	1.19E-08	2.76E-03	3.77E-04	1.38E-02	0.00E+00	2.227E-01	8.056E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9499045	0.9747357	0.9769556	0.9919891	0.9996096	1.371E+02	3.554E+00
α_2	2.93E-03	1.51E-02	1.29E-02	3.50E-02	3.82E-04	2.130E+00	1.386E+02
α_3	3.39E-04	6.95E-03	4.80E-03	2.09E-02	8.13E-06	9.777E-01	1.397E+02
α_4	1.75E-06	2.66E-03	8.95E-04	1.13E-02	0.00E+00	3.744E-01	1.403E+02
α_5	4.24E-21	5.14E-04	2.90E-07	2.97E-03	0.00E+00	7.228E-02	1.406E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9523916	0.9747533	0.9765918	0.9908374	0.9995274	1.661E+02	4.302E+00
α_2	2.75E-03	1.33E-02	1.14E-02	3.01E-02	4.55E-04	2.262E+00	1.681E+02
α_3	4.72E-04	6.71E-03	4.90E-03	1.91E-02	1.72E-05	1.143E+00	1.693E+02
α_4	3.10E-05	3.48E-03	1.82E-03	1.25E-02	0.00E+00	5.922E-01	1.698E+02
α_5	5.45E-09	1.30E-03	1.77E-04	6.53E-03	0.00E+00	2.222E-01	1.702E+02
α_6	8.27E-19	4.88E-04	8.54E-07	2.85E-03	0.00E+00	8.324E-02	1.703E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553484	0.9738700	0.9751373	0.9880711	0.9994488	2.414E+02	6.477E+00
α_2	3.57E-03	1.26E-02	1.13E-02	2.60E-02	5.24E-04	3.118E+00	2.447E+02
α_3	8.88E-04	6.59E-03	5.32E-03	1.66E-02	2.72E-05	1.633E+00	2.462E+02
α_4	2.00E-04	3.99E-03	2.76E-03	1.20E-02	0.00E+00	9.889E-01	2.469E+02
α_5	1.03E-05	2.11E-03	9.96E-04	7.96E-03	0.00E+00	5.218E-01	2.473E+02
α_6	2.71E-10	7.52E-04	6.41E-05	3.94E-03	0.00E+00	1.863E-01	2.477E+02
α_7	4.10E-48	1.17E-04	1.03E-13	4.41E-04	0.00E+00	2.907E-02	2.478E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9574498	0.9742855	0.9753644	0.9874484	0.9993724	2.842E+02	7.502E+00
α_2	3.52E-03	1.16E-02	1.05E-02	2.34E-02	5.88E-04	3.383E+00	2.884E+02
α_3	8.84E-04	5.97E-03	4.88E-03	1.48E-02	3.83E-05	1.741E+00	2.900E+02
α_4	2.78E-04	3.93E-03	2.87E-03	1.12E-02	1.37E-06	1.147E+00	2.906E+02
α_5	4.42E-05	2.43E-03	1.43E-03	8.22E-03	0.00E+00	7.083E-01	2.910E+02
α_6	7.11E-07	1.26E-03	4.12E-04	5.38E-03	0.00E+00	3.670E-01	2.914E+02
α_7	5.58E-14	4.21E-04	7.58E-06	2.40E-03	0.00E+00	1.230E-01	2.916E+02
α_8	1.05E-42	1.14E-04	1.62E-12	4.80E-04	0.00E+00	3.312E-02	2.917E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01	9.99E-01
α_2	1.02E-04	2.03E-04	3.05E-04	3.82E-04	4.55E-04	5.24E-04	5.88E-04
α_3		0.00E+00	0.00E+00	8.13E-06	1.72E-05	2.72E-05	3.83E-05
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-06
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.99E-01	9.99E-01
Beta	1.02E-04	2.03E-04	3.05E-04	3.90E-04	4.73E-04	5.51E-04	6.28E-04
Gamma		0.00E+00	0.00E+00	2.08E-02	3.63E-02	4.94E-02	6.33E-02
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-02
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	16.30	24.45	32.60	40.75	48.90	57.05	65.20
N_1	0.0967	0.1400	0.1800	0.2175	0.2523	0.2845	0.3143

N_2	0.0017	0.0050	0.0100	0.0157	0.0224	0.0301	0.0385
N_3		0.0000	0.0000	0.0003	0.0008	0.0016	0.0025
N_4			0.0000	0.0000	0.0000	0.0000	0.0001
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.9.3 PWR Pressurizer Power Operated Relief Valves

2.9.3.1 PRESSURIZER PORVS FAIL TO OPEN

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Open
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 20.6
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9432882	0.9856440	0.9939089	0.9999631	0.9990467	3.121E+01	4.545E-01
α_2	3.40E-05	1.44E-02	6.09E-03	5.67E-02	9.53E-04	4.545E-01	3.121E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474648	0.9813701	0.9862367	0.9986461	0.9982189	6.094E+01	1.157E+00
α_2	5.42E-04	1.43E-02	9.52E-03	4.44E-02	1.72E-03	8.877E-01	6.121E+01
α_3	1.64E-07	4.34E-03	8.84E-04	2.05E-02	6.36E-05	2.692E-01	6.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9484490	0.9781964	0.9816399	0.9961722	0.9975029	8.792E+01	1.960E+00
α_2	1.41E-03	1.47E-02	1.13E-02	3.98E-02	2.32E-03	1.325E+00	8.855E+01
α_3	5.77E-06	4.58E-03	1.73E-03	1.88E-02	1.72E-04	4.115E-01	8.947E+01
α_4	1.08E-08	2.48E-03	3.39E-04	1.24E-02	4.77E-06	2.229E-01	8.966E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	9.99E-01	9.98E-01	9.98E-01
α_2	9.53E-04	1.72E-03	2.32E-03
α_3		6.36E-05	1.72E-04
α_4			4.77E-06

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	9.99E-01	9.98E-01	9.98E-01

Beta	9.53E-04	1.78E-03	2.50E-03
Gamma		3.57E-02	7.07E-02
Delta			2.70E-02

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**
Adj. Ind. Events	20.60	30.90	41.20
N_1	0.3600	0.4860	0.5832
N_2	0.0200	0.0540	0.0972
N_3		0.0020	0.0072
N_4			0.0002

2.9.3.2 PWR PRESSURIZER PORVS FAIL TO CLOSE

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Power Operated Relief Valve
Failure Modes/Fail to Close
CCF Categories/OpStatMode/May occur during both power operations and shutdown conditions
CCF Categories/OpStatMode/Can only happen during power operations
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 5.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8927940	0.9731455	0.9888968	0.9999464	1.0000000	1.575E+01	4.345E-01
α_2	4.96E-05	2.69E-02	1.11E-02	1.07E-01	0.00E+00	4.345E-01	1.575E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9131810	0.9695518	0.9777180	0.9979796	1.0000000	3.506E+01	1.101E+00
α_2	7.35E-04	2.31E-02	1.50E-02	7.28E-02	0.00E+00	8.337E-01	3.532E+01
α_3	2.60E-07	7.39E-03	1.50E-03	3.51E-02	0.00E+00	2.672E-01	3.589E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9170655	0.9653198	0.9709527	0.9942793	1.0000000	5.164E+01	1.855E+00
α_2	1.91E-03	2.30E-02	1.73E-02	6.33E-02	0.00E+00	1.228E+00	5.226E+01
α_3	8.53E-06	7.56E-03	2.81E-03	3.12E-02	0.00E+00	4.043E-01	5.309E+01
α_4	1.80E-08	4.16E-03	5.71E-04	2.09E-02	0.00E+00	2.227E-01	5.327E+01

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4
α_1	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00
α_4			0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4
1-Beta	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00
Delta			0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4
Adj. Ind. Events	5.50	5.50	5.50
N_1	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000
N_3		0.0000	0.0000
N_4			0.0000

2.10 Main Steam Isolation Valves

2.10.1 PWR Main Steam Isolation Valves

2.10.1.1 PWR MSIV FAIL TO OPEN

Plants/PWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 21.9
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9011325	0.9683148	0.9790204	0.9989116	0.9742533	2.601E+01	8.512E-01
α_2	1.09E-03	3.17E-02	2.10E-02	9.89E-02	2.57E-02	8.512E-01	2.601E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9113750	0.9614028	0.9669195	0.9925306	0.9579390	5.233E+01	2.101E+00
α_2	4.61E-03	3.14E-02	2.58E-02	7.72E-02	3.68E-02	1.709E+00	5.272E+01
α_3	6.62E-06	7.21E-03	2.58E-03	3.01E-02	5.26E-03	3.922E-01	5.404E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9117979	0.9552301	0.9590187	0.9856937	0.9458049	7.559E+01	3.543E+00
α_2	8.00E-03	3.29E-02	2.90E-02	7.10E-02	4.42E-02	2.603E+00	7.653E+01
α_3	1.12E-04	8.27E-03	4.65E-03	2.87E-02	8.03E-03	6.543E-01	7.847E+01
α_4	2.41E-07	3.60E-03	8.13E-04	1.67E-02	2.01E-03	2.852E-01	7.884E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9311055	0.9612736	0.9634850	0.9838914	0.9528838	1.328E+02	5.351E+00
α_2	6.34E-03	2.24E-02	2.01E-02	4.62E-02	2.55E-02	3.093E+00	1.351E+02
α_3	1.58E-03	1.17E-02	9.49E-03	2.96E-02	1.68E-02	1.623E+00	1.365E+02
α_4	2.06E-05	3.84E-03	1.85E-03	1.44E-02	4.06E-03	5.306E-01	1.376E+02
α_5	1.20E-15	7.49E-04	5.48E-06	4.35E-03	8.12E-04	1.035E-01	1.381E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9363862	0.9630589	0.9648980	0.9834590	0.9587059	1.608E+02	6.169E+00
α_2	4.69E-03	1.75E-02	1.56E-02	3.67E-02	1.48E-02	2.918E+00	1.641E+02
α_3	1.90E-03	1.14E-02	9.49E-03	2.73E-02	1.65E-02	1.899E+00	1.651E+02
α_4	2.45E-04	5.61E-03	3.81E-03	1.72E-02	7.55E-03	9.377E-01	1.661E+02
α_5	3.23E-07	1.89E-03	5.02E-04	8.51E-03	2.05E-03	3.160E-01	1.667E+02

α_6	2.52E-16	5.92E-04	3.29E-06	3.44E-03	3.41E-04	9.886E-02	1.669E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444896	0.9655873	0.9668531	0.9823600	0.9635069	2.352E+02	8.382E+00
α_2	4.59E-03	1.46E-02	1.33E-02	2.90E-02	8.67E-03	3.548E+00	2.400E+02
α_3	2.08E-03	9.64E-03	8.34E-03	2.17E-02	1.35E-02	2.349E+00	2.412E+02
α_4	7.06E-04	6.09E-03	4.81E-03	1.59E-02	9.34E-03	1.485E+00	2.421E+02
α_5	5.81E-05	2.97E-03	1.76E-03	9.97E-03	3.79E-03	7.229E-01	2.429E+02
α_6	1.10E-08	9.89E-04	1.60E-04	4.84E-03	1.03E-03	2.410E-01	2.433E+02
α_7	1.27E-38	1.51E-04	1.64E-11	6.92E-04	1.47E-04	3.688E-02	2.436E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9481586	0.9671101	0.9681936	0.9823687	0.9674674	2.772E+02	9.426E+00
α_2	4.10E-03	1.27E-02	1.16E-02	2.52E-02	5.08E-03	3.652E+00	2.829E+02
α_3	1.77E-03	8.21E-03	7.09E-03	1.84E-02	1.02E-02	2.352E+00	2.842E+02
α_4	8.69E-04	5.99E-03	4.89E-03	1.49E-02	9.43E-03	1.716E+00	2.849E+02
α_5	1.96E-04	3.58E-03	2.51E-03	1.06E-02	5.26E-03	1.026E+00	2.856E+02
α_6	5.95E-06	1.71E-03	7.62E-04	6.60E-03	2.02E-03	4.887E-01	2.861E+02
α_7	8.09E-12	5.38E-04	2.48E-05	2.95E-03	5.17E-04	1.542E-01	2.864E+02
α_8	1.48E-38	1.29E-04	1.50E-11	5.92E-04	6.47E-05	3.703E-02	2.866E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.74E-01	9.58E-01	9.46E-01	9.53E-01	9.59E-01	9.64E-01	9.67E-01
α_2	2.57E-02	3.68E-02	4.42E-02	2.55E-02	1.48E-02	8.67E-03	5.08E-03
α_3		5.26E-03	8.03E-03	1.68E-02	1.65E-02	1.35E-02	1.02E-02
α_4			2.01E-03	4.06E-03	7.55E-03	9.34E-03	9.43E-03
α_5				8.12E-04	2.05E-03	3.79E-03	5.26E-03
α_6					3.41E-04	1.03E-03	2.02E-03
α_7						1.47E-04	5.17E-04
α_8							6.47E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.74E-01	9.58E-01	9.46E-01	9.53E-01	9.59E-01	9.64E-01	9.67E-01
Beta	2.57E-02	4.21E-02	5.42E-02	4.71E-02	4.13E-02	3.65E-02	3.25E-02
Gamma		1.25E-01	1.85E-01	4.60E-01	6.41E-01	7.62E-01	8.44E-01
Delta			2.00E-01	2.25E-01	3.75E-01	5.14E-01	6.30E-01
Epsilon				1.67E-01	2.40E-01	3.47E-01	4.54E-01
Mu					1.43E-01	2.37E-01	3.31E-01
Omega						1.25E-01	2.24E-01
Sigma							1.11E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	14.60	21.90	29.20	36.50	43.80	51.10	58.40
N_1	1.1667	0.8750	0.2500	0.1563	0.0938	0.0547	0.0313

N_2	0.4167	0.8750	1.3750	0.9792	0.6788	0.4604	0.3069
N_3		0.1250	0.2500	0.6458	0.7569	0.7179	0.6138
N_4			0.0625	0.1563	0.3455	0.4957	0.5697
N_5				0.0313	0.0938	0.2011	0.3175
N_6					0.0156	0.0547	0.1217
N_7						0.0078	0.0313
N_8							0.0039

2.10.1.2 PWR MSIV FAIL TO CLOSE

Plants/PWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 35.3
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8812812	0.9544029	0.9638795	0.9950362	0.9517948	2.940E+01	1.405E+00
α_2	4.96E-03	4.56E-02	3.61E-02	1.19E-01	4.82E-02	1.405E+00	2.940E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8807067	0.9385339	0.9433984	0.9797104	0.9114293	5.590E+01	3.661E+00
α_2	1.61E-02	5.40E-02	4.91E-02	1.09E-01	8.25E-02	3.219E+00	5.634E+01
α_3	1.48E-05	7.42E-03	3.04E-03	2.97E-02	6.05E-03	4.422E-01	5.912E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8875856	0.9359923	0.9393792	0.9728050	0.9034037	7.987E+01	5.462E+00
α_2	1.51E-02	4.48E-02	4.13E-02	8.65E-02	6.95E-02	3.822E+00	8.151E+01
α_3	1.58E-03	1.59E-02	1.23E-02	4.25E-02	2.55E-02	1.355E+00	8.397E+01
α_4	2.23E-07	3.34E-03	7.53E-04	1.55E-02	1.67E-03	2.852E-01	8.504E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9147997	0.9480774	0.9501216	0.9743608	0.9122006	1.378E+02	7.548E+00
α_2	9.68E-03	2.78E-02	2.56E-02	5.32E-02	4.21E-02	4.039E+00	1.413E+02
α_3	4.39E-03	1.81E-02	1.59E-02	3.91E-02	3.61E-02	2.625E+00	1.427E+02
α_4	1.37E-04	5.37E-03	3.34E-03	1.75E-02	8.90E-03	7.807E-01	1.446E+02
α_5	1.14E-15	7.12E-04	5.20E-06	4.13E-03	6.84E-04	1.035E-01	1.453E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9225045	0.9516891	0.9533990	0.9750274	0.9224562	1.667E+02	8.463E+00
α_2	5.73E-03	1.90E-02	1.72E-02	3.85E-02	2.03E-02	3.334E+00	1.718E+02
α_3	5.55E-03	1.87E-02	1.69E-02	3.80E-02	3.96E-02	3.277E+00	1.719E+02
α_4	6.99E-04	7.49E-03	5.72E-03	2.03E-02	1.34E-02	1.313E+00	1.739E+02
α_5	4.88E-06	2.52E-03	1.02E-03	1.01E-02	4.05E-03	4.410E-01	1.747E+02
α_6	2.40E-16	5.64E-04	3.13E-06	3.28E-03	2.90E-04	9.886E-02	1.751E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9348108	0.9574978	0.9586986	0.9760787	0.9309648	2.420E+02	1.074E+01
α_2	5.31E-03	1.56E-02	1.43E-02	3.02E-02	1.37E-02	3.940E+00	2.488E+02
α_3	3.73E-03	1.28E-02	1.15E-02	2.61E-02	2.57E-02	3.229E+00	2.495E+02
α_4	1.85E-03	8.94E-03	7.68E-03	2.03E-02	2.04E-02	2.260E+00	2.505E+02
α_5	1.85E-04	3.85E-03	2.65E-03	1.16E-02	7.25E-03	9.729E-01	2.518E+02
α_6	1.43E-07	1.20E-03	2.99E-04	5.47E-03	1.88E-03	3.035E-01	2.524E+02
α_7	1.22E-38	1.46E-04	1.58E-11	6.67E-04	1.26E-04	3.688E-02	2.527E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9397756	0.9600440	0.9610771	0.9767986	0.9376814	2.848E+02	1.185E+01
α_2	4.74E-03	1.37E-02	1.26E-02	2.63E-02	1.00E-02	4.052E+00	2.926E+02
α_3	2.64E-03	9.86E-03	8.78E-03	2.08E-02	1.68E-02	2.926E+00	2.938E+02
α_4	1.96E-03	8.47E-03	7.39E-03	1.87E-02	1.94E-02	2.512E+00	2.942E+02
α_5	5.94E-04	5.05E-03	3.99E-03	1.31E-02	1.12E-02	1.498E+00	2.952E+02
α_6	2.77E-05	2.17E-03	1.20E-03	7.61E-03	3.94E-03	6.449E-01	2.961E+02
α_7	2.11E-10	6.25E-04	5.27E-05	3.28E-03	8.86E-04	1.855E-01	2.965E+02
α_8	1.43E-38	1.25E-04	1.45E-11	5.72E-04	5.54E-05	3.703E-02	2.967E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.52E-01	9.11E-01	9.03E-01	9.12E-01	9.22E-01	9.31E-01	9.38E-01
α_2	4.82E-02	8.25E-02	6.95E-02	4.21E-02	2.03E-02	1.37E-02	1.00E-02
α_3		6.05E-03	2.55E-02	3.61E-02	3.96E-02	2.57E-02	1.68E-02
α_4			1.67E-03	8.90E-03	1.34E-02	2.04E-02	1.94E-02
α_5				6.84E-04	4.05E-03	7.25E-03	1.12E-02
α_6					2.90E-04	1.88E-03	3.94E-03
α_7						1.26E-04	8.86E-04
α_8							5.54E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.52E-01	9.11E-01	9.03E-01	9.12E-01	9.22E-01	9.31E-01	9.38E-01
Beta	4.82E-02	8.86E-02	9.66E-02	8.78E-02	7.75E-02	6.90E-02	6.23E-02
Gamma		6.84E-02	2.81E-01	5.20E-01	7.38E-01	8.02E-01	8.39E-01
Delta			6.17E-02	2.10E-01	3.09E-01	5.36E-01	6.78E-01
Epsilon				7.14E-02	2.45E-01	3.12E-01	4.54E-01
Mu					6.67E-02	2.17E-01	3.04E-01
Omega						6.25E-02	1.93E-01
Sigma							5.88E-02

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	16.29	24.44	32.58	40.73	48.88	57.02	65.17
N_1	2.8600	1.9050	1.1447	0.9270	0.9024	0.9218	0.9427
N_2	0.9700	2.3850	2.5935	1.9248	1.0949	0.8523	0.7070

N_3		0.1750	0.9505	1.6472	2.1347	1.5976	1.1872
N_4			0.0625	0.4063	0.7206	1.2709	1.3652
N_5				0.0313	0.2188	0.4511	0.7900
N_6					0.0156	0.1172	0.2780
N_7						0.0078	0.0625
N_8							0.0039

2.10.2BWR Main Steam Isolation Valves

2.10.2.1 BWR MSIV FAIL TO OPEN

Plants/BWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 4.3
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8537668	0.9631933	0.9845574	0.9999326	1.0000000	1.137E+01	4.345E-01
α_2	6.92E-05	3.68E-02	1.54E-02	1.46E-01	0.00E+00	4.345E-01	1.137E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9031265	0.9659593	0.9750336	0.9977327	0.9999365	3.124E+01	1.101E+00
α_2	8.25E-04	2.58E-02	1.68E-02	8.13E-02	6.35E-05	8.338E-01	3.151E+01
α_3	2.91E-07	8.26E-03	1.68E-03	3.92E-02	0.00E+00	2.672E-01	3.208E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9117853	0.9630720	0.9690498	0.9938975	0.9999048	4.839E+01	1.855E+00
α_2	2.03E-03	2.44E-02	1.85E-02	6.73E-02	9.52E-05	1.228E+00	4.901E+01
α_3	9.09E-06	8.05E-03	2.99E-03	3.32E-02	0.00E+00	4.043E-01	4.984E+01
α_4	1.92E-08	4.43E-03	6.08E-04	2.22E-02	0.00E+00	2.227E-01	5.002E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9317069	0.9654809	0.9684707	0.9890347	0.9998730	9.897E+01	3.539E+00
α_2	3.98E-03	2.06E-02	1.76E-02	4.76E-02	1.27E-04	2.115E+00	1.004E+02
α_3	4.66E-04	9.53E-03	6.59E-03	2.87E-02	0.00E+00	9.774E-01	1.015E+02
α_4	2.40E-06	3.65E-03	1.23E-03	1.55E-02	0.00E+00	3.744E-01	1.021E+02
α_5	5.82E-21	7.05E-04	3.99E-07	4.08E-03	0.00E+00	7.228E-02	1.024E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9353506	0.9656547	0.9681218	0.9875277	0.9998412	1.203E+02	4.279E+00
α_2	3.70E-03	1.80E-02	1.55E-02	4.08E-02	1.59E-04	2.240E+00	1.224E+02
α_3	6.46E-04	9.16E-03	6.71E-03	2.61E-02	0.00E+00	1.142E+00	1.235E+02
α_4	4.25E-05	4.75E-03	2.49E-03	1.71E-02	0.00E+00	5.922E-01	1.240E+02
α_5	7.46E-09	1.78E-03	2.42E-04	8.94E-03	0.00E+00	2.222E-01	1.244E+02
α_6	1.13E-18	6.68E-04	1.17E-06	3.90E-03	0.00E+00	8.324E-02	1.245E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9434050	0.9668483	0.9684405	0.9848569	0.9998095	1.880E+02	6.446E+00
α_2	4.48E-03	1.59E-02	1.43E-02	3.29E-02	1.91E-04	3.089E+00	1.913E+02
α_3	1.13E-03	8.39E-03	6.77E-03	2.12E-02	0.00E+00	1.631E+00	1.928E+02
α_4	2.55E-04	5.09E-03	3.52E-03	1.53E-02	0.00E+00	9.889E-01	1.934E+02
α_5	1.32E-05	2.68E-03	1.27E-03	1.01E-02	0.00E+00	5.218E-01	1.939E+02
α_6	3.46E-10	9.58E-04	8.18E-05	5.03E-03	0.00E+00	1.863E-01	1.942E+02
α_7	5.23E-48	1.50E-04	1.31E-13	5.63E-04	0.00E+00	2.907E-02	1.944E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9465106	0.9676536	0.9690000	0.9842125	0.9997777	2.232E+02	7.462E+00
α_2	4.36E-03	1.45E-02	1.31E-02	2.94E-02	2.22E-04	3.346E+00	2.273E+02
α_3	1.12E-03	7.54E-03	6.17E-03	1.86E-02	0.00E+00	1.738E+00	2.290E+02
α_4	3.52E-04	4.97E-03	3.63E-03	1.42E-02	0.00E+00	1.147E+00	2.295E+02
α_5	5.59E-05	3.07E-03	1.80E-03	1.04E-02	0.00E+00	7.083E-01	2.300E+02
α_6	9.00E-07	1.59E-03	5.21E-04	6.80E-03	0.00E+00	3.670E-01	2.303E+02
α_7	7.06E-14	5.33E-04	9.59E-06	3.03E-03	0.00E+00	1.230E-01	2.306E+02
α_8	1.32E-42	1.44E-04	2.05E-12	6.07E-04	0.00E+00	3.312E-02	2.307E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	6.35E-05	9.52E-05	1.27E-04	1.59E-04	1.91E-04	2.22E-04
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	6.35E-05	9.52E-05	1.27E-04	1.59E-04	1.91E-04	2.22E-04
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	1.07	1.61	2.15	2.69	3.22	3.76	4.30
N_1	0.0499	0.0748	0.0996	0.1243	0.1489	0.1735	0.1980
N_2	0.0000	0.0001	0.0002	0.0004	0.0005	0.0008	0.0010

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.10.2.2 BWR MSIV FAIL TO CLOSE

Plants/BWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 11.4
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8714003	0.9662849	0.9843069	0.9998741	0.9858890	1.399E+01	4.881E-01
α_2	1.23E-04	3.37E-02	1.57E-02	1.29E-01	1.41E-02	4.881E-01	1.399E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9055746	0.9652167	0.9733751	0.9969248	0.9713740	3.501E+01	1.262E+00
α_2	1.42E-03	2.74E-02	1.93E-02	8.11E-02	2.86E-02	9.944E-01	3.528E+01
α_3	2.59E-07	7.37E-03	1.49E-03	3.49E-02	0.00E+00	2.672E-01	3.600E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9107425	0.9606913	0.9661131	0.9920629	0.9564376	5.319E+01	2.177E+00
α_2	3.54E-03	2.80E-02	2.25E-02	7.12E-02	4.36E-02	1.550E+00	5.382E+01
α_3	8.24E-06	7.30E-03	2.71E-03	3.02E-02	0.00E+00	4.043E-01	5.497E+01
α_4	1.74E-08	4.02E-03	5.51E-04	2.01E-02	0.00E+00	2.227E-01	5.515E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9286923	0.9625516	0.9653588	0.9868199	0.9410609	1.047E+02	4.074E+00
α_2	6.00E-03	2.44E-02	2.15E-02	5.25E-02	5.89E-02	2.650E+00	1.061E+02
α_3	4.39E-04	8.98E-03	6.21E-03	2.70E-02	0.00E+00	9.774E-01	1.078E+02
α_4	2.26E-06	3.44E-03	1.16E-03	1.46E-02	0.00E+00	3.744E-01	1.084E+02
α_5	5.49E-21	6.64E-04	3.76E-07	3.85E-03	0.00E+00	7.228E-02	1.087E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9306330	0.9614881	0.9637983	0.9844423	0.9252243	1.269E+02	5.082E+00
α_2	6.44E-03	2.31E-02	2.07E-02	4.78E-02	7.48E-02	3.043E+00	1.289E+02
α_3	6.09E-04	8.65E-03	6.33E-03	2.46E-02	0.00E+00	1.142E+00	1.308E+02
α_4	4.01E-05	4.49E-03	2.35E-03	1.62E-02	0.00E+00	5.922E-01	1.314E+02
α_5	7.04E-09	1.68E-03	2.28E-04	8.44E-03	0.00E+00	2.222E-01	1.317E+02
α_6	1.07E-18	6.31E-04	1.10E-06	3.68E-03	0.00E+00	8.324E-02	1.319E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9385597	0.9626809	0.9641958	0.9816379	0.9089069	1.953E+02	7.570E+00
α_2	7.42E-03	2.08E-02	1.92E-02	3.94E-02	9.11E-02	4.213E+00	1.986E+02
α_3	1.08E-03	8.04E-03	6.49E-03	2.03E-02	0.00E+00	1.631E+00	2.012E+02
α_4	2.44E-04	4.88E-03	3.37E-03	1.46E-02	0.00E+00	9.889E-01	2.019E+02
α_5	1.26E-05	2.57E-03	1.22E-03	9.72E-03	0.00E+00	5.218E-01	2.023E+02
α_6	3.31E-10	9.18E-04	7.84E-05	4.82E-03	0.00E+00	1.863E-01	2.027E+02
α_7	5.01E-48	1.43E-04	1.25E-13	5.40E-04	0.00E+00	2.907E-02	2.028E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9406443	0.9626767	0.9639528	0.9803456	0.8920863	2.311E+02	8.961E+00
α_2	7.87E-03	2.02E-02	1.89E-02	3.70E-02	1.08E-01	4.845E+00	2.352E+02
α_3	1.07E-03	7.24E-03	5.93E-03	1.79E-02	0.00E+00	1.738E+00	2.384E+02
α_4	3.38E-04	4.78E-03	3.49E-03	1.36E-02	0.00E+00	1.147E+00	2.389E+02
α_5	5.37E-05	2.95E-03	1.73E-03	9.98E-03	0.00E+00	7.083E-01	2.394E+02
α_6	8.65E-07	1.53E-03	5.00E-04	6.54E-03	0.00E+00	3.670E-01	2.397E+02
α_7	6.78E-14	5.12E-04	9.21E-06	2.92E-03	0.00E+00	1.230E-01	2.400E+02
α_8	1.27E-42	1.38E-04	1.97E-12	5.83E-04	0.00E+00	3.312E-02	2.401E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.86E-01	9.71E-01	9.56E-01	9.41E-01	9.25E-01	9.09E-01	8.92E-01
α_2	1.41E-02	2.86E-02	4.36E-02	5.89E-02	7.48E-02	9.11E-02	1.08E-01
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.71E-01	9.56E-01	9.41E-01	9.25E-01	9.09E-01	8.92E-01
Beta	1.41E-02	2.86E-02	4.36E-02	5.89E-02	7.48E-02	9.11E-02	1.08E-01
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind. Events	2.85	4.28	5.70	7.13	8.55	9.98	11.40
N_1	0.8929	1.1786	1.3571	1.4286	1.3929	1.2500	1.0000
N_2	0.0536	0.1607	0.3214	0.5357	0.8036	1.1250	1.5000
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.11 Generators

2.11.1 Emergency Diesel Generators

2.11.1.1 EMERGENCY DIESEL GENERATOR SPAR: DGN-FS

Systems/Electrical/Emergency power supply
Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 258.4
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9791869	0.9904158	0.9915741	0.9976702	0.9916730	2.722E+02	2.635E+00
α_2	2.33E-03	9.58E-03	8.42E-03	2.08E-02	8.33E-03	2.635E+00	2.722E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9829837	0.9913998	0.9921549	0.9972355	0.9935193	4.220E+02	3.661E+00
α_2	1.21E-03	5.58E-03	4.82E-03	1.25E-02	3.90E-03	2.374E+00	4.233E+02
α_3	2.71E-04	3.02E-03	2.29E-03	8.28E-03	2.58E-03	1.287E+00	4.244E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9843228	0.9914566	0.9920184	0.9966636	0.9942056	5.688E+02	4.901E+00
α_2	1.17E-03	4.71E-03	4.14E-03	1.02E-02	2.80E-03	2.700E+00	5.710E+02
α_3	2.95E-04	2.57E-03	2.02E-03	6.73E-03	2.04E-03	1.476E+00	5.722E+02
α_4	2.49E-05	1.26E-03	7.51E-04	4.24E-03	9.55E-04	7.247E-01	5.729E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9840813	0.9905179	0.9909450	0.9954898	0.9944693	7.487E+02	7.167E+00
α_2	1.68E-03	5.06E-03	4.63E-03	9.90E-03	2.60E-03	3.822E+00	7.521E+02
α_3	4.13E-04	2.50E-03	2.08E-03	6.03E-03	1.39E-03	1.889E+00	7.540E+02
α_4	1.03E-04	1.50E-03	1.09E-03	4.30E-03	1.16E-03	1.133E+00	7.548E+02
α_5	8.65E-08	4.27E-04	1.17E-04	1.91E-03	3.81E-04	3.225E-01	7.556E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9847494	0.9905661	0.9909218	0.9951618	0.9945519	8.992E+02	8.564E+00
α_2	1.72E-03	4.77E-03	4.41E-03	9.05E-03	2.66E-03	4.333E+00	9.035E+02
α_3	3.63E-04	2.13E-03	1.78E-03	5.10E-03	1.01E-03	1.933E+00	9.059E+02
α_4	1.50E-04	1.51E-03	1.16E-03	4.04E-03	9.84E-04	1.367E+00	9.064E+02

α_5	1.56E-05	7.97E-04	4.73E-04	2.68E-03	6.37E-04	7.233E-01	9.071E+02
α_6	4.09E-10	2.29E-04	2.65E-05	1.17E-03	1.59E-04	2.083E-01	9.076E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.92E-01	9.94E-01	9.94E-01	9.94E-01	9.95E-01
α_2	8.33E-03	3.90E-03	2.80E-03	2.60E-03	2.66E-03
α_3		2.58E-03	2.04E-03	1.39E-03	1.01E-03
α_4			9.55E-04	1.16E-03	9.84E-04
α_5				3.81E-04	6.37E-04
α_6					1.59E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.92E-01	9.94E-01	9.94E-01	9.94E-01	9.95E-01
Beta	8.33E-03	6.48E-03	5.79E-03	5.53E-03	5.45E-03
Gamma		3.98E-01	5.17E-01	5.29E-01	5.12E-01
Delta			3.19E-01	5.25E-01	6.39E-01
Epsilon				2.48E-01	4.47E-01
Mu					2.00E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	258.40	387.60	516.80	646.00	775.20
N_1	3.6000	4.8600	5.8320	6.5610	7.0859
N_2	2.2000	1.5400	1.4720	1.7080	2.0933
N_3		1.0200	1.0720	0.9120	0.7916
N_4			0.5020	0.7590	0.7743
N_5				0.2502	0.5011
N_6					0.1250

2.11.1.2 EMERGENCY DIESEL GENERATOR SPAR: DGN-LR

Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Load and-or Run
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 271.3
Total Number of Common-Cause Failure Events: 5

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9815183	0.9942263	0.9963090	0.9998281	0.9970508	1.419E+02	8.239E-01
α_2	1.74E-04	5.77E-03	3.69E-03	1.85E-02	2.95E-03	8.239E-01	1.419E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9775030	0.9901090	0.9915042	0.9979562	0.9941491	2.258E+02	2.256E+00
α_2	1.54E-03	8.69E-03	7.30E-03	2.06E-02	5.82E-03	1.982E+00	2.261E+02
α_3	5.30E-08	1.20E-03	2.50E-04	5.65E-03	3.24E-05	2.736E-01	2.278E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744894	0.9866583	0.9876915	0.9953015	0.9912863	3.063E+02	4.142E+00
α_2	3.50E-03	1.12E-02	1.02E-02	2.25E-02	8.63E-03	3.492E+00	3.070E+02
α_3	2.17E-06	1.37E-03	5.37E-04	5.58E-03	8.50E-05	4.266E-01	3.101E+02
α_4	3.23E-09	7.20E-04	9.87E-05	3.60E-03	3.12E-06	2.235E-01	3.103E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9755577	0.9860055	0.9867551	0.9938871	0.9925490	4.212E+02	5.978E+00
α_2	2.99E-03	8.97E-03	8.22E-03	1.75E-02	5.25E-03	3.834E+00	4.234E+02
α_3	5.64E-04	3.97E-03	3.22E-03	9.91E-03	2.19E-03	1.694E+00	4.255E+02
α_4	6.20E-07	8.85E-04	3.00E-04	3.75E-03	1.10E-05	3.780E-01	4.268E+02
α_5	1.47E-21	1.69E-04	9.66E-08	9.79E-04	3.05E-07	7.238E-02	4.271E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9773659	0.9866253	0.9872500	0.9937509	0.9933960	5.068E+02	6.871E+00
α_2	2.24E-03	7.04E-03	6.41E-03	1.40E-02	3.51E-03	3.615E+00	5.101E+02
α_3	7.93E-04	4.13E-03	3.51E-03	9.61E-03	2.50E-03	2.124E+00	5.116E+02
α_4	4.86E-05	1.61E-03	1.02E-03	5.15E-03	5.94E-04	8.255E-01	5.129E+02
α_5	1.88E-09	4.34E-04	5.91E-05	2.17E-03	1.72E-06	2.229E-01	5.135E+02
α_6	2.74E-19	1.62E-04	2.83E-07	9.44E-04	0.00E+00	8.324E-02	5.136E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.97E-01	9.94E-01	9.91E-01	9.93E-01	9.93E-01
α_2	2.95E-03	5.82E-03	8.63E-03	5.25E-03	3.51E-03

α_3		3.24E-05	8.50E-05	2.19E-03	2.50E-03
α_4			3.12E-06	1.10E-05	5.94E-04
α_5				3.05E-07	1.72E-06
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.97E-01	9.94E-01	9.91E-01	9.93E-01	9.93E-01
Beta	2.95E-03	5.85E-03	8.71E-03	7.45E-03	6.60E-03
Gamma		5.54E-03	1.01E-02	2.95E-01	4.69E-01
Delta			3.54E-02	5.13E-03	1.92E-01
Epsilon				2.70E-02	2.89E-03
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	129.19	193.79	258.38	322.98	387.57
N_1	2.4313	2.4982	1.8215	2.0857	2.3207
N_2	0.3893	1.1488	2.2641	1.7194	1.3759
N_3		0.0064	0.0223	0.7171	0.9821
N_4			0.0008	0.0036	0.2333
N_5				0.0001	0.0007
N_6					0.0000

2.11.1.3 EMERGENCY DIESEL GENERATOR SPAR: DGN-FR

Systems/Electrical/Emergency power supply
Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 222.0
Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668184	0.9843498	0.9860991	0.9959157	0.9859189	1.782E+02	2.834E+00
α_2	4.09E-03	1.57E-02	1.39E-02	3.32E-02	1.41E-02	2.834E+00	1.782E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9714987	0.9849570	0.9860762	0.9945795	0.9874756	2.804E+02	4.282E+00
α_2	2.90E-03	1.06E-02	9.44E-03	2.21E-02	8.55E-03	3.006E+00	2.816E+02
α_3	3.95E-04	4.48E-03	3.39E-03	1.23E-02	3.97E-03	1.276E+00	2.834E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9756928	0.9865466	0.9873819	0.9945535	0.9901295	3.804E+02	5.187E+00
α_2	1.53E-03	6.56E-03	5.73E-03	1.44E-02	3.86E-03	2.529E+00	3.830E+02
α_3	8.57E-04	5.02E-03	4.19E-03	1.20E-02	4.53E-03	1.934E+00	3.836E+02
α_4	3.68E-05	1.88E-03	1.12E-03	6.31E-03	1.48E-03	7.237E-01	3.848E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9772332	0.9864718	0.9870879	0.9936061	0.9916716	5.137E+02	7.045E+00
α_2	1.63E-03	5.86E-03	5.24E-03	1.22E-02	2.23E-03	3.052E+00	5.177E+02
α_3	9.21E-04	4.40E-03	3.79E-03	9.99E-03	3.12E-03	2.292E+00	5.185E+02
α_4	2.69E-04	2.65E-03	2.04E-03	7.09E-03	2.39E-03	1.379E+00	5.194E+02
α_5	1.25E-07	6.19E-04	1.69E-04	2.77E-03	5.94E-04	3.224E-01	5.204E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9791451	0.9872814	0.9878000	0.9936619	0.9927059	6.178E+02	7.959E+00
α_2	1.34E-03	4.85E-03	4.34E-03	1.01E-02	1.58E-03	3.038E+00	6.227E+02
α_3	6.58E-04	3.41E-03	2.90E-03	7.92E-03	1.97E-03	2.134E+00	6.236E+02
α_4	4.05E-04	2.77E-03	2.26E-03	6.86E-03	2.26E-03	1.731E+00	6.240E+02
α_5	4.44E-05	1.36E-03	8.75E-04	4.30E-03	1.24E-03	8.480E-01	6.249E+02
α_6	5.94E-10	3.33E-04	3.84E-05	1.70E-03	2.48E-04	2.083E-01	6.256E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.86E-01	9.87E-01	9.90E-01	9.92E-01	9.93E-01
α_2	1.41E-02	8.55E-03	3.86E-03	2.23E-03	1.58E-03
α_3		3.97E-03	4.53E-03	3.12E-03	1.97E-03
α_4			1.48E-03	2.39E-03	2.26E-03
α_5				5.94E-04	1.24E-03
α_6					2.48E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.86E-01	9.87E-01	9.90E-01	9.92E-01	9.93E-01
Beta	1.41E-02	1.25E-02	9.87E-03	8.33E-03	7.29E-03
Gamma		3.17E-01	6.09E-01	7.33E-01	7.83E-01
Delta			2.47E-01	4.88E-01	6.56E-01
Epsilon				1.99E-01	3.97E-01
Mu					1.67E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. IEs	166.50	249.75	333.00	416.25	499.50
N_1	1.4947	1.0692	1.2247	1.3122	1.3666
N_2	2.3993	2.1728	1.3013	0.9374	0.7983
N_3		1.0084	1.5295	1.3148	0.9927
N_4			0.5010	1.0045	1.1384
N_5				0.2501	0.6258
N_6					0.1250

2.12 Vacuum Breakers

2.12.1 BWR Pressure Suppression Vacuum Breakers

2.12.1.1 CONTAINMENT VACUUM RELIEF CHECK FAIL TO OPEN

Systems/Atmosphere/Vapor suppression
Components/Valve/Vacuum Breaker
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 9.5
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8695632	0.9630354	0.9797275	0.9996343	0.9701493	1.566E+01	6.012E-01
α_2	3.69E-04	3.70E-02	2.03E-02	1.30E-01	2.99E-02	6.012E-01	1.566E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8968252	0.9587199	0.9663525	0.9944536	0.9384615	3.718E+01	1.601E+00
α_2	3.38E-03	3.44E-02	2.67E-02	9.16E-02	6.15E-02	1.334E+00	3.745E+01
α_3	2.42E-07	6.89E-03	1.39E-03	3.27E-02	0.00E+00	2.672E-01	3.851E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8980965	0.9511878	0.9562605	0.9869237	0.9047619	5.564E+01	2.855E+00
α_2	7.89E-03	3.81E-02	3.29E-02	8.59E-02	9.52E-02	2.228E+00	5.626E+01
α_3	7.79E-06	6.91E-03	2.57E-03	2.85E-02	0.00E+00	4.043E-01	5.809E+01
α_4	1.64E-08	3.81E-03	5.22E-04	1.91E-02	0.00E+00	2.227E-01	5.827E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9253872	0.9596866	0.9623821	0.9847619	0.9223301	1.080E+02	4.538E+00
α_2	6.37E-03	2.47E-02	2.19E-02	5.25E-02	5.18E-02	2.781E+00	1.098E+02
α_3	1.09E-03	1.16E-02	8.90E-03	3.16E-02	2.59E-02	1.311E+00	1.113E+02
α_4	2.19E-06	3.33E-03	1.12E-03	1.41E-02	0.00E+00	3.744E-01	1.122E+02
α_5	5.30E-21	6.42E-04	3.63E-07	3.72E-03	0.00E+00	7.228E-02	1.125E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9309640	0.9613196	0.9635538	0.9840301	0.9344262	1.312E+02	5.279E+00
α_2	4.89E-03	1.97E-02	1.74E-02	4.23E-02	2.91E-02	2.684E+00	1.338E+02
α_3	1.50E-03	1.16E-02	9.34E-03	2.96E-02	2.91E-02	1.586E+00	1.349E+02
α_4	9.17E-05	5.15E-03	3.02E-03	1.75E-02	7.29E-03	7.033E-01	1.358E+02
α_5	6.81E-09	1.63E-03	2.21E-04	8.16E-03	0.00E+00	2.222E-01	1.362E+02
α_6	1.03E-18	6.10E-04	1.07E-06	3.56E-03	0.00E+00	8.324E-02	1.364E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.70E-01	9.38E-01	9.05E-01	9.22E-01	9.34E-01
α_2	2.99E-02	6.15E-02	9.52E-02	5.18E-02	2.91E-02
α_3		0.00E+00	0.00E+00	2.59E-02	2.91E-02
α_4			0.00E+00	0.00E+00	7.29E-03
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.70E-01	9.38E-01	9.05E-01	9.22E-01	9.34E-01
Beta	2.99E-02	6.15E-02	9.52E-02	7.77E-02	6.56E-02
Gamma		0.00E+00	0.00E+00	3.33E-01	5.56E-01
Delta			0.00E+00	0.00E+00	2.00E-01
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	4.75	7.13	9.50	11.88	14.25
N_1	0.6667	0.5000	0.0000	0.0000	0.0000
N_2	0.1667	0.5000	1.0000	0.6667	0.4444
N_3		0.0000	0.0000	0.3333	0.4444
N_4			0.0000	0.0000	0.1111
N_5				0.0000	0.0000
N_6					0.0000

2.13 AC Power Distribution Breakers

2.13.1480 Vac Circuit Breakers

2.13.1.1 480 V CIRCUIT BREAKERS FAIL TO OPEN

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.3
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8806448	0.9693000	0.9863678	0.9999165	0.9931572	1.468E+01	4.651E-01
α_2	8.52E-05	3.07E-02	1.36E-02	1.19E-01	6.84E-03	4.651E-01	1.468E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9118441	0.9682762	0.9762137	0.9975335	0.9875419	3.613E+01	1.184E+00
α_2	1.01E-03	2.44E-02	1.66E-02	7.47E-02	1.18E-02	9.123E-01	3.641E+01
α_3	3.02E-07	7.28E-03	1.52E-03	3.43E-02	6.56E-04	2.716E-01	3.705E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9176673	0.9647087	0.9700195	0.9935599	0.9829814	5.482E+01	2.005E+00
α_2	2.43E-03	2.40E-02	1.87E-02	6.38E-02	1.52E-02	1.363E+00	5.546E+01
α_3	1.06E-05	7.38E-03	2.85E-03	3.01E-02	1.71E-03	4.194E-01	5.641E+01
α_4	1.76E-08	3.93E-03	5.42E-04	1.97E-02	6.86E-05	2.233E-01	5.660E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9337918	0.9659809	0.9687558	0.9886873	0.9793232	1.069E+02	3.765E+00
α_2	4.44E-03	2.08E-02	1.80E-02	4.69E-02	1.75E-02	2.306E+00	1.084E+02
α_3	4.84E-04	9.12E-03	6.39E-03	2.71E-02	2.95E-03	1.010E+00	1.097E+02
α_4	2.36E-06	3.41E-03	1.16E-03	1.44E-02	2.39E-04	3.770E-01	1.103E+02
α_5	5.65E-21	6.54E-04	3.73E-07	3.79E-03	7.34E-06	7.236E-02	1.106E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9368316	0.9658487	0.9681398	0.9870380	0.9764339	1.298E+02	4.588E+00
α_2	4.26E-03	1.85E-02	1.62E-02	4.07E-02	1.88E-02	2.485E+00	1.319E+02
α_3	6.94E-04	8.91E-03	6.62E-03	2.50E-02	4.25E-03	1.198E+00	1.331E+02
α_4	4.19E-05	4.46E-03	2.35E-03	1.60E-02	5.20E-04	5.990E-01	1.337E+02
α_5	7.10E-09	1.66E-03	2.26E-04	8.30E-03	3.21E-05	2.226E-01	1.341E+02
α_6	1.05E-18	6.20E-04	1.08E-06	3.62E-03	0.00E+00	8.324E-02	1.343E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9440017	0.9667618	0.9682667	0.9843923	0.9741939	1.989E+02	6.838E+00
α_2	5.00E-03	1.64E-02	1.49E-02	3.31E-02	1.93E-02	3.382E+00	2.024E+02
α_3	1.21E-03	8.34E-03	6.81E-03	2.07E-02	5.50E-03	1.715E+00	2.040E+02
α_4	2.53E-04	4.87E-03	3.39E-03	1.46E-02	9.04E-04	1.003E+00	2.047E+02
α_5	1.27E-05	2.54E-03	1.21E-03	9.60E-03	8.43E-05	5.231E-01	2.052E+02
α_6	3.29E-10	9.06E-04	7.74E-05	4.75E-03	4.17E-06	1.863E-01	2.055E+02
α_7	4.94E-48	1.41E-04	1.24E-13	5.32E-04	0.00E+00	2.907E-02	2.057E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9468023	0.9674057	0.9686807	0.9836679	0.9725035	2.356E+02	7.938E+00
α_2	4.89E-03	1.51E-02	1.38E-02	2.98E-02	1.93E-02	3.680E+00	2.399E+02
α_3	1.23E-03	7.61E-03	6.31E-03	1.84E-02	6.63E-03	1.853E+00	2.417E+02
α_4	3.55E-04	4.81E-03	3.54E-03	1.36E-02	1.37E-03	1.170E+00	2.424E+02
α_5	5.40E-05	2.92E-03	1.72E-03	9.87E-03	1.72E-04	7.113E-01	2.428E+02
α_6	8.57E-07	1.51E-03	4.94E-04	6.45E-03	1.28E-05	3.672E-01	2.432E+02
α_7	6.69E-14	5.05E-04	9.08E-06	2.87E-03	0.00E+00	1.230E-01	2.434E+02
α_8	1.25E-42	1.36E-04	1.94E-12	5.75E-04	0.00E+00	3.312E-02	2.435E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.93E-01	9.88E-01	9.83E-01	9.79E-01	9.76E-01	9.74E-01	9.73E-01
α_2	6.84E-03	1.18E-02	1.52E-02	1.75E-02	1.88E-02	1.93E-02	1.93E-02
α_3		6.56E-04	1.71E-03	2.95E-03	4.25E-03	5.50E-03	6.63E-03
α_4			6.86E-05	2.39E-04	5.20E-04	9.04E-04	1.37E-03
α_5				7.34E-06	3.21E-05	8.43E-05	1.72E-04
α_6					0.00E+00	4.17E-06	1.28E-05
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.93E-01	9.88E-01	9.83E-01	9.79E-01	9.76E-01	9.74E-01	9.73E-01
Beta	6.84E-03	1.25E-02	1.70E-02	2.07E-02	2.36E-02	2.58E-02	2.75E-02
Gamma		5.27E-02	1.04E-01	1.55E-01	2.04E-01	2.51E-01	2.98E-01
Delta			3.86E-02	7.70E-02	1.15E-01	1.53E-01	1.90E-01
Epsilon				2.98E-02	5.82E-02	8.91E-02	1.19E-01
Mu					0.00E+00	4.71E-02	6.94E-02
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	4.04	6.06	8.07	10.09	12.11	14.13	16.15
N_1	0.4013	0.5234	0.6081	0.6641	0.6984	0.7167	0.7233
N_2	0.0306	0.0786	0.1347	0.1920	0.2462	0.2944	0.3351

N_3		0.0044	0.0151	0.0324	0.0557	0.0838	0.1150
N_4			0.0006	0.0026	0.0068	0.0138	0.0238
N_5				0.0001	0.0004	0.0013	0.0030
N_6					0.0000	0.0001	0.0002
N_7						0.0000	0.0000
N_8							0.0000

2.13.1.2 480 V CIRCUIT BREAKERS FAIL TO CLOSE

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 59.2
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9023651	0.9750674	0.9891421	0.9999320	0.9967742	1.797E+01	4.595E-01
α_2	6.40E-05	2.49E-02	1.09E-02	9.76E-02	3.23E-03	4.595E-01	1.797E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9224689	0.9722499	0.9793040	0.9978943	0.9938367	4.107E+01	1.172E+00
α_2	8.58E-04	2.14E-02	1.44E-02	6.57E-02	6.01E-03	9.033E-01	4.134E+01
α_3	2.39E-07	6.37E-03	1.30E-03	3.01E-02	1.54E-04	2.690E-01	4.198E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9264434	0.9685986	0.9733958	0.9943377	0.9911915	6.141E+01	1.991E+00
α_2	2.15E-03	2.14E-02	1.66E-02	5.71E-02	8.34E-03	1.357E+00	6.204E+01
α_3	8.20E-06	6.49E-03	2.46E-03	2.66E-02	4.64E-04	4.115E-01	6.299E+01
α_4	1.52E-08	3.51E-03	4.81E-04	1.76E-02	0.00E+00	2.227E-01	6.318E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9384686	0.9684408	0.9710313	0.9895436	0.9888424	1.152E+02	3.753E+00
α_2	4.14E-03	1.94E-02	1.68E-02	4.37E-02	1.02E-02	2.311E+00	1.166E+02
α_3	4.28E-04	8.37E-03	5.82E-03	2.50E-02	9.30E-04	9.952E-01	1.179E+02
α_4	2.07E-06	3.15E-03	1.06E-03	1.34E-02	0.00E+00	3.744E-01	1.185E+02
α_5	5.02E-21	6.08E-04	3.44E-07	3.52E-03	0.00E+00	7.228E-02	1.188E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9411651	0.9682241	0.9703645	0.9879609	0.9867930	1.396E+02	4.582E+00
α_2	4.04E-03	1.74E-02	1.52E-02	3.82E-02	1.17E-02	2.507E+00	1.417E+02
α_3	6.14E-04	8.17E-03	6.03E-03	2.30E-02	1.55E-03	1.178E+00	1.430E+02
α_4	3.67E-05	4.11E-03	2.15E-03	1.48E-02	0.00E+00	5.922E-01	1.436E+02
α_5	6.44E-09	1.54E-03	2.09E-04	7.72E-03	0.00E+00	2.222E-01	1.440E+02
α_6	9.78E-19	5.77E-04	1.01E-06	3.37E-03	0.00E+00	8.324E-02	1.441E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9469022	0.9684918	0.9699182	0.9852033	0.9850467	2.104E+02	6.845E+00

α_2	4.84E-03	1.58E-02	1.43E-02	3.17E-02	1.26E-02	3.425E+00	2.138E+02
α_3	1.11E-03	7.80E-03	6.35E-03	1.94E-02	2.34E-03	1.694E+00	2.156E+02
α_4	2.28E-04	4.55E-03	3.15E-03	1.37E-02	0.00E+00	9.889E-01	2.163E+02
α_5	1.18E-05	2.40E-03	1.14E-03	9.08E-03	0.00E+00	5.218E-01	2.167E+02
α_6	3.09E-10	8.57E-04	7.32E-05	4.50E-03	0.00E+00	1.863E-01	2.171E+02
α_7	4.68E-48	1.34E-04	1.17E-13	5.04E-04	0.00E+00	2.907E-02	2.172E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9493914	0.9689861	0.9701955	0.9844489	0.9836066	2.487E+02	7.961E+00
α_2	4.79E-03	1.46E-02	1.33E-02	2.86E-02	1.31E-02	3.745E+00	2.529E+02
α_3	1.15E-03	7.16E-03	5.93E-03	1.74E-02	3.28E-03	1.838E+00	2.549E+02
α_4	3.16E-04	4.47E-03	3.26E-03	1.27E-02	0.00E+00	1.147E+00	2.555E+02
α_5	5.02E-05	2.76E-03	1.62E-03	9.34E-03	0.00E+00	7.083E-01	2.560E+02
α_6	8.09E-07	1.43E-03	4.68E-04	6.12E-03	0.00E+00	3.670E-01	2.563E+02
α_7	6.34E-14	4.79E-04	8.61E-06	2.73E-03	0.00E+00	1.230E-01	2.566E+02
α_8	1.19E-42	1.29E-04	1.84E-12	5.45E-04	0.00E+00	3.312E-02	2.567E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.97E-01	9.94E-01	9.91E-01	9.89E-01	9.87E-01	9.85E-01	9.84E-01
α_2	3.23E-03	6.01E-03	8.34E-03	1.02E-02	1.17E-02	1.26E-02	1.31E-02
α_3		1.54E-04	4.64E-04	9.30E-04	1.55E-03	2.34E-03	3.28E-03
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.97E-01	9.94E-01	9.91E-01	9.89E-01	9.87E-01	9.85E-01	9.84E-01
Beta	3.23E-03	6.16E-03	8.81E-03	1.12E-02	1.32E-02	1.50E-02	1.64E-02
Gamma		2.50E-02	5.26E-02	8.33E-02	1.18E-01	1.56E-01	2.00E-01
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	7.40	11.10	14.80	18.50	22.20	25.90	29.60
N_1	0.3250	0.4179	0.4714	0.4911	0.4821	0.4500	0.4000
N_2	0.0250	0.0696	0.1286	0.1964	0.2679	0.3375	0.4000
N_3		0.0018	0.0071	0.0179	0.0357	0.0625	0.1000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.13.1.3 480 V CIRCUIT BREAKERS SPURIOUS ACTUATION

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 65.2
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9513151	0.9863719	0.9927164	0.9998665	0.9950150	4.351E+01	6.012E-01
α_2	1.32E-04	1.36E-02	7.29E-03	4.87E-02	4.99E-03	6.012E-01	4.351E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9498103	0.9801271	0.9839484	0.9973766	0.9899800	7.895E+01	1.601E+00
α_2	1.60E-03	1.66E-02	1.28E-02	4.45E-02	1.00E-02	1.334E+00	7.922E+01
α_3	1.16E-07	3.32E-03	6.65E-04	1.57E-02	0.00E+00	2.672E-01	8.029E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9472939	0.9749973	0.9777216	0.9933951	0.9848943	1.113E+02	2.855E+00
α_2	3.99E-03	1.95E-02	1.68E-02	4.44E-02	1.51E-02	2.228E+00	1.120E+02
α_3	3.97E-06	3.54E-03	1.31E-03	1.46E-02	0.00E+00	4.043E-01	1.138E+02
α_4	8.38E-09	1.95E-03	2.66E-04	9.76E-03	0.00E+00	2.227E-01	1.140E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9536565	0.9750918	0.9768138	0.9906522	0.9878788	1.777E+02	4.538E+00
α_2	3.92E-03	1.53E-02	1.35E-02	3.25E-02	8.08E-03	2.781E+00	1.794E+02
α_3	6.69E-04	7.19E-03	5.49E-03	1.95E-02	4.04E-03	1.311E+00	1.809E+02
α_4	1.35E-06	2.05E-03	6.91E-04	8.73E-03	0.00E+00	3.744E-01	1.818E+02
α_5	3.27E-21	3.97E-04	2.24E-07	2.29E-03	0.00E+00	7.228E-02	1.821E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9569786	0.9760081	0.9774398	0.9901566	0.9898785	2.147E+02	5.279E+00
α_2	3.02E-03	1.22E-02	1.08E-02	2.63E-02	4.50E-03	2.684E+00	2.173E+02
α_3	9.30E-04	7.21E-03	5.78E-03	1.84E-02	4.50E-03	1.586E+00	2.184E+02
α_4	5.67E-05	3.20E-03	1.87E-03	1.08E-02	1.12E-03	7.033E-01	2.193E+02
α_5	4.21E-09	1.01E-03	1.37E-04	5.06E-03	0.00E+00	2.222E-01	2.198E+02
α_6	6.40E-19	3.78E-04	6.61E-07	2.21E-03	0.00E+00	8.324E-02	2.199E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9596014	0.9756377	0.9766711	0.9881525	0.9913119	2.981E+02	7.445E+00
α_2	3.36E-03	1.11E-02	1.00E-02	2.24E-02	2.57E-03	3.384E+00	3.022E+02
α_3	1.27E-03	6.79E-03	5.75E-03	1.59E-02	3.86E-03	2.076E+00	3.035E+02
α_4	3.15E-04	3.96E-03	2.95E-03	1.11E-02	1.93E-03	1.211E+00	3.044E+02
α_5	1.25E-05	1.83E-03	9.14E-04	6.74E-03	3.22E-04	5.588E-01	3.050E+02
α_6	2.20E-10	6.10E-04	5.20E-05	3.20E-03	0.00E+00	1.863E-01	3.054E+02
α_7	3.32E-48	9.51E-05	8.32E-14	3.58E-04	0.00E+00	2.907E-02	3.056E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9617959	0.9763389	0.9772244	0.9878625	0.9923896	3.491E+02	8.461E+00
α_2	3.11E-03	9.91E-03	9.01E-03	1.98E-02	1.50E-03	3.542E+00	3.540E+02
α_3	1.15E-03	5.97E-03	5.07E-03	1.38E-02	3.01E-03	2.133E+00	3.555E+02
α_4	4.45E-04	4.03E-03	3.16E-03	1.06E-02	2.25E-03	1.443E+00	3.561E+02
α_5	6.37E-05	2.26E-03	1.42E-03	7.29E-03	7.52E-04	8.071E-01	3.568E+02
α_6	7.63E-07	1.06E-03	3.62E-04	4.49E-03	9.40E-05	3.793E-01	3.572E+02
α_7	4.55E-14	3.44E-04	6.18E-06	1.96E-03	0.00E+00	1.230E-01	3.575E+02
α_8	8.52E-43	9.26E-05	1.32E-12	3.91E-04	0.00E+00	3.312E-02	3.576E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.95E-01	9.90E-01	9.85E-01	9.88E-01	9.90E-01	9.91E-01	9.92E-01
α_2	4.99E-03	1.00E-02	1.51E-02	8.08E-03	4.50E-03	2.57E-03	1.50E-03
α_3		0.00E+00	0.00E+00	4.04E-03	4.50E-03	3.86E-03	3.01E-03
α_4			0.00E+00	0.00E+00	1.12E-03	1.93E-03	2.25E-03
α_5				0.00E+00	0.00E+00	3.22E-04	7.52E-04
α_6					0.00E+00	0.00E+00	9.40E-05
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.90E-01	9.85E-01	9.88E-01	9.90E-01	9.91E-01	9.92E-01
Beta	4.99E-03	1.00E-02	1.51E-02	1.21E-02	1.01E-02	8.69E-03	7.61E-03
Gamma		0.00E+00	0.00E+00	3.33E-01	5.56E-01	7.04E-01	8.02E-01
Delta			0.00E+00	0.00E+00	2.00E-01	3.68E-01	5.08E-01
Epsilon				0.00E+00	0.00E+00	1.43E-01	2.73E-01
Mu					0.00E+00	0.00E+00	1.11E-01
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	32.60	48.90	65.20	81.50	97.80	114.10	130.40
N_1	0.6667	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.1667	0.5000	1.0000	0.6667	0.4444	0.2963	0.1975
N_3		0.0000	0.0000	0.3333	0.4444	0.4444	0.3951
N_4			0.0000	0.0000	0.1111	0.2222	0.2963

N_5				0.0000	0.0000	0.0370	0.0988
N_6					0.0000	0.0000	0.0123
N_7						0.0000	0.0000
N_8							0.0000

2.13.1.4 480 CIRCUIT BREAKERS FAIL TO OPEN/CLOSE

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 92.5
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9184232	0.9787142	0.9902170	0.9999191	0.9954973	2.253E+01	4.901E-01
α_2	7.77E-05	2.13E-02	9.78E-03	8.16E-02	4.50E-03	4.901E-01	2.253E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9301425	0.9744311	0.9805526	0.9977747	0.9916249	4.784E+01	1.255E+00
α_2	1.00E-03	2.00E-02	1.39E-02	5.97E-02	8.04E-03	9.819E-01	4.811E+01
α_3	2.46E-07	5.57E-03	1.17E-03	2.62E-02	3.34E-04	2.734E-01	4.882E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9322965	0.9704597	0.9746808	0.9941890	0.9883201	7.034E+01	2.141E+00
α_2	2.43E-03	2.06E-02	1.64E-02	5.32E-02	1.07E-02	1.491E+00	7.099E+01
α_3	9.35E-06	5.88E-03	2.31E-03	2.39E-02	9.07E-04	4.265E-01	7.206E+01
α_4	1.37E-08	3.08E-03	4.24E-04	1.54E-02	2.47E-05	2.233E-01	7.226E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9413006	0.9694347	0.9718063	0.9894472	0.9855286	1.262E+02	3.980E+00
α_2	4.46E-03	1.92E-02	1.68E-02	4.22E-02	1.27E-02	2.503E+00	1.277E+02
α_3	4.36E-04	7.89E-03	5.56E-03	2.33E-02	1.65E-03	1.028E+00	1.292E+02
α_4	2.00E-06	2.90E-03	9.83E-04	1.23E-02	8.61E-05	3.770E-01	1.298E+02
α_5	4.80E-21	5.56E-04	3.17E-07	3.22E-03	2.64E-06	7.236E-02	1.301E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9434755	0.9689827	0.9709438	0.9877790	0.9832032	1.528E+02	4.891E+00
α_2	4.44E-03	1.75E-02	1.55E-02	3.73E-02	1.41E-02	2.753E+00	1.549E+02
α_3	6.46E-04	7.82E-03	5.86E-03	2.17E-02	2.51E-03	1.233E+00	1.565E+02
α_4	3.57E-05	3.80E-03	2.00E-03	1.37E-02	1.87E-04	5.990E-01	1.571E+02
α_5	6.04E-09	1.41E-03	1.92E-04	7.07E-03	1.16E-05	2.226E-01	1.575E+02
α_6	8.94E-19	5.28E-04	9.23E-07	3.08E-03	0.00E+00	8.324E-02	1.576E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9482570	0.9689241	0.9702560	0.9850347	0.9813024	2.257E+02	7.238E+00
α_2	5.22E-03	1.60E-02	1.46E-02	3.14E-02	1.49E-02	3.720E+00	2.292E+02
α_3	1.17E-03	7.63E-03	6.28E-03	1.87E-02	3.45E-03	1.777E+00	2.311E+02
α_4	2.23E-04	4.30E-03	3.00E-03	1.29E-02	3.25E-04	1.003E+00	2.319E+02
α_5	1.12E-05	2.25E-03	1.07E-03	8.48E-03	3.03E-05	5.231E-01	2.324E+02
α_6	2.90E-10	8.00E-04	6.83E-05	4.20E-03	1.50E-06	1.863E-01	2.327E+02
α_7	4.36E-48	1.25E-04	1.09E-13	4.70E-04	0.00E+00	2.907E-02	2.329E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9504415	0.9692649	0.9703966	0.9842217	0.9797918	2.661E+02	8.438E+00
α_2	5.18E-03	1.49E-02	1.37E-02	2.85E-02	1.52E-02	4.080E+00	2.705E+02
α_3	1.23E-03	7.12E-03	5.96E-03	1.69E-02	4.45E-03	1.953E+00	2.726E+02
α_4	3.15E-04	4.26E-03	3.14E-03	1.21E-02	4.93E-04	1.170E+00	2.734E+02
α_5	4.79E-05	2.59E-03	1.53E-03	8.76E-03	6.17E-05	7.113E-01	2.738E+02
α_6	7.60E-07	1.34E-03	4.38E-04	5.72E-03	4.60E-06	3.672E-01	2.742E+02
α_7	5.93E-14	4.48E-04	8.05E-06	2.55E-03	0.00E+00	1.230E-01	2.744E+02
α_8	1.11E-42	1.21E-04	1.72E-12	5.10E-04	0.00E+00	3.312E-02	2.745E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.95E-01	9.92E-01	9.88E-01	9.86E-01	9.83E-01	9.81E-01	9.80E-01
α_2	4.50E-03	8.04E-03	1.07E-02	1.27E-02	1.41E-02	1.49E-02	1.52E-02
α_3		3.34E-04	9.07E-04	1.65E-03	2.51E-03	3.45E-03	4.45E-03
α_4			2.47E-05	8.61E-05	1.87E-04	3.25E-04	4.93E-04
α_5				2.64E-06	1.16E-05	3.03E-05	6.17E-05
α_6					0.00E+00	1.50E-06	4.60E-06
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.92E-01	9.88E-01	9.86E-01	9.83E-01	9.81E-01	9.80E-01
Beta	4.50E-03	8.38E-03	1.17E-02	1.45E-02	1.68E-02	1.87E-02	2.02E-02
Gamma		3.99E-02	7.98E-02	1.20E-01	1.61E-01	2.03E-01	2.48E-01
Delta			2.65E-02	5.11E-02	7.34E-02	9.37E-02	1.12E-01
Epsilon				2.98E-02	5.82E-02	8.91E-02	1.19E-01
Mu					0.00E+00	4.71E-02	6.94E-02
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	11.56	17.34	23.13	28.91	34.69	40.47	46.25
N_1	0.7263	0.9412	1.0795	1.1551	1.1805	1.1667	1.1233
N_2	0.0556	0.1483	0.2632	0.3884	0.5141	0.6319	0.7351
N_3		0.0062	0.0222	0.0503	0.0915	0.1463	0.2150
N_4			0.0006	0.0026	0.0068	0.0138	0.0238

N_5				0.0001	0.0004	0.0013	0.0030
N_6					0.0000	0.0001	0.0002
N_7						0.0000	0.0000
N_8							0.0000

2.13.2 4160 vac and 6.9Kva Distribution Circuit Breakers

2.13.2.1 ACP 4160 AND 6.9 CIRCUIT BREAKERS FAIL TO OPEN

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 17.6
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8721817	0.9667783	0.9848563	0.9998950	0.9884442	1.388E+01	4.770E-01
α_2	1.07E-04	3.32E-02	1.51E-02	1.28E-01	1.16E-02	4.770E-01	1.388E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9068050	0.9659996	0.9741909	0.9971529	0.9767378	3.488E+01	1.228E+00
α_2	1.26E-03	2.66E-02	1.85E-02	7.97E-02	2.32E-02	9.602E-01	3.515E+01
α_3	2.64E-07	7.41E-03	1.50E-03	3.51E-02	5.91E-05	2.675E-01	3.584E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9123685	0.9618051	0.9672580	0.9925826	0.9648751	5.307E+01	2.108E+00
α_2	3.14E-03	2.68E-02	2.13E-02	6.93E-02	3.50E-02	1.479E+00	5.370E+01
α_3	8.46E-06	7.35E-03	2.74E-03	3.03E-02	1.74E-04	4.056E-01	5.477E+01
α_4	1.74E-08	4.04E-03	5.53E-04	2.02E-02	0.00E+00	2.227E-01	5.496E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9300551	0.9635571	0.9663744	0.9874334	0.9528498	1.046E+02	3.957E+00
α_2	5.48E-03	2.33E-02	2.04E-02	5.09E-02	4.68E-02	2.530E+00	1.060E+02
α_3	4.45E-04	9.03E-03	6.25E-03	2.71E-02	3.43E-04	9.804E-01	1.076E+02
α_4	2.27E-06	3.45E-03	1.16E-03	1.46E-02	0.00E+00	3.744E-01	1.082E+02
α_5	5.50E-21	6.66E-04	3.76E-07	3.85E-03	0.00E+00	7.228E-02	1.085E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9323470	0.9627799	0.9650994	0.9852761	0.9406443	1.268E+02	4.904E+00
α_2	5.73E-03	2.17E-02	1.93E-02	4.58E-02	5.88E-02	2.858E+00	1.289E+02
α_3	6.20E-04	8.71E-03	6.38E-03	2.48E-02	5.63E-04	1.148E+00	1.306E+02
α_4	4.02E-05	4.50E-03	2.36E-03	1.62E-02	1.22E-05	5.923E-01	1.312E+02
α_5	7.05E-09	1.69E-03	2.29E-04	8.45E-03	0.00E+00	2.222E-01	1.315E+02
α_6	1.07E-18	6.32E-04	1.11E-06	3.69E-03	0.00E+00	8.324E-02	1.317E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9401062	0.9638961	0.9654161	0.9825083	0.9282634	1.953E+02	7.316E+00
α_2	6.65E-03	1.95E-02	1.79E-02	3.76E-02	7.09E-02	3.948E+00	1.987E+02
α_3	1.10E-03	8.10E-03	6.55E-03	2.04E-02	8.30E-04	1.641E+00	2.010E+02
α_4	2.45E-04	4.88E-03	3.38E-03	1.46E-02	2.44E-05	9.892E-01	2.016E+02
α_5	1.27E-05	2.57E-03	1.22E-03	9.73E-03	0.00E+00	5.218E-01	2.021E+02
α_6	3.32E-10	9.19E-04	7.85E-05	4.83E-03	0.00E+00	1.863E-01	2.024E+02
α_7	5.02E-48	1.43E-04	1.26E-13	5.40E-04	0.00E+00	2.907E-02	2.026E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9424074	0.9640817	0.9653673	0.9813775	0.9156944	2.313E+02	8.617E+00
α_2	6.95E-03	1.87E-02	1.74E-02	3.50E-02	8.31E-02	4.484E+00	2.354E+02
α_3	1.10E-03	7.31E-03	6.00E-03	1.80E-02	1.14E-03	1.754E+00	2.381E+02
α_4	3.39E-04	4.78E-03	3.50E-03	1.36E-02	4.25E-05	1.147E+00	2.388E+02
α_5	5.37E-05	2.95E-03	1.74E-03	9.99E-03	0.00E+00	7.083E-01	2.392E+02
α_6	8.66E-07	1.53E-03	5.01E-04	6.54E-03	0.00E+00	3.670E-01	2.395E+02
α_7	6.79E-14	5.13E-04	9.22E-06	2.92E-03	0.00E+00	1.230E-01	2.398E+02
α_8	1.27E-42	1.38E-04	1.97E-12	5.84E-04	0.00E+00	3.312E-02	2.399E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.88E-01	9.77E-01	9.65E-01	9.53E-01	9.41E-01	9.28E-01	9.16E-01
α_2	1.16E-02	2.32E-02	3.50E-02	4.68E-02	5.88E-02	7.09E-02	8.31E-02
α_3		5.91E-05	1.74E-04	3.43E-04	5.63E-04	8.30E-04	1.14E-03
α_4			0.00E+00	0.00E+00	1.22E-05	2.44E-05	4.25E-05
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.77E-01	9.65E-01	9.53E-01	9.41E-01	9.28E-01	9.16E-01
Beta	1.16E-02	2.33E-02	3.51E-02	4.72E-02	5.94E-02	7.17E-02	8.43E-02
Gamma		2.54E-03	4.97E-03	7.28E-03	9.69E-03	1.19E-02	1.40E-02
Delta			0.00E+00	0.00E+00	2.12E-02	2.85E-02	3.59E-02
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	2.93	4.40	5.87	7.33	8.80	10.27	11.73
N_1	0.7025	0.9272	1.0688	1.1281	1.1061	1.0036	0.8214
N_2	0.0425	0.1266	0.2512	0.4157	0.6190	0.8606	1.1396
N_3		0.0003	0.0013	0.0030	0.0059	0.0101	0.0157

N_4			0.0000	0.0000	0.0001	0.0003	0.0006
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.13.2.2 ACP 4160 AND 6.9 CIRCUIT BREAKERS FAIL TO CLOSE

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 78.3
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9803198	0.9951167	0.9980488	0.9999921	1.0000000	8.855E+01	4.345E-01
α_2	8.69E-06	4.88E-03	1.95E-03	1.97E-02	0.00E+00	4.345E-01	8.855E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9708876	0.9898961	0.9926920	0.9993400	1.0000000	1.079E+02	1.101E+00
α_2	2.40E-04	7.65E-03	4.92E-03	2.44E-02	0.00E+00	8.337E-01	1.081E+02
α_3	8.53E-08	2.45E-03	4.91E-04	1.16E-02	0.00E+00	2.672E-01	1.087E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9645504	0.9853111	0.9877875	0.9976115	1.0000000	1.244E+02	1.855E+00
α_2	7.98E-04	9.72E-03	7.29E-03	2.70E-02	0.00E+00	1.228E+00	1.251E+02
α_3	3.59E-06	3.20E-03	1.18E-03	1.32E-02	0.00E+00	4.043E-01	1.259E+02
α_4	7.57E-09	1.76E-03	2.40E-04	8.83E-03	0.00E+00	2.227E-01	1.261E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9604624	0.9801221	0.9818909	0.9937356	1.0000000	1.745E+02	3.538E+00
α_2	2.28E-03	1.19E-02	1.01E-02	2.75E-02	0.00E+00	2.114E+00	1.759E+02
α_3	2.67E-04	5.49E-03	3.79E-03	1.65E-02	0.00E+00	9.774E-01	1.770E+02
α_4	1.38E-06	2.10E-03	7.07E-04	8.93E-03	0.00E+00	3.744E-01	1.776E+02
α_5	3.35E-21	4.06E-04	2.29E-07	2.35E-03	0.00E+00	7.228E-02	1.779E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9594562	0.9785551	0.9801328	0.9922617	1.0000000	1.952E+02	4.279E+00
α_2	2.30E-03	1.12E-02	9.64E-03	2.56E-02	0.00E+00	2.239E+00	1.973E+02
α_3	4.02E-04	5.72E-03	4.18E-03	1.63E-02	0.00E+00	1.142E+00	1.984E+02
α_4	2.65E-05	2.97E-03	1.55E-03	1.07E-02	0.00E+00	5.922E-01	1.989E+02
α_5	4.65E-09	1.11E-03	1.51E-04	5.58E-03	0.00E+00	2.222E-01	1.993E+02
α_6	7.06E-19	4.17E-04	7.29E-07	2.43E-03	0.00E+00	8.324E-02	1.994E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9589562	0.9760227	0.9771971	0.9890826	1.0000000	2.624E+02	6.445E+00

α_2	3.23E-03	1.15E-02	1.03E-02	2.38E-02	0.00E+00	3.088E+00	2.657E+02
α_3	8.17E-04	6.07E-03	4.90E-03	1.53E-02	0.00E+00	1.631E+00	2.672E+02
α_4	1.84E-04	3.68E-03	2.54E-03	1.10E-02	0.00E+00	9.889E-01	2.678E+02
α_5	9.54E-06	1.94E-03	9.18E-04	7.34E-03	0.00E+00	5.218E-01	2.683E+02
α_6	2.50E-10	6.93E-04	5.91E-05	3.64E-03	0.00E+00	1.863E-01	2.686E+02
α_7	3.78E-48	1.08E-04	9.46E-14	4.07E-04	0.00E+00	2.907E-02	2.688E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9593929	0.9754969	0.9765336	0.9880724	1.0000000	2.970E+02	7.461E+00
α_2	3.30E-03	1.10E-02	9.93E-03	2.23E-02	0.00E+00	3.345E+00	3.011E+02
α_3	8.44E-04	5.71E-03	4.67E-03	1.41E-02	0.00E+00	1.738E+00	3.028E+02
α_4	2.66E-04	3.77E-03	2.75E-03	1.07E-02	0.00E+00	1.147E+00	3.033E+02
α_5	4.23E-05	2.33E-03	1.37E-03	7.88E-03	0.00E+00	7.083E-01	3.038E+02
α_6	6.82E-07	1.21E-03	3.94E-04	5.16E-03	0.00E+00	3.670E-01	3.041E+02
α_7	5.35E-14	4.04E-04	7.26E-06	2.30E-03	0.00E+00	1.230E-01	3.044E+02
α_8	1.00E-42	1.09E-04	1.55E-12	4.60E-04	0.00E+00	3.312E-02	3.045E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	78.30	78.30	78.30	78.30	78.30	78.30	78.30
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.13.2.3 ACP 4160 AND 6.9 CIRCUIT BREAKERS SPURIOUS OP

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 44.5
Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8967425	0.9725308	0.9867773	0.9998750	0.9902225	1.815E+01	5.125E-01
α_2	1.28E-04	2.75E-02	1.32E-02	1.03E-01	9.78E-03	5.125E-01	1.815E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9162316	0.9686020	0.9756289	0.9969215	0.9802774	4.117E+01	1.335E+00
α_2	1.54E-03	2.51E-02	1.81E-02	7.26E-02	1.97E-02	1.067E+00	4.144E+01
α_3	2.22E-07	6.29E-03	1.27E-03	2.98E-02	1.27E-05	2.674E-01	4.224E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9186576	0.9635121	0.9682678	0.9920950	0.9701593	6.131E+01	2.322E+00
α_2	3.85E-03	2.66E-02	2.18E-02	6.58E-02	2.98E-02	1.694E+00	6.194E+01
α_3	7.23E-06	6.36E-03	2.36E-03	2.63E-02	3.66E-05	4.049E-01	6.323E+01
α_4	1.51E-08	3.50E-03	4.79E-04	1.75E-02	0.00E+00	2.227E-01	6.341E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9319652	0.9637549	0.9663233	0.9867545	0.9598624	1.147E+02	4.315E+00
α_2	6.48E-03	2.43E-02	2.17E-02	5.10E-02	4.01E-02	2.890E+00	1.162E+02
α_3	4.03E-04	8.22E-03	5.68E-03	2.47E-02	7.05E-05	9.787E-01	1.181E+02
α_4	2.07E-06	3.14E-03	1.06E-03	1.34E-02	0.00E+00	3.744E-01	1.187E+02
α_5	5.01E-21	6.07E-04	3.43E-07	3.51E-03	0.00E+00	7.228E-02	1.190E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9331084	0.9622588	0.9643773	0.9841605	0.9493767	1.388E+02	5.443E+00
α_2	7.22E-03	2.36E-02	2.14E-02	4.74E-02	5.05E-02	3.401E+00	1.408E+02
α_3	5.61E-04	7.94E-03	5.81E-03	2.26E-02	1.13E-04	1.144E+00	1.431E+02
α_4	3.67E-05	4.11E-03	2.15E-03	1.48E-02	4.15E-06	5.923E-01	1.436E+02
α_5	6.44E-09	1.54E-03	2.09E-04	7.72E-03	0.00E+00	2.222E-01	1.440E+02
α_6	9.77E-19	5.77E-04	1.01E-06	3.37E-03	0.00E+00	8.324E-02	1.441E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9419512	0.9646597	0.9660755	0.9825270	0.9538755	2.094E+02	7.673E+00
α_2	6.65E-03	1.89E-02	1.75E-02	3.62E-02	3.84E-02	4.111E+00	2.130E+02
α_3	1.35E-03	8.45E-03	7.00E-03	2.05E-02	7.67E-03	1.836E+00	2.153E+02
α_4	2.28E-04	4.56E-03	3.15E-03	1.37E-02	8.00E-06	9.891E-01	2.161E+02
α_5	1.18E-05	2.40E-03	1.14E-03	9.08E-03	0.00E+00	5.218E-01	2.166E+02
α_6	3.10E-10	8.58E-04	7.32E-05	4.50E-03	0.00E+00	1.863E-01	2.169E+02
α_7	4.68E-48	1.34E-04	1.17E-13	5.04E-04	0.00E+00	2.907E-02	2.171E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9453642	0.9658283	0.9670355	0.9821762	0.9569558	2.477E+02	8.763E+00
α_2	6.01E-03	1.67E-02	1.54E-02	3.16E-02	3.09E-02	4.280E+00	2.522E+02
α_3	1.50E-03	8.05E-03	6.81E-03	1.88E-02	1.08E-02	2.065E+00	2.544E+02
α_4	3.53E-04	4.63E-03	3.42E-03	1.30E-02	1.34E-03	1.187E+00	2.552E+02
α_5	5.03E-05	2.76E-03	1.62E-03	9.35E-03	0.00E+00	7.083E-01	2.557E+02
α_6	8.10E-07	1.43E-03	4.68E-04	6.12E-03	0.00E+00	3.670E-01	2.561E+02
α_7	6.35E-14	4.80E-04	8.62E-06	2.73E-03	0.00E+00	1.230E-01	2.563E+02
α_8	1.19E-42	1.29E-04	1.84E-12	5.46E-04	0.00E+00	3.312E-02	2.564E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.90E-01	9.80E-01	9.70E-01	9.60E-01	9.49E-01	9.54E-01	9.57E-01
α_2	9.78E-03	1.97E-02	2.98E-02	4.01E-02	5.05E-02	3.84E-02	3.09E-02
α_3		1.27E-05	3.66E-05	7.05E-05	1.13E-04	7.67E-03	1.08E-02
α_4			0.00E+00	0.00E+00	4.15E-06	8.00E-06	1.34E-03
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.80E-01	9.70E-01	9.60E-01	9.49E-01	9.54E-01	9.57E-01
Beta	9.78E-03	1.97E-02	2.98E-02	4.01E-02	5.06E-02	4.61E-02	4.30E-02
Gamma		6.42E-04	1.23E-03	1.76E-03	2.32E-03	1.67E-01	2.82E-01
Delta			0.00E+00	0.00E+00	3.54E-02	1.04E-03	1.10E-01
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	7.03	10.54	14.05	17.57	21.08	24.59	28.11
N_1	0.8732	1.0762	1.1241	1.0173	0.7561	0.8076	0.8387
N_2	0.0780	0.2335	0.4662	0.7757	1.1616	1.0236	0.9349
N_3		0.0001	0.0006	0.0014	0.0026	0.2043	0.3266
N_4			0.0000	0.0000	0.0001	0.0002	0.0404

N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.13.2.4 ACP 4160 AND 6.9 CIRCUIT BREAKERS FAIL TO OPEN/CLOSE

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 103.4
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9354433	0.9833550	0.9925849	0.9999447	0.9976357	2.818E+01	4.770E-01
α_2	5.21E-05	1.66E-02	7.42E-03	6.46E-02	2.36E-03	4.770E-01	2.818E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9411478	0.9786700	0.9839204	0.9982357	0.9952842	5.633E+01	1.228E+00
α_2	7.85E-04	1.67E-02	1.15E-02	5.03E-02	4.70E-03	9.602E-01	5.660E+01
α_3	1.64E-07	4.65E-03	9.37E-04	2.20E-02	1.20E-05	2.675E-01	5.729E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9419453	0.9748439	0.9785245	0.9951580	0.9929452	8.167E+01	2.108E+00
α_2	2.05E-03	1.77E-02	1.40E-02	4.58E-02	7.02E-03	1.479E+00	8.230E+01
α_3	5.55E-06	4.84E-03	1.80E-03	2.00E-02	3.50E-05	4.056E-01	8.337E+01
α_4	1.14E-08	2.66E-03	3.63E-04	1.33E-02	0.00E+00	2.227E-01	8.356E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9472154	0.9725839	0.9747418	0.9905858	0.9906184	1.404E+02	3.957E+00
α_2	4.11E-03	1.75E-02	1.54E-02	3.84E-02	9.31E-03	2.530E+00	1.418E+02
α_3	3.34E-04	6.79E-03	4.69E-03	2.04E-02	6.83E-05	9.804E-01	1.433E+02
α_4	1.70E-06	2.59E-03	8.73E-04	1.10E-02	0.00E+00	3.744E-01	1.440E+02
α_5	4.13E-21	5.01E-04	2.83E-07	2.90E-03	0.00E+00	7.228E-02	1.443E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9488109	0.9719224	0.9737082	0.9889343	0.9883011	1.697E+02	4.904E+00
α_2	4.31E-03	1.64E-02	1.46E-02	3.46E-02	1.16E-02	2.858E+00	1.718E+02
α_3	4.67E-04	6.57E-03	4.81E-03	1.87E-02	1.11E-04	1.148E+00	1.735E+02
α_4	3.03E-05	3.39E-03	1.77E-03	1.22E-02	2.40E-06	5.923E-01	1.741E+02
α_5	5.31E-09	1.27E-03	1.72E-04	6.37E-03	0.00E+00	2.222E-01	1.744E+02
α_6	8.07E-19	4.77E-04	8.33E-07	2.78E-03	0.00E+00	8.324E-02	1.746E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9518752	0.9710472	0.9722795	0.9860006	0.9859952	2.454E+02	7.316E+00
α_2	5.33E-03	1.56E-02	1.44E-02	3.02E-02	1.38E-02	3.948E+00	2.487E+02
α_3	8.83E-04	6.50E-03	5.25E-03	1.64E-02	1.62E-04	1.641E+00	2.510E+02
α_4	1.96E-04	3.91E-03	2.71E-03	1.17E-02	4.75E-06	9.892E-01	2.517E+02
α_5	1.01E-05	2.06E-03	9.77E-04	7.81E-03	0.00E+00	5.218E-01	2.522E+02
α_6	2.66E-10	7.37E-04	6.29E-05	3.87E-03	0.00E+00	1.863E-01	2.525E+02
α_7	4.02E-48	1.15E-04	1.01E-13	4.33E-04	0.00E+00	2.907E-02	2.527E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9534088	0.9709969	0.9720461	0.9849947	0.9836995	2.885E+02	8.617E+00
α_2	5.60E-03	1.51E-02	1.40E-02	2.83E-02	1.61E-02	4.484E+00	2.926E+02
α_3	8.84E-04	5.90E-03	4.84E-03	1.46E-02	2.21E-04	1.754E+00	2.953E+02
α_4	2.73E-04	3.86E-03	2.82E-03	1.10E-02	8.23E-06	1.147E+00	2.960E+02
α_5	4.34E-05	2.38E-03	1.40E-03	8.07E-03	0.00E+00	7.083E-01	2.964E+02
α_6	6.99E-07	1.24E-03	4.04E-04	5.28E-03	0.00E+00	3.670E-01	2.967E+02
α_7	5.48E-14	4.14E-04	7.44E-06	2.36E-03	0.00E+00	1.230E-01	2.970E+02
α_8	1.03E-42	1.11E-04	1.59E-12	4.71E-04	0.00E+00	3.312E-02	2.971E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.98E-01	9.95E-01	9.93E-01	9.91E-01	9.88E-01	9.86E-01	9.84E-01
α_2	2.36E-03	4.70E-03	7.02E-03	9.31E-03	1.16E-02	1.38E-02	1.61E-02
α_3		1.20E-05	3.50E-05	6.83E-05	1.11E-04	1.62E-04	2.21E-04
α_4			0.00E+00	0.00E+00	2.40E-06	4.75E-06	8.23E-06
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.98E-01	9.95E-01	9.93E-01	9.91E-01	9.88E-01	9.86E-01	9.84E-01
Beta	2.36E-03	4.72E-03	7.05E-03	9.38E-03	1.17E-02	1.40E-02	1.63E-02
Gamma		2.54E-03	4.97E-03	7.28E-03	9.69E-03	1.19E-02	1.40E-02
Delta			0.00E+00	0.00E+00	2.12E-02	2.85E-02	3.59E-02
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	17.23	25.85	34.47	43.08	51.70	60.32	68.93
N_1	0.7025	0.9272	1.0688	1.1281	1.1061	1.0036	0.8214
N_2	0.0425	0.1266	0.2512	0.4157	0.6190	0.8606	1.1396

N_3		0.0003	0.0013	0.0030	0.0059	0.0101	0.0157
N_4			0.0000	0.0000	0.0001	0.0003	0.0006
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.14 DC Power System - Batteries, Chargers, and Breakers

2.14.1 Batteries

2.14.1.1 DC POWER BATTERY NO OUTPUT SPAR: BAT-LP

Systems/Electrical/dc power
Components/Electrical/Battery
Failure Modes/Fail to Operate
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 32.1
Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9320570	0.9824860	0.9921960	0.9999424	0.9974760	2.671E+01	4.762E-01
α_2	5.43E-05	1.75E-02	7.80E-03	6.79E-02	2.52E-03	4.762E-01	2.671E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9388920	0.9778546	0.9833061	0.9981675	0.9949393	5.413E+01	1.226E+00
α_2	8.12E-04	1.73E-02	1.19E-02	5.22E-02	5.06E-03	9.587E-01	5.440E+01
α_3	1.69E-07	4.83E-03	9.71E-04	2.29E-02	0.00E+00	2.672E-01	5.509E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9399081	0.9739603	0.9777681	0.9949918	0.9923896	7.874E+01	2.105E+00
α_2	2.12E-03	1.83E-02	1.45E-02	4.74E-02	7.61E-03	1.478E+00	7.936E+01
α_3	5.62E-06	5.00E-03	1.85E-03	2.07E-02	0.00E+00	4.043E-01	8.044E+01
α_4	1.19E-08	2.75E-03	3.76E-04	1.38E-02	0.00E+00	2.227E-01	8.062E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9467065	0.9724792	0.9746919	0.9906931	0.9918658	1.368E+02	3.872E+00
α_2	3.80E-03	1.71E-02	1.49E-02	3.80E-02	7.12E-03	2.406E+00	1.383E+02
α_3	3.92E-04	7.24E-03	5.08E-03	2.15E-02	1.02E-03	1.019E+00	1.397E+02
α_4	1.75E-06	2.66E-03	8.95E-04	1.13E-02	0.00E+00	3.744E-01	1.403E+02
α_5	4.24E-21	5.14E-04	2.90E-07	2.97E-03	0.00E+00	7.228E-02	1.406E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9491584	0.9724103	0.9742426	0.9894033	0.9914416	1.656E+02	4.699E+00
α_2	3.58E-03	1.51E-02	1.32E-02	3.29E-02	6.72E-03	2.569E+00	1.677E+02
α_3	5.86E-04	7.19E-03	5.38E-03	2.00E-02	1.70E-03	1.225E+00	1.691E+02
α_4	3.31E-05	3.52E-03	1.86E-03	1.26E-02	1.41E-04	5.992E-01	1.697E+02
α_5	5.45E-09	1.30E-03	1.77E-04	6.54E-03	0.00E+00	2.222E-01	1.701E+02

α_6	8.27E-19	4.89E-04	8.54E-07	2.85E-03	0.00E+00	8.324E-02	1.702E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9528109	0.9719322	0.9731907	0.9867446	0.9911355	2.407E+02	6.952E+00
α_2	4.29E-03	1.39E-02	1.26E-02	2.80E-02	6.32E-03	3.449E+00	2.442E+02
α_3	1.06E-03	7.09E-03	5.81E-03	1.75E-02	2.18E-03	1.756E+00	2.459E+02
α_4	2.14E-04	4.07E-03	2.84E-03	1.21E-02	3.44E-04	1.009E+00	2.467E+02
α_5	1.05E-05	2.11E-03	1.00E-03	7.97E-03	2.02E-05	5.229E-01	2.472E+02
α_6	2.71E-10	7.52E-04	6.42E-05	3.95E-03	0.00E+00	1.863E-01	2.475E+02
α_7	4.10E-48	1.17E-04	1.03E-13	4.42E-04	0.00E+00	2.907E-02	2.477E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9549810	0.9723729	0.9734443	0.9860925	0.9909406	2.834E+02	8.052E+00
α_2	4.18E-03	1.28E-02	1.17E-02	2.52E-02	5.91E-03	3.731E+00	2.877E+02
α_3	1.09E-03	6.53E-03	5.44E-03	1.57E-02	2.51E-03	1.902E+00	2.896E+02
α_4	3.07E-04	4.06E-03	3.00E-03	1.14E-02	5.69E-04	1.184E+00	2.903E+02
α_5	4.54E-05	2.44E-03	1.44E-03	8.26E-03	6.50E-05	7.126E-01	2.908E+02
α_6	7.15E-07	1.26E-03	4.12E-04	5.39E-03	2.96E-06	3.672E-01	2.911E+02
α_7	5.58E-14	4.22E-04	7.58E-06	2.40E-03	0.00E+00	1.230E-01	2.913E+02
α_8	1.05E-42	1.14E-04	1.62E-12	4.80E-04	0.00E+00	3.312E-02	2.914E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.97E-01	9.95E-01	9.92E-01	9.92E-01	9.91E-01	9.91E-01	9.91E-01
α_2	2.52E-03	5.06E-03	7.61E-03	7.12E-03	6.72E-03	6.32E-03	5.91E-03
α_3		0.00E+00	0.00E+00	1.02E-03	1.70E-03	2.18E-03	2.51E-03
α_4			0.00E+00	0.00E+00	1.41E-04	3.44E-04	5.69E-04
α_5				0.00E+00	0.00E+00	2.02E-05	6.50E-05
α_6					0.00E+00	0.00E+00	2.96E-06
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.97E-01	9.95E-01	9.92E-01	9.92E-01	9.91E-01	9.91E-01	9.91E-01
Beta	2.52E-03	5.06E-03	7.61E-03	8.13E-03	8.56E-03	8.86E-03	9.06E-03
Gamma		0.00E+00	0.00E+00	1.25E-01	2.15E-01	2.87E-01	3.48E-01
Delta			0.00E+00	0.00E+00	7.69E-02	1.43E-01	2.02E-01
Epsilon				0.00E+00	0.00E+00	5.56E-02	1.07E-01
Mu					0.00E+00	0.00E+00	4.35E-02
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	16.05	24.07	32.10	40.12	48.15	56.17	64.20
N_1	0.4167	0.5000	0.5000	0.5208	0.5208	0.5064	0.4823

DC POWER BATTERY NO OUTPUT SPAR: BAT-LP

N_2	0.0417	0.1250	0.2500	0.2917	0.3299	0.3617	0.3858
N_3		0.0000	0.0000	0.0417	0.0833	0.1244	0.1640
N_4			0.0000	0.0000	0.0069	0.0197	0.0371
N_5				0.0000	0.0000	0.0012	0.0042
N_6					0.0000	0.0000	0.0002
N_7						0.0000	0.0000
N_8							0.0000

2.14.2 Battery Chargers

2.14.2.1 DC POWER BATTERY CHARGER LOSS OF FUNCTION SPAR: BCH-LP

Systems/Electrical/dc power
Components/Electrical/Battery Charger
Failure Modes/Fail to Operate
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 319.0
Total Number of Common-Cause Failure Events: 9

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9718184	0.9873090	0.9889577	0.9971535	0.9889600	1.893E+02	2.434E+00
α_2	2.85E-03	1.27E-02	1.10E-02	2.82E-02	1.10E-02	2.434E+00	1.893E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9716052	0.9847468	0.9858071	0.9942642	0.9870932	2.960E+02	4.584E+00
α_2	3.74E-03	1.18E-02	1.08E-02	2.36E-02	1.01E-02	3.560E+00	2.970E+02
α_3	1.86E-04	3.41E-03	2.39E-03	1.01E-02	2.81E-03	1.024E+00	2.995E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736947	0.9848216	0.9856077	0.9932572	0.9879651	4.002E+02	6.168E+00
α_2	2.87E-03	8.95E-03	8.16E-03	1.77E-02	6.72E-03	3.638E+00	4.028E+02
α_3	8.11E-04	4.76E-03	3.97E-03	1.14E-02	4.26E-03	1.933E+00	4.045E+02
α_4	1.36E-05	1.47E-03	7.73E-04	5.30E-03	1.05E-03	5.977E-01	4.058E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749546	0.9845226	0.9851074	0.9920802	0.9889882	5.380E+02	8.458E+00
α_2	2.75E-03	7.74E-03	7.14E-03	1.47E-02	4.73E-03	4.228E+00	5.423E+02
α_3	1.19E-03	4.87E-03	4.28E-03	1.06E-02	3.76E-03	2.659E+00	5.438E+02
α_4	2.23E-04	2.40E-03	1.83E-03	6.54E-03	2.10E-03	1.312E+00	5.452E+02
α_5	1.22E-08	4.75E-04	8.97E-05	2.27E-03	4.20E-04	2.598E-01	5.462E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9766611	0.9851669	0.9856545	0.9919990	0.9898031	6.465E+02	9.734E+00
α_2	2.27E-03	6.41E-03	5.92E-03	1.22E-02	3.68E-03	4.207E+00	6.521E+02
α_3	1.04E-03	4.16E-03	3.67E-03	8.96E-03	2.97E-03	2.729E+00	6.535E+02
α_4	4.45E-04	2.80E-03	2.31E-03	6.81E-03	2.32E-03	1.836E+00	6.544E+02
α_5	3.08E-05	1.20E-03	7.43E-04	3.90E-03	1.05E-03	7.847E-01	6.555E+02

α_6	4.36E-11	2.70E-04	1.97E-05	1.43E-03	1.75E-04	1.770E-01	6.561E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9771820	0.9848380	0.9852306	0.9911390	0.9905448	8.014E+02	1.234E+01
α_2	2.40E-03	6.10E-03	5.70E-03	1.12E-02	3.01E-03	4.966E+00	8.088E+02
α_3	1.04E-03	3.75E-03	3.35E-03	7.82E-03	2.28E-03	3.051E+00	8.107E+02
α_4	6.00E-04	2.84E-03	2.45E-03	6.43E-03	2.12E-03	2.312E+00	8.114E+02
α_5	1.86E-04	1.74E-03	1.36E-03	4.62E-03	1.44E-03	1.418E+00	8.123E+02
α_6	2.88E-06	6.32E-04	2.95E-04	2.40E-03	5.26E-04	5.144E-01	8.132E+02
α_7	5.42E-21	9.33E-05	7.97E-08	5.41E-04	7.52E-05	7.595E-02	8.137E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783364	0.9853241	0.9856649	0.9911394	0.9911458	9.238E+02	1.376E+01
α_2	2.25E-03	5.56E-03	5.22E-03	1.01E-02	2.63E-03	5.217E+00	9.323E+02
α_3	8.73E-04	3.20E-03	2.85E-03	6.70E-03	1.77E-03	2.999E+00	9.346E+02
α_4	5.65E-04	2.56E-03	2.22E-03	5.74E-03	1.77E-03	2.405E+00	9.352E+02
α_5	2.95E-04	1.91E-03	1.57E-03	4.70E-03	1.53E-03	1.794E+00	9.358E+02
α_6	5.06E-05	1.04E-03	7.17E-04	3.15E-03	8.58E-04	9.776E-01	9.366E+02
α_7	4.83E-08	3.31E-04	8.53E-05	1.50E-03	2.64E-04	3.105E-01	9.373E+02
α_8	6.24E-27	6.03E-05	2.99E-09	3.33E-04	3.29E-05	5.656E-02	9.375E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.89E-01	9.87E-01	9.88E-01	9.89E-01	9.90E-01	9.91E-01	9.91E-01
α_2	1.10E-02	1.01E-02	6.72E-03	4.73E-03	3.68E-03	3.01E-03	2.63E-03
α_3		2.81E-03	4.26E-03	3.76E-03	2.97E-03	2.28E-03	1.77E-03
α_4			1.05E-03	2.10E-03	2.32E-03	2.12E-03	1.77E-03
α_5				4.20E-04	1.05E-03	1.44E-03	1.53E-03
α_6					1.75E-04	5.26E-04	8.58E-04
α_7						7.52E-05	2.64E-04
α_8							3.29E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.87E-01	9.88E-01	9.89E-01	9.90E-01	9.91E-01	9.91E-01
Beta	1.10E-02	1.29E-02	1.20E-02	1.10E-02	1.02E-02	9.46E-03	8.85E-03
Gamma		2.17E-01	4.41E-01	5.70E-01	6.39E-01	6.81E-01	7.03E-01
Delta			1.97E-01	4.01E-01	5.45E-01	6.46E-01	7.15E-01
Epsilon				1.67E-01	3.45E-01	4.90E-01	6.03E-01
Mu					1.43E-01	2.95E-01	4.31E-01
Omega						1.25E-01	2.57E-01
Sigma							1.11E-01

DC POWER BATTERY CHARGER LOSS OF FUNCTION SPAR: BCH-LP

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	174.00	261.00	348.00	435.00	522.00	609.00	696.00
N_1	5.0850	5.4013	6.0949	6.8606	7.5896	8.3446	9.0729
N_2	1.9992	2.7263	2.4102	2.1133	1.9681	1.8786	1.8727
N_3		0.7571	1.5282	1.6814	1.5876	1.4197	1.2604
N_4			0.3750	0.9376	1.2438	1.3234	1.2582
N_5				0.1875	0.5625	0.8961	1.0858
N_6					0.0938	0.3281	0.6106
N_7						0.0469	0.1875
N_8							0.0234

2.14.3DC Power Distribution Circuit Breakers

2.14.3.1 DC POWER BREAKER FAIL TO OPEN

Systems/Electrical/dc power
Components/Electrical/Circuit Breaker/250V DC Breaker
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 1.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8581893	0.9643266	0.9850586	0.9999348	1.0000000	1.175E+01	4.345E-01
α_2	6.69E-05	3.57E-02	1.49E-02	1.42E-01	0.00E+00	4.345E-01	1.175E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9025784	0.9657643	0.9748883	0.9977197	1.0000000	3.106E+01	1.101E+00
α_2	8.29E-04	2.59E-02	1.69E-02	8.18E-02	0.00E+00	8.337E-01	3.132E+01
α_3	2.93E-07	8.31E-03	1.69E-03	3.94E-02	0.00E+00	2.672E-01	3.189E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9104794	0.9625169	0.9685784	0.9938042	1.0000000	4.764E+01	1.855E+00
α_2	2.06E-03	2.48E-02	1.87E-02	6.83E-02	0.00E+00	1.228E+00	4.826E+01
α_3	9.23E-06	8.17E-03	3.04E-03	3.37E-02	0.00E+00	4.043E-01	4.909E+01
α_4	1.95E-08	4.50E-03	6.18E-04	2.25E-02	0.00E+00	2.227E-01	4.927E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9308381	0.9650368	0.9680622	0.9888921	1.0000000	9.766E+01	3.538E+00
α_2	4.03E-03	2.09E-02	1.78E-02	4.83E-02	0.00E+00	2.114E+00	9.909E+01
α_3	4.72E-04	9.66E-03	6.68E-03	2.90E-02	0.00E+00	9.774E-01	1.002E+02
α_4	2.43E-06	3.70E-03	1.25E-03	1.57E-02	0.00E+00	3.744E-01	1.008E+02
α_5	5.90E-21	7.14E-04	4.04E-07	4.14E-03	0.00E+00	7.228E-02	1.011E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9343810	0.9651344	0.9676322	0.9873369	1.0000000	1.184E+02	4.279E+00
α_2	3.75E-03	1.82E-02	1.57E-02	4.15E-02	0.00E+00	2.239E+00	1.205E+02
α_3	6.56E-04	9.30E-03	6.81E-03	2.65E-02	0.00E+00	1.142E+00	1.216E+02
α_4	4.32E-05	4.83E-03	2.53E-03	1.74E-02	0.00E+00	5.922E-01	1.221E+02
α_5	7.57E-09	1.81E-03	2.46E-04	9.07E-03	0.00E+00	2.222E-01	1.225E+02
α_6	1.15E-18	6.78E-04	1.19E-06	3.96E-03	0.00E+00	8.324E-02	1.226E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9426994	0.9664315	0.9680419	0.9846647	1.0000000	1.856E+02	6.445E+00
α_2	4.53E-03	1.61E-02	1.44E-02	3.33E-02	0.00E+00	3.088E+00	1.889E+02
α_3	1.15E-03	8.50E-03	6.86E-03	2.14E-02	0.00E+00	1.631E+00	1.904E+02
α_4	2.58E-04	5.15E-03	3.57E-03	1.55E-02	0.00E+00	9.889E-01	1.910E+02
α_5	1.34E-05	2.72E-03	1.29E-03	1.03E-02	0.00E+00	5.218E-01	1.915E+02
α_6	3.50E-10	9.70E-04	8.29E-05	5.09E-03	0.00E+00	1.863E-01	1.918E+02
α_7	5.30E-48	1.51E-04	1.33E-13	5.70E-04	0.00E+00	2.907E-02	1.920E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9458181	0.9672320	0.9685945	0.9840055	1.0000000	2.202E+02	7.461E+00
α_2	4.42E-03	1.47E-02	1.33E-02	2.97E-02	0.00E+00	3.345E+00	2.243E+02
α_3	1.13E-03	7.63E-03	6.25E-03	1.89E-02	0.00E+00	1.738E+00	2.260E+02
α_4	3.57E-04	5.04E-03	3.68E-03	1.43E-02	0.00E+00	1.147E+00	2.265E+02
α_5	5.66E-05	3.11E-03	1.83E-03	1.05E-02	0.00E+00	7.083E-01	2.270E+02
α_6	9.12E-07	1.61E-03	5.28E-04	6.89E-03	0.00E+00	3.670E-01	2.273E+02
α_7	7.15E-14	5.40E-04	9.71E-06	3.07E-03	0.00E+00	1.230E-01	2.276E+02
α_8	1.34E-42	1.45E-04	2.07E-12	6.15E-04	0.00E+00	3.312E-02	2.277E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	1.50	1.50	1.50	1.50	1.50	1.50	1.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.14.3.2 DC POWER BREAKER FAIL TO CLOSE

Systems/Electrical/dc power
Components/Electrical/Circuit Breaker
Failure Modes/Fail to Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 13.0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9264696	0.9816507	0.9925138	0.9999636	1.0000000	2.325E+01	4.345E-01
α_2	3.34E-05	1.83E-02	7.49E-03	7.35E-02	0.00E+00	4.345E-01	2.325E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9278986	0.9747828	0.9816046	0.9983333	1.0000000	4.256E+01	1.101E+00
α_2	6.06E-04	1.91E-02	1.24E-02	6.04E-02	0.00E+00	8.337E-01	4.282E+01
α_3	2.15E-07	6.12E-03	1.24E-03	2.90E-02	0.00E+00	2.672E-01	4.339E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9271178	0.9695844	0.9745677	0.9949934	1.0000000	5.914E+01	1.855E+00
α_2	1.67E-03	2.01E-02	1.52E-02	5.56E-02	0.00E+00	1.228E+00	5.976E+01
α_3	7.47E-06	6.63E-03	2.46E-03	2.74E-02	0.00E+00	4.043E-01	6.059E+01
α_4	1.58E-08	3.65E-03	5.00E-04	1.83E-02	0.00E+00	2.227E-01	6.077E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9378126	0.9686045	0.9713360	0.9900432	1.0000000	1.092E+02	3.538E+00
α_2	3.61E-03	1.88E-02	1.60E-02	4.34E-02	0.00E+00	2.114E+00	1.106E+02
α_3	4.23E-04	8.67E-03	5.99E-03	2.61E-02	0.00E+00	9.774E-01	1.117E+02
α_4	2.18E-06	3.32E-03	1.12E-03	1.41E-02	0.00E+00	3.744E-01	1.123E+02
α_5	5.29E-21	6.41E-04	3.63E-07	3.71E-03	0.00E+00	7.228E-02	1.126E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9399414	0.9681217	0.9704192	0.9884373	1.0000000	1.299E+02	4.279E+00
α_2	3.43E-03	1.67E-02	1.43E-02	3.79E-02	0.00E+00	2.239E+00	1.320E+02
α_3	5.99E-04	8.51E-03	6.22E-03	2.42E-02	0.00E+00	1.142E+00	1.331E+02
α_4	3.95E-05	4.41E-03	2.31E-03	1.59E-02	0.00E+00	5.922E-01	1.336E+02
α_5	6.92E-09	1.66E-03	2.24E-04	8.29E-03	0.00E+00	2.222E-01	1.340E+02
α_6	1.05E-18	6.20E-04	1.08E-06	3.62E-03	0.00E+00	8.324E-02	1.341E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9459113	0.9683285	0.9698502	0.9855412	1.0000000	1.971E+02	6.445E+00
α_2	4.27E-03	1.52E-02	1.36E-02	3.14E-02	0.00E+00	3.088E+00	2.004E+02
α_3	1.08E-03	8.02E-03	6.47E-03	2.02E-02	0.00E+00	1.631E+00	2.019E+02
α_4	2.44E-04	4.86E-03	3.36E-03	1.46E-02	0.00E+00	9.889E-01	2.025E+02
α_5	1.26E-05	2.56E-03	1.21E-03	9.69E-03	0.00E+00	5.218E-01	2.030E+02
α_6	3.30E-10	9.15E-04	7.82E-05	4.80E-03	0.00E+00	1.863E-01	2.033E+02
α_7	5.00E-48	1.43E-04	1.25E-13	5.38E-04	0.00E+00	2.907E-02	2.035E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483959	0.9688074	0.9701044	0.9847820	1.0000000	2.317E+02	7.461E+00
α_2	4.21E-03	1.40E-02	1.27E-02	2.83E-02	0.00E+00	3.345E+00	2.358E+02
α_3	1.08E-03	7.27E-03	5.95E-03	1.80E-02	0.00E+00	1.738E+00	2.375E+02
α_4	3.39E-04	4.79E-03	3.50E-03	1.37E-02	0.00E+00	1.147E+00	2.380E+02
α_5	5.39E-05	2.96E-03	1.74E-03	1.00E-02	0.00E+00	7.083E-01	2.385E+02
α_6	8.68E-07	1.53E-03	5.02E-04	6.56E-03	0.00E+00	3.670E-01	2.388E+02
α_7	6.81E-14	5.14E-04	9.25E-06	2.93E-03	0.00E+00	1.230E-01	2.391E+02
α_8	1.28E-42	1.38E-04	1.97E-12	5.85E-04	0.00E+00	3.312E-02	2.392E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	13.00	13.00	13.00	13.00	13.00	13.00	13.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.14.3.3 DC POWER BREAKER SPURIOUS ACTUATION

Systems/Electrical/dc power
Components/Electrical/Circuit Breaker
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9098504	0.9774633	0.9907420	0.9999552	1.0000000	1.885E+01	4.345E-01
α_2	4.13E-05	2.25E-02	9.26E-03	9.01E-02	0.00E+00	4.345E-01	1.885E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9199363	0.9719563	0.9795076	0.9981476	1.0000000	3.816E+01	1.101E+00
α_2	6.76E-04	2.12E-02	1.38E-02	6.71E-02	0.00E+00	8.337E-01	3.842E+01
α_3	2.39E-07	6.81E-03	1.38E-03	3.23E-02	0.00E+00	2.672E-01	3.899E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9215384	0.9672196	0.9725618	0.9946002	1.0000000	5.474E+01	1.855E+00
α_2	1.80E-03	2.17E-02	1.64E-02	5.99E-02	0.00E+00	1.228E+00	5.536E+01
α_3	8.06E-06	7.14E-03	2.65E-03	2.95E-02	0.00E+00	4.043E-01	5.619E+01
α_4	1.70E-08	3.93E-03	5.39E-04	1.97E-02	0.00E+00	2.227E-01	5.637E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9353168	0.9673290	0.9701651	0.9896321	1.0000000	1.048E+02	3.538E+00
α_2	3.76E-03	1.95E-02	1.66E-02	4.51E-02	0.00E+00	2.114E+00	1.062E+02
α_3	4.41E-04	9.02E-03	6.24E-03	2.71E-02	0.00E+00	9.774E-01	1.073E+02
α_4	2.27E-06	3.46E-03	1.16E-03	1.47E-02	0.00E+00	3.744E-01	1.079E+02
α_5	5.51E-21	6.67E-04	3.77E-07	3.86E-03	0.00E+00	7.228E-02	1.082E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379289	0.9670413	0.9694122	0.9880396	1.0000000	1.255E+02	4.279E+00
α_2	3.55E-03	1.72E-02	1.48E-02	3.92E-02	0.00E+00	2.239E+00	1.276E+02
α_3	6.19E-04	8.80E-03	6.43E-03	2.50E-02	0.00E+00	1.142E+00	1.287E+02
α_4	4.08E-05	4.56E-03	2.39E-03	1.65E-02	0.00E+00	5.922E-01	1.292E+02
α_5	7.16E-09	1.71E-03	2.32E-04	8.58E-03	0.00E+00	2.222E-01	1.296E+02
α_6	1.09E-18	6.41E-04	1.12E-06	3.74E-03	0.00E+00	8.324E-02	1.297E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9447269	0.9676286	0.9691868	0.9852219	1.0000000	1.927E+02	6.445E+00
α_2	4.37E-03	1.55E-02	1.39E-02	3.21E-02	0.00E+00	3.088E+00	1.960E+02
α_3	1.10E-03	8.19E-03	6.62E-03	2.07E-02	0.00E+00	1.631E+00	1.975E+02
α_4	2.49E-04	4.97E-03	3.44E-03	1.49E-02	0.00E+00	9.889E-01	1.981E+02
α_5	1.29E-05	2.62E-03	1.24E-03	9.90E-03	0.00E+00	5.218E-01	1.986E+02
α_6	3.38E-10	9.36E-04	7.99E-05	4.91E-03	0.00E+00	1.863E-01	1.989E+02
α_7	5.11E-48	1.46E-04	1.28E-13	5.50E-04	0.00E+00	2.907E-02	1.991E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474421	0.9682229	0.9695428	0.9844940	1.0000000	2.273E+02	7.461E+00
α_2	4.29E-03	1.42E-02	1.29E-02	2.88E-02	0.00E+00	3.345E+00	2.314E+02
α_3	1.10E-03	7.40E-03	6.06E-03	1.83E-02	0.00E+00	1.738E+00	2.331E+02
α_4	3.46E-04	4.88E-03	3.57E-03	1.39E-02	0.00E+00	1.147E+00	2.336E+02
α_5	5.49E-05	3.02E-03	1.77E-03	1.02E-02	0.00E+00	7.083E-01	2.341E+02
α_6	8.85E-07	1.56E-03	5.12E-04	6.69E-03	0.00E+00	3.670E-01	2.344E+02
α_7	6.94E-14	5.24E-04	9.42E-06	2.98E-03	0.00E+00	1.230E-01	2.347E+02
α_8	1.30E-42	1.41E-04	2.01E-12	5.96E-04	0.00E+00	3.312E-02	2.348E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	8.60	8.60	8.60	8.60	8.60	8.60	8.60
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.14.3.4 DC POWER BREAKER FAIL TO OPEN/CLOSE

Systems/Electrical/dc power
Components/Electrical/Circuit Breaker/250V DC Breaker
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 14.5
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9308132	0.9827438	0.9929710	0.9999658	1.0000000	2.475E+01	4.345E-01
α_2	3.14E-05	1.73E-02	7.03E-03	6.92E-02	0.00E+00	4.345E-01	2.475E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9302590	0.9756205	0.9822246	0.9983905	1.0000000	4.406E+01	1.101E+00
α_2	5.86E-04	1.85E-02	1.20E-02	5.85E-02	0.00E+00	8.337E-01	4.432E+01
α_3	2.07E-07	5.92E-03	1.19E-03	2.81E-02	0.00E+00	2.672E-01	4.489E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9288473	0.9703145	0.9751848	0.9951160	1.0000000	6.064E+01	1.855E+00
α_2	1.63E-03	1.97E-02	1.48E-02	5.43E-02	0.00E+00	1.228E+00	6.126E+01
α_3	7.29E-06	6.47E-03	2.40E-03	2.67E-02	0.00E+00	4.043E-01	6.209E+01
α_4	1.54E-08	3.56E-03	4.88E-04	1.78E-02	0.00E+00	2.227E-01	6.227E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9386200	0.9690169	0.9717145	0.9901760	1.0000000	1.107E+02	3.538E+00
α_2	3.56E-03	1.85E-02	1.58E-02	4.28E-02	0.00E+00	2.114E+00	1.121E+02
α_3	4.18E-04	8.56E-03	5.91E-03	2.57E-02	0.00E+00	9.774E-01	1.132E+02
α_4	2.15E-06	3.28E-03	1.10E-03	1.39E-02	0.00E+00	3.744E-01	1.138E+02
α_5	5.22E-21	6.33E-04	3.58E-07	3.66E-03	0.00E+00	7.228E-02	1.141E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9405980	0.9684741	0.9707476	0.9885669	1.0000000	1.314E+02	4.279E+00
α_2	3.39E-03	1.65E-02	1.42E-02	3.75E-02	0.00E+00	2.239E+00	1.335E+02
α_3	5.92E-04	8.41E-03	6.15E-03	2.40E-02	0.00E+00	1.142E+00	1.346E+02
α_4	3.90E-05	4.36E-03	2.29E-03	1.57E-02	0.00E+00	5.922E-01	1.351E+02
α_5	6.84E-09	1.64E-03	2.22E-04	8.20E-03	0.00E+00	2.222E-01	1.355E+02
α_6	1.04E-18	6.13E-04	1.07E-06	3.58E-03	0.00E+00	8.324E-02	1.356E+02

CCCG = 7

DC POWER BREAKER FAIL TO OPEN/CLOSE

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9463035	0.9685603	0.9700714	0.9856529	1.0000000	1.986E+02	6.445E+00
α_2	4.24E-03	1.51E-02	1.35E-02	3.12E-02	0.00E+00	3.088E+00	2.019E+02
α_3	1.07E-03	7.96E-03	6.42E-03	2.01E-02	0.00E+00	1.631E+00	2.034E+02
α_4	2.42E-04	4.82E-03	3.34E-03	1.45E-02	0.00E+00	9.889E-01	2.040E+02
α_5	1.25E-05	2.55E-03	1.21E-03	9.62E-03	0.00E+00	5.218E-01	2.045E+02
α_6	3.28E-10	9.09E-04	7.76E-05	4.77E-03	0.00E+00	1.863E-01	2.048E+02
α_7	4.96E-48	1.42E-04	1.24E-13	5.34E-04	0.00E+00	2.907E-02	2.050E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9487149	0.9690018	0.9702911	0.9848777	1.0000000	2.332E+02	7.461E+00
α_2	4.18E-03	1.39E-02	1.26E-02	2.81E-02	0.00E+00	3.345E+00	2.373E+02
α_3	1.07E-03	7.22E-03	5.91E-03	1.79E-02	0.00E+00	1.738E+00	2.390E+02
α_4	3.37E-04	4.76E-03	3.48E-03	1.36E-02	0.00E+00	1.147E+00	2.395E+02
α_5	5.36E-05	2.94E-03	1.73E-03	9.96E-03	0.00E+00	7.083E-01	2.400E+02
α_6	8.63E-07	1.52E-03	4.99E-04	6.52E-03	0.00E+00	3.670E-01	2.403E+02
α_7	6.77E-14	5.11E-04	9.19E-06	2.91E-03	0.00E+00	1.230E-01	2.406E+02
α_8	1.27E-42	1.38E-04	1.96E-12	5.82E-04	0.00E+00	3.312E-02	2.407E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. IEs	14.50	14.50	14.50	14.50	14.50	14.50	14.50
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.15 Reactor Trip Breakers

2.15.1 Reactor Protection System Reactor Trip Breakers

2.15.1.1 REACTOR TRIP BREAKERS FAIL TO OPEN

Systems/Electrical/Reactor protection
Components/Electrical/Circuit Breaker/Reactor Trip Breaker
Failure Modes/Fail to Open
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 8.6
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9098504	0.9774633	0.9907420	0.9999552	1.0000000	1.885E+01	4.345E-01
α_2	4.13E-05	2.25E-02	9.26E-03	9.01E-02	0.00E+00	4.345E-01	1.885E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9199363	0.9719563	0.9795076	0.9981476	1.0000000	3.816E+01	1.101E+00
α_2	6.76E-04	2.12E-02	1.38E-02	6.71E-02	0.00E+00	8.337E-01	3.842E+01
α_3	2.39E-07	6.81E-03	1.38E-03	3.23E-02	0.00E+00	2.672E-01	3.899E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9215384	0.9672196	0.9725618	0.9946002	1.0000000	5.474E+01	1.855E+00
α_2	1.80E-03	2.17E-02	1.64E-02	5.99E-02	0.00E+00	1.228E+00	5.536E+01
α_3	8.06E-06	7.14E-03	2.65E-03	2.95E-02	0.00E+00	4.043E-01	5.619E+01
α_4	1.70E-08	3.93E-03	5.39E-04	1.97E-02	0.00E+00	2.227E-01	5.637E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9353168	0.9673290	0.9701651	0.9896321	1.0000000	1.048E+02	3.538E+00
α_2	3.76E-03	1.95E-02	1.66E-02	4.51E-02	0.00E+00	2.114E+00	1.062E+02
α_3	4.41E-04	9.02E-03	6.24E-03	2.71E-02	0.00E+00	9.774E-01	1.073E+02
α_4	2.27E-06	3.46E-03	1.16E-03	1.47E-02	0.00E+00	3.744E-01	1.079E+02
α_5	5.51E-21	6.67E-04	3.77E-07	3.86E-03	0.00E+00	7.228E-02	1.082E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9379289	0.9670413	0.9694122	0.9880396	1.0000000	1.255E+02	4.279E+00
α_2	3.55E-03	1.72E-02	1.48E-02	3.92E-02	0.00E+00	2.239E+00	1.276E+02
α_3	6.19E-04	8.80E-03	6.43E-03	2.50E-02	0.00E+00	1.142E+00	1.287E+02
α_4	4.08E-05	4.56E-03	2.39E-03	1.65E-02	0.00E+00	5.922E-01	1.292E+02
α_5	7.16E-09	1.71E-03	2.32E-04	8.58E-03	0.00E+00	2.222E-01	1.296E+02
α_6	1.09E-18	6.41E-04	1.12E-06	3.74E-03	0.00E+00	8.324E-02	1.297E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9447269	0.9676286	0.9691868	0.9852219	1.0000000	1.927E+02	6.445E+00
α_2	4.37E-03	1.55E-02	1.39E-02	3.21E-02	0.00E+00	3.088E+00	1.960E+02
α_3	1.10E-03	8.19E-03	6.62E-03	2.07E-02	0.00E+00	1.631E+00	1.975E+02
α_4	2.49E-04	4.97E-03	3.44E-03	1.49E-02	0.00E+00	9.889E-01	1.981E+02
α_5	1.29E-05	2.62E-03	1.24E-03	9.90E-03	0.00E+00	5.218E-01	1.986E+02
α_6	3.38E-10	9.36E-04	7.99E-05	4.91E-03	0.00E+00	1.863E-01	1.989E+02
α_7	5.11E-48	1.46E-04	1.28E-13	5.50E-04	0.00E+00	2.907E-02	1.991E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474421	0.9682229	0.9695428	0.9844940	1.0000000	2.273E+02	7.461E+00
α_2	4.29E-03	1.42E-02	1.29E-02	2.88E-02	0.00E+00	3.345E+00	2.314E+02
α_3	1.10E-03	7.40E-03	6.06E-03	1.83E-02	0.00E+00	1.738E+00	2.331E+02
α_4	3.46E-04	4.88E-03	3.57E-03	1.39E-02	0.00E+00	1.147E+00	2.336E+02
α_5	5.49E-05	3.02E-03	1.77E-03	1.02E-02	0.00E+00	7.083E-01	2.341E+02
α_6	8.85E-07	1.56E-03	5.12E-04	6.69E-03	0.00E+00	3.670E-01	2.344E+02
α_7	6.94E-14	5.24E-04	9.42E-06	2.98E-03	0.00E+00	1.230E-01	2.347E+02
α_8	1.30E-42	1.41E-04	2.01E-12	5.96E-04	0.00E+00	3.312E-02	2.348E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Omega						0.00E+00	0.00E+00
Sigma							0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind. Events	8.60	8.60	8.60	8.60	8.60	8.60	8.60
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

N_3		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			0.0000	0.0000	0.0000	0.0000	0.0000
N_5				0.0000	0.0000	0.0000	0.0000
N_6					0.0000	0.0000	0.0000
N_7						0.0000	0.0000
N_8							0.0000

2.16 Air Compressors

2.16.1 Motor Driven Air Compressors

2.16.1.1 MOTOR DRIVEN AIR COMPRESSOR FAIL TO START

Components/Other/Compressor/Motor Driven
Failure Modes/Fail to Start
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 297.2
Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9843281	0.9952292	0.9970647	0.9998818	0.9977817	1.602E+02	7.679E-01
α_2	1.15E-04	4.77E-03	2.94E-03	1.57E-02	2.22E-03	7.679E-01	1.602E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9808660	0.9917792	0.9930240	0.9984424	0.9955536	2.535E+02	2.101E+00
α_2	1.14E-03	7.18E-03	5.94E-03	1.74E-02	4.45E-03	1.834E+00	2.537E+02
α_3	3.62E-08	1.05E-03	2.09E-04	4.96E-03	0.00E+00	2.672E-01	2.553E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783456	0.9888964	0.9898227	0.9962876	0.9933155	3.433E+02	3.855E+00
α_2	2.71E-03	9.30E-03	8.37E-03	1.90E-02	6.68E-03	3.228E+00	3.440E+02
α_3	1.30E-06	1.16E-03	4.28E-04	4.82E-03	0.00E+00	4.043E-01	3.468E+02
α_4	2.75E-09	6.41E-04	8.72E-05	3.21E-03	0.00E+00	2.227E-01	3.470E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9791767	0.9882962	0.9889740	0.9950899	0.9946452	4.677E+02	5.538E+00
α_2	2.24E-03	7.29E-03	6.60E-03	1.47E-02	3.57E-03	3.448E+00	4.698E+02
α_3	4.72E-04	3.47E-03	2.80E-03	8.77E-03	1.78E-03	1.644E+00	4.716E+02
α_4	5.18E-07	7.91E-04	2.65E-04	3.36E-03	0.00E+00	3.744E-01	4.728E+02
α_5	1.26E-21	1.53E-04	8.61E-08	8.82E-04	0.00E+00	7.228E-02	4.731E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9809265	0.9889658	0.9895360	0.9950669	0.9955337	5.627E+02	6.279E+00
α_2	1.56E-03	5.50E-03	4.93E-03	1.14E-02	1.99E-03	3.128E+00	5.659E+02
α_3	6.48E-04	3.57E-03	3.01E-03	8.41E-03	1.99E-03	2.031E+00	5.670E+02
α_4	4.15E-05	1.43E-03	9.06E-04	4.61E-03	4.96E-04	8.144E-01	5.682E+02
α_5	1.63E-09	3.90E-04	5.28E-05	1.96E-03	0.00E+00	2.222E-01	5.688E+02
α_6	2.47E-19	1.46E-04	2.55E-07	8.52E-04	0.00E+00	8.324E-02	5.689E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.98E-01	9.96E-01	9.93E-01	9.95E-01	9.96E-01
α_2	2.22E-03	4.45E-03	6.68E-03	3.57E-03	1.99E-03
α_3		0.00E+00	0.00E+00	1.78E-03	1.99E-03
α_4			0.00E+00	0.00E+00	4.96E-04
α_5				0.00E+00	0.00E+00
α_6					0.00E+00

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.98E-01	9.96E-01	9.93E-01	9.95E-01	9.96E-01
Beta	2.22E-03	4.45E-03	6.68E-03	5.35E-03	4.47E-03
Gamma		0.00E+00	0.00E+00	3.33E-01	5.56E-01
Delta			0.00E+00	0.00E+00	2.00E-01
Epsilon				0.00E+00	0.00E+00
Mu					0.00E+00

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	148.60	222.90	297.20	371.50	445.80
N_1	1.3333	1.0000	0.0000	0.0000	0.0000
N_2	0.3333	1.0000	2.0000	1.3333	0.8889
N_3		0.0000	0.0000	0.6667	0.8889
N_4			0.0000	0.0000	0.2222
N_5				0.0000	0.0000
N_6					0.0000

2.16.1.2 MOTOR DRIVEN AIR COMPRESSOR FAIL TO RUN

Components/Other/Compressor/Motor Driven
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 729.7
Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9876283	0.9937039	0.9942430	0.9979307	0.9943288	5.947E+02	3.768E+00
α_2	2.07E-03	6.30E-03	5.76E-03	1.24E-02	5.67E-03	3.768E+00	5.947E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9898076	0.9943965	0.9947524	0.9977590	0.9954527	9.052E+02	5.101E+00
α_2	8.07E-04	3.11E-03	2.76E-03	6.63E-03	2.27E-03	2.834E+00	9.075E+02
α_3	5.14E-04	2.49E-03	2.14E-03	5.67E-03	2.27E-03	2.267E+00	9.080E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9915529	0.9951988	0.9954688	0.9979297	0.9965856	1.214E+03	5.855E+00
α_2	3.70E-04	1.83E-03	1.56E-03	4.19E-03	8.54E-04	2.228E+00	1.217E+03
α_3	4.34E-04	1.97E-03	1.71E-03	4.41E-03	1.71E-03	2.404E+00	1.217E+03
α_4	8.09E-05	1.00E-03	7.47E-04	2.80E-03	8.54E-04	1.223E+00	1.218E+03

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9919811	0.9951774	0.9953896	0.9976538	0.9972666	1.556E+03	7.538E+00
α_2	4.01E-04	1.67E-03	1.47E-03	3.65E-03	3.42E-04	2.614E+00	1.560E+03
α_3	3.60E-04	1.58E-03	1.38E-03	3.52E-03	1.03E-03	2.477E+00	1.561E+03
α_4	1.96E-04	1.20E-03	9.94E-04	2.90E-03	1.03E-03	1.874E+00	1.561E+03
α_5	2.79E-06	3.66E-04	1.86E-04	1.34E-03	3.42E-04	5.723E-01	1.563E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9928060	0.9955882	0.9957600	0.9977677	0.9977212	1.868E+03	8.279E+00
α_2	3.03E-04	1.33E-03	1.15E-03	2.94E-03	1.42E-04	2.489E+00	1.874E+03
α_3	2.21E-04	1.14E-03	9.70E-04	2.65E-03	5.70E-04	2.142E+00	1.874E+03
α_4	2.10E-04	1.11E-03	9.44E-04	2.61E-03	8.55E-04	2.092E+00	1.874E+03
α_5	5.25E-05	6.51E-04	4.85E-04	1.82E-03	5.70E-04	1.222E+00	1.875E+03
α_6	4.73E-08	1.78E-04	5.09E-05	7.85E-04	1.42E-04	3.332E-01	1.876E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
α_1	9.94E-01	9.95E-01	9.97E-01	9.97E-01	9.98E-01
α_2	5.67E-03	2.27E-03	8.54E-04	3.42E-04	1.42E-04
α_3		2.27E-03	1.71E-03	1.03E-03	5.70E-04
α_4			8.54E-04	1.03E-03	8.55E-04
α_5				3.42E-04	5.70E-04
α_6					1.42E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
1-Beta	9.94E-01	9.95E-01	9.97E-01	9.97E-01	9.98E-01
Beta	5.67E-03	4.55E-03	3.41E-03	2.73E-03	2.28E-03
Gamma		5.00E-01	7.50E-01	8.75E-01	9.38E-01
Delta			3.33E-01	5.71E-01	7.33E-01
Epsilon				2.50E-01	4.55E-01
Mu					2.00E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6
Adj. Ind. Events	583.76	875.64	1167.52	1459.40	1751.28
N_1	0.6667	0.0000	0.0000	0.0000	0.0000
N_2	3.3333	2.0000	1.0000	0.5000	0.2500
N_3		2.0000	2.0000	1.5000	1.0000
N_4			1.0000	1.5000	1.5000
N_5				0.5000	1.0000
N_6					0.2500

3 Generic CCF Distributions

This section shows generic CCF distributions including the Generic Demand, Generic Rate, and No Data (Prior Only) pooled distributions. The distributions for the Generic Demand and Generic Rate are updated with the latest data (i.e., up to 2015). The No Data (Prior Only) section shows the prior used in the CCF database and uses the same data version of 12/31/2012 as in the *2012 Update*. This is the result of calculating an application without any data, which is the same as calculating an application with all the events in the CCF database. These generic CCF parameters may be used for those cases where there is no reasonable set of data to approximate the intended event.

3.1 Generic Distributions

3.1.1 Generic Demand CCF Distribution

3.1.1.1 ALL CCF DEMAND BASED EVENTS 1997 TO CURRENT SPAR: CCF-DEM

Failure Modes/Fail to Close
Failure Modes/Fail to Load and-or Run
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Failure Modes/Fail to Start
Failure Modes/Fail to Stop
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3598.9
Total Number of Common-Cause Failure Events: 107

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9739095	0.9802993	0.9805202	0.9859305	0.9804566	1.407E+03	2.827E+01
α_2	1.41E-02	1.97E-02	1.95E-02	2.61E-02	1.95E-02	2.827E+01	1.407E+03

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736531	0.9789883	0.9791353	0.9838123	0.9792043	2.100E+03	4.508E+01
α_2	1.07E-02	1.47E-02	1.46E-02	1.92E-02	1.45E-02	3.154E+01	2.114E+03
α_3	3.78E-03	6.31E-03	6.16E-03	9.36E-03	6.28E-03	1.354E+01	2.132E+03

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736328	0.9783076	0.9784225	0.9826016	0.9785984	2.786E+03	6.177E+01
α_2	1.02E-02	1.35E-02	1.34E-02	1.72E-02	1.33E-02	3.847E+01	2.809E+03
α_3	3.50E-03	5.59E-03	5.47E-03	8.07E-03	5.54E-03	1.591E+01	2.832E+03
α_4	1.25E-03	2.60E-03	2.48E-03	4.34E-03	2.56E-03	7.393E+00	2.840E+03

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763661	0.9803297	0.9804199	0.9839886	0.9807825	3.512E+03	7.047E+01
α_2	7.06E-03	9.57E-03	9.48E-03	1.24E-02	9.24E-03	3.430E+01	3.548E+03
α_3	3.87E-03	5.78E-03	5.69E-03	8.01E-03	5.67E-03	2.072E+01	3.562E+03
α_4	1.85E-03	3.24E-03	3.15E-03	4.94E-03	3.22E-03	1.161E+01	3.571E+03
α_5	3.57E-04	1.07E-03	9.82E-04	2.10E-03	1.08E-03	3.847E+00	3.579E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9784444	0.9819123	0.9819850	0.9851296	0.9824132	4.209E+03	7.753E+01
α_2	5.32E-03	7.32E-03	7.25E-03	9.59E-03	7.00E-03	3.140E+01	4.255E+03

α_3	3.50E-03	5.15E-03	5.08E-03	7.08E-03	5.03E-03	2.209E+01	4.264E+03
α_4	1.97E-03	3.26E-03	3.19E-03	4.81E-03	3.22E-03	1.398E+01	4.272E+03
α_5	9.19E-04	1.85E-03	1.77E-03	3.05E-03	1.85E-03	7.937E+00	4.278E+03
α_6	9.39E-05	4.94E-04	4.18E-04	1.15E-03	4.88E-04	2.115E+00	4.284E+03

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9800577	0.9831435	0.9832097	0.9860157	0.9838109	4.952E+03	8.490E+01
α_2	4.39E-03	6.07E-03	6.00E-03	7.97E-03	5.67E-03	3.056E+01	5.006E+03
α_3	2.86E-03	4.24E-03	4.18E-03	5.85E-03	4.07E-03	2.138E+01	5.015E+03
α_4	1.98E-03	3.16E-03	3.09E-03	4.56E-03	3.08E-03	1.590E+01	5.021E+03
α_5	1.17E-03	2.11E-03	2.05E-03	3.28E-03	2.09E-03	1.065E+01	5.026E+03
α_6	4.23E-04	1.04E-03	9.78E-04	1.89E-03	1.05E-03	5.253E+00	5.031E+03
α_7	1.64E-05	2.29E-04	1.68E-04	6.53E-04	2.32E-04	1.155E+00	5.035E+03

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9813790	0.9841756	0.9842349	0.9867847	0.9848780	5.661E+03	9.103E+01
α_2	3.81E-03	5.28E-03	5.22E-03	6.94E-03	4.89E-03	3.038E+01	5.722E+03
α_3	2.35E-03	3.53E-03	3.47E-03	4.91E-03	3.36E-03	2.031E+01	5.732E+03
α_4	1.76E-03	2.79E-03	2.74E-03	4.03E-03	2.70E-03	1.607E+01	5.736E+03
α_5	1.25E-03	2.14E-03	2.09E-03	3.24E-03	2.10E-03	1.234E+01	5.740E+03
α_6	6.76E-04	1.37E-03	1.31E-03	2.26E-03	1.36E-03	7.870E+00	5.745E+03
α_7	1.77E-04	5.88E-04	5.32E-04	1.19E-03	5.90E-04	3.384E+00	5.749E+03
α_8	1.84E-06	1.18E-04	6.75E-05	4.06E-04	1.17E-04	6.793E-01	5.752E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.79E-01	9.79E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
α_2	1.95E-02	1.45E-02	1.33E-02	9.24E-03	7.00E-03	5.67E-03	4.89E-03
α_3		6.28E-03	5.54E-03	5.67E-03	5.03E-03	4.07E-03	3.36E-03
α_4			2.56E-03	3.22E-03	3.22E-03	3.08E-03	2.70E-03
α_5				1.08E-03	1.85E-03	2.09E-03	2.10E-03
α_6					4.88E-04	1.05E-03	1.36E-03
α_7						2.32E-04	5.90E-04
α_8							1.17E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.79E-01	9.79E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
Beta	1.95E-02	2.08E-02	2.14E-02	1.92E-02	1.76E-02	1.62E-02	1.51E-02
Gamma		3.02E-01	3.78E-01	5.19E-01	6.02E-01	6.50E-01	6.77E-01
Delta			3.16E-01	4.32E-01	5.25E-01	6.13E-01	6.72E-01
Epsilon				2.52E-01	4.21E-01	5.23E-01	6.07E-01
Mu					2.08E-01	3.79E-01	4.95E-01
Omega						1.82E-01	3.42E-01
Sigma							1.65E-01

Generic Demand CCF Distribution
ALL CCF DEMAND BASED EVENTS 1997 TO CURRENT SPAR: CCF-DEM

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	1348.80	2023.20	2697.60	3372.00	4046.40	4720.80	5395.20
N_1	47.8719	47.6000	42.2126	43.9978	45.2212	46.6856	47.5072
N_2	27.8397	30.7078	37.2396	32.1887	29.1560	27.4736	27.0331
N_3		13.2705	15.5089	19.7389	20.9525	19.7457	18.5705
N_4			7.1704	11.2312	13.3918	14.9121	14.9247
N_5				3.7744	7.7144	10.1274	11.6290
N_6					2.0320	5.0672	7.5035
N_7						1.1256	3.2614
N_8							0.6462

3.1.2 Generic Rate CCF Distribution

3.1.2.1 ALL CCF RATE BASED EVENTS 1997 TO CURRENT SPAR: CCF-RATE

Failure Modes/Bypass
Failure Modes/Control Function
Failure Modes/Fail to Control
Failure Modes/Fail to Operate
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Failure Modes/High dP
Failure Modes/Loss of Heat Transfer
Failure Modes/Plug
Failure Modes/Spurious Operation
Date Range: 1997 through 2015

Total Number of Independent Failure Events: 3224.0
Total Number of Common-Cause Failure Events: 116

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9619669	0.9694654	0.9696695	0.9762778	0.9695356	1.508E+03	4.748E+01
α_2	2.37E-02	3.05E-02	3.03E-02	3.80E-02	3.05E-02	4.748E+01	1.508E+03

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9646529	0.9706436	0.9707767	0.9761762	0.9707316	2.246E+03	6.792E+01
α_2	1.33E-02	1.75E-02	1.74E-02	2.22E-02	1.74E-02	4.050E+01	2.273E+03
α_3	8.41E-03	1.19E-02	1.17E-02	1.58E-02	1.19E-02	2.743E+01	2.286E+03

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678618	0.9728563	0.9729563	0.9775041	0.9730394	2.982E+03	8.320E+01
α_2	9.75E-03	1.29E-02	1.28E-02	1.64E-02	1.27E-02	3.960E+01	3.025E+03
α_3	6.19E-03	8.77E-03	8.66E-03	1.17E-02	8.77E-03	2.688E+01	3.038E+03
α_4	3.47E-03	5.46E-03	5.35E-03	7.81E-03	5.47E-03	1.672E+01	3.048E+03

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9716549	0.9758620	0.9759421	0.9797885	0.9761639	3.756E+03	9.290E+01
α_2	6.59E-03	8.93E-03	8.85E-03	1.16E-02	8.61E-03	3.438E+01	3.814E+03
α_3	5.33E-03	7.46E-03	7.37E-03	9.88E-03	7.40E-03	2.870E+01	3.820E+03
α_4	3.14E-03	4.81E-03	4.73E-03	6.78E-03	4.84E-03	1.852E+01	3.830E+03
α_5	1.66E-03	2.94E-03	2.85E-03	4.50E-03	2.99E-03	1.130E+01	3.837E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746515	0.9783006	0.9783677	0.9817130	0.9786685	4.501E+03	9.984E+01

α_2	4.55E-03	6.34E-03	6.27E-03	8.38E-03	6.02E-03	2.919E+01	4.572E+03
α_3	4.42E-03	6.19E-03	6.12E-03	8.20E-03	6.10E-03	2.847E+01	4.572E+03
α_4	3.16E-03	4.69E-03	4.62E-03	6.46E-03	4.68E-03	2.158E+01	4.579E+03
α_5	1.48E-03	2.58E-03	2.51E-03	3.92E-03	2.60E-03	1.187E+01	4.589E+03
α_6	9.78E-04	1.90E-03	1.83E-03	3.06E-03	1.93E-03	8.727E+00	4.592E+03

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9771278	0.9803354	0.9803974	0.9833355	0.9808535	5.294E+03	1.062E+02
α_2	3.51E-03	4.98E-03	4.91E-03	6.65E-03	4.56E-03	2.687E+01	5.373E+03
α_3	3.25E-03	4.67E-03	4.60E-03	6.29E-03	4.52E-03	2.519E+01	5.375E+03
α_4	2.85E-03	4.18E-03	4.12E-03	5.72E-03	4.14E-03	2.257E+01	5.378E+03
α_5	1.95E-03	3.07E-03	3.01E-03	4.41E-03	3.09E-03	1.660E+01	5.384E+03
α_6	1.02E-03	1.87E-03	1.81E-03	2.93E-03	1.90E-03	1.009E+01	5.390E+03
α_7	3.50E-04	9.02E-04	8.41E-04	1.66E-03	9.30E-04	4.872E+00	5.395E+03

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9790895	0.9819652	0.9820155	0.9846638	0.9825346	6.054E+03	1.112E+02
α_2	2.94E-03	4.20E-03	4.14E-03	5.63E-03	3.79E-03	2.587E+01	6.139E+03
α_3	2.34E-03	3.47E-03	3.42E-03	4.79E-03	3.31E-03	2.140E+01	6.144E+03
α_4	2.42E-03	3.57E-03	3.52E-03	4.91E-03	3.52E-03	2.204E+01	6.143E+03
α_5	1.92E-03	2.96E-03	2.91E-03	4.18E-03	2.96E-03	1.826E+01	6.147E+03
α_6	1.31E-03	2.19E-03	2.13E-03	3.25E-03	2.21E-03	1.348E+01	6.152E+03
α_7	5.53E-04	1.16E-03	1.11E-03	1.96E-03	1.19E-03	7.177E+00	6.158E+03
α_8	1.30E-04	4.81E-04	4.29E-04	1.01E-03	4.94E-04	2.968E+00	6.162E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.70E-01	9.71E-01	9.73E-01	9.76E-01	9.79E-01	9.81E-01	9.83E-01
α_2	3.05E-02	1.74E-02	1.27E-02	8.61E-03	6.02E-03	4.56E-03	3.79E-03
α_3		1.19E-02	8.77E-03	7.40E-03	6.10E-03	4.52E-03	3.31E-03
α_4			5.47E-03	4.84E-03	4.68E-03	4.14E-03	3.52E-03
α_5				2.99E-03	2.60E-03	3.09E-03	2.96E-03
α_6					1.93E-03	1.90E-03	2.21E-03
α_7						9.30E-04	1.19E-03
α_8							4.94E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.70E-01	9.71E-01	9.73E-01	9.76E-01	9.79E-01	9.81E-01	9.83E-01
Beta	3.05E-02	2.93E-02	2.70E-02	2.38E-02	2.13E-02	1.91E-02	1.75E-02
Gamma		4.06E-01	5.28E-01	6.39E-01	7.18E-01	7.62E-01	7.83E-01
Delta			3.84E-01	5.14E-01	6.02E-01	6.90E-01	7.58E-01
Epsilon				3.82E-01	4.92E-01	5.88E-01	6.61E-01
Mu					4.26E-01	4.78E-01	5.68E-01
Omega						3.28E-01	4.32E-01
Sigma							2.94E-01

Generic Rate CCF Distribution
ALL CCF RATE BASED EVENTS 1997 TO CURRENT SPAR: CCF-RATE

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. IEs	1449.55	2174.33	2899.10	3623.88	4348.65	5073.43	5798.20
N_1	47.7581	41.9740	36.6079	35.7355	35.4466	36.4674	37.1269
N_2	47.0479	39.6632	38.3696	32.2624	26.9507	23.7810	22.5211
N_3		27.1602	26.4711	27.7270	27.3329	23.5617	19.6615
N_4			16.5007	18.1478	20.9842	21.5780	20.8925
N_5				11.2236	11.6460	16.0829	17.5552
N_6					8.6438	9.9000	13.1087
N_7						4.8429	7.0536
N_8							2.9351

3.1.3 CCF Prior Distribution

3.1.3.1 No Data (Prior Only)

Data Version : 2007/12/31

Total Number of Independent Failure Events: 0
Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8993200	0.9742690	0.9887700	0.9999290	----	1.7418E+01	4.6002E-01
α_2	6.65E-05	2.57E-02	1.12E-02	1.00E-01	----	4.6002E-01	1.7418E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9306240	0.9755060	0.9819700	0.9982830	----	4.5105E+01	1.1325E+00
α_2	6.61E-04	1.87E-02	1.23E-02	5.84E-02	----	8.6476E-01	4.5372E+01
α_3	2.07E-07	5.79E-03	1.17E-03	2.74E-02	----	2.6776E-01	4.5969E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9380870	0.9740820	0.9782970	0.9956540	----	7.0868E+01	1.8856E+00
α_2	1.43E-03	1.70E-02	1.28E-02	4.69E-02	----	1.2400E+00	7.1513E+01
α_3	9.66E-06	5.89E-03	2.32E-03	2.38E-02	----	4.2870E-01	7.2324E+01
α_4	9.21E-09	2.98E-03	3.83E-04	1.50E-02	----	2.1695E-01	7.2536E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521790	0.9760740	0.9782400	0.9925770	----	1.4106E+02	3.4576E+00
α_2	2.59E-03	1.41E-02	1.19E-02	3.30E-02	----	2.0400E+00	1.4247E+02
α_3	3.01E-04	6.59E-03	4.50E-03	2.00E-02	----	9.5369E-01	1.4356E+02
α_4	2.21E-06	2.67E-03	9.37E-04	1.12E-02	----	3.8684E-01	1.4413E+02
α_5	5.61E-20	5.33E-04	5.18E-07	3.10E-03	----	7.7129E-02	1.4444E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553700	0.9762820	0.9779970	0.9913440	----	1.7893E+02	4.3470E+00
α_2	2.60E-03	1.24E-02	1.07E-02	2.81E-02	----	2.2804E+00	1.8099E+02
α_3	4.16E-04	6.13E-03	4.45E-03	1.75E-02	----	1.1245E+00	1.8215E+02
α_4	3.82E-05	3.40E-03	1.85E-03	1.20E-02	----	6.2471E-01	1.8265E+02
α_5	1.60E-08	1.32E-03	2.18E-04	6.46E-03	----	2.4272E-01	1.8303E+02
α_6	1.26E-20	4.07E-04	3.05E-07	2.36E-03	----	7.4722E-02	1.8320E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9603690	0.9769760	0.9781320	0.9896440	----	2.6720E+02	6.2971E+00
α_2	3.14E-03	1.12E-02	1.00E-02	2.33E-02	----	3.0721E+00	2.7042E+02
α_3	6.66E-04	5.55E-03	4.40E-03	1.43E-02	----	1.5182E+00	2.7197E+02
α_4	1.58E-04	3.48E-03	2.37E-03	1.06E-02	----	9.5310E-01	2.7254E+02
α_5	1.00E-05	1.93E-03	9.22E-04	7.26E-03	----	5.2795E-01	2.7296E+02
α_6	4.58E-10	7.08E-04	6.75E-05	3.68E-03	----	1.9373E-01	2.7330E+02
α_7	5.03E-44	1.17E-04	8.41E-13	4.81E-04	----	3.2027E-02	2.7346E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9622170	0.9773660	0.9783580	0.9891370	----	3.1221E+02	7.2302E+00
α_2	3.13E-03	1.04E-02	9.45E-03	2.12E-02	----	3.3414E+00	3.1609E+02
α_3	6.67E-04	5.04E-03	4.06E-03	1.28E-02	----	1.6130E+00	3.1782E+02
α_4	1.86E-04	3.26E-03	2.30E-03	9.62E-03	----	1.0438E+00	3.1839E+02
α_5	3.88E-05	2.20E-03	1.28E-03	7.47E-03	----	7.0280E-01	3.1873E+02
α_6	5.77E-07	1.13E-03	3.63E-04	4.86E-03	----	3.6184E-01	3.1907E+02
α_7	1.19E-13	3.98E-04	8.44E-06	2.25E-03	----	1.2739E-01	3.1931E+02
α_8	5.47E-36	1.25E-04	5.43E-11	6.01E-04	----	4.0005E-02	3.1940E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
α_2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_3		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_4			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_5				0.00E+00	0.00E+00	0.00E+00	0.00E+00
α_6					0.00E+00	0.00E+00	0.00E+00
α_7						0.00E+00	0.00E+00
α_8							0.00E+00

MGL Parameter	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gamma		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Delta			0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Epsilon				0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mu					0.00E+00	0.00E+00	0.00E+00
Upsilon						0.00E+00	0.00E+00
Sigma							0.00E+00

4 Glossary

Adjusted Independent Events
The equivalent number of independent events that would be observed from target systems of size, given data on independent events in different size systems.

Application
A particular set of CCF events selected from the CCF database for use in a specific study.

Available
The component is available if it is capable of performing its function according to a specified success criterion.

Average Impact Vector
An average over the impact vectors for different hypotheses regarding the number of components failed in an event.

Basic Event
An event in a reliability logic model that represents the state in which a component or group of components is unavailable and does not require further development in terms of contributing causes.

Common Cause Basic Event
In system modeling, a basic event that represents the unavailability of a specific set of components because of shared causes that are not explicitly represented in the system logic model as other basic events.

Common Cause Component Group
A group of (usually similar [in mission, manufacturer, maintenance, environment, etc.]) components that are considered to have a high potential for failure due to the same cause or causes.

Common Cause Event
A dependent failure in which two or more component fault states exist simultaneously, or within a short time interval, and are a direct result of a shared cause.

Common Cause Failure Model
The basis for quantifying the frequency of common cause events. Examples include the beta factor, alpha factor, and basic parameter, and the binomial failure rate models.

Complete Common Cause Failure
A CCF in which all redundant components are failed simultaneously as a direct result of a shared cause; i.e., the component degradation value equals 1.0 for all components, and both the timing factor and the shared cause factor are equal to 1.0.

Component
An element of plant hardware designed to provide a particular function.

Component Boundary
The component boundary encompasses the set of piece parts that are considered to form the component.

Component Degradation Value (p)
The assessed probability ($0.0 \leq p \leq 1.0$) that a functionally or physically degraded component would fail to complete the mission.

Component State
Component state defines the component status in regard to its intended function. Two general categories of component states are defined as available and unavailable.

Defense
Any operational, maintenance, and design measures taken to diminish the frequency and/or consequences of CCFs.

Degraded
The component is in such a state that it exhibits reduced performance but insufficient degradation to declare the component unavailable according to the specified success criterion.

Exposed Population
The set of components within the plant that are potentially affected by the CCF under consideration.

Failure
The component is not capable of performing its specified operation according to a success criterion.

Failure Mechanism
The history describing the events and influences leading to a given failure.

Failure Mode
A description of component failure in terms of the component function that was actually or potentially unavailable.

Failure Mode Applicability
The analyst's probability that the specified component failure mode for a given event is appropriate to the particular application.

Functionally Unavailable
The component is capable of operation, but the function normally provided by the component is unavailable due to lack of proper input, lack of support function from a source outside the component (i.e., motive power, actuation signal), maintenance, testing, the improper interference of a person, etc.

Impact Vector
An assessment of the impact an event would have on a common cause component group. The impact is usually measured as the number of failed components out of a set of similar components in the common cause component group.

Incipient
The component is in a condition that, if left unremedied, could ultimately lead to a degraded or unavailable state.

Independent Events
Two basic events, A and B, are statistically independent if, and only if, $P[A \cap B] = P[A]P[B]$, where P[X] denotes the probability of event X.

Mapping
The impact vector of an event must be "mapped up" or "mapped down" when the exposed population of the target plant is higher or lower than that of the original plant that experienced the CCF. The end result of mapping an impact vector is an adjusted impact vector applicable to the target plant.

Mapping Down Factor
A factor used to adjust the impact vector of an event when the exposed population of the target plan is lower than that of the original plant that experienced the CCF.

Mapping Up Factor
A factor used to adjust the impact vector of an event when the exposed population of the target plan is higher than that of the original plant that experienced the CCF.

Multiple Greek Letter
For a system of *m* redundant components and for each given failure mode, *m* different parameters are defined. Each parameter represents the conditional probability that the common cause of a component failure will be shared by *n* or more additional components.

Potential Common Cause Failure
Any common cause event in which at least one component degradation value is less than 1.0.

Potentially Unavailable
The component is capable of performing its function according to a success criterion, but an incipient or degraded condition exists. (N.B., potentially unavailable is not synonymous with hypothetical.)

Proximate Cause
A characterization of the condition that is readily identified as leading to failure of the component. It might alternatively be characterized as a symptom.

Reliability Logic Model
A logical representation of the combinations of component states that could lead to system failure. A fault tree is an example of a system logic model.

Root Cause
The most basic reason for a component failure, which, if corrected, could prevent recurrence. The identified root cause may vary depending on the particular defensive strategy adopted against the failure mechanism.

Shared-Cause Factor (c)
A number that reflects the analyst's uncertainty ($0.0 \leq c \leq 1.0$) about the existence of coupling among the failures of two or more components, i.e., whether a shared cause of failure can be clearly identified.

Shared Cause Factor/Mechanism
A set of causes and factors characterizing why and how a failure is systematically induced in several components.

Shock
A shock is an event that occurs at a random point in time and acts on the system; i.e., all the components in the system simultaneously. There are two kinds of shocks distinguished by the potential impact of the shock event, i.e., lethal and non-lethal.

System
The entity that encompasses an interacting collection of components to provide a particular function or functions.

Timing Factor (q)
The probability ($0.0 \leq q \leq 1.0$) that two or more component failures (or degraded states) separated in time represent a CCF. This can be viewed as an indication of the strength-of-coupling in synchronizing failure times.

Unavailable
The component is unavailable if the component is unable to perform its intended function according to a stated success criterion. Two subsets of unavailable states are failure and functionally unavailable.

Appendix A CCF Parameter Estimations 2012 Report vs. 2015 Report

CCF Report		2012 Report / SPAR Rules 2012				2015 Report / SPAR Rules 2015A				Comments
Section Number (2012 Report -> 2015 Report)		Sub-Section	Rule Name	CCF Events	Ind. Events	Sub-Section	Rule Name	CCF Events	Ind. Events	
1.3 MDPs -> 2.1	1.3.1 Pooled MDPs -> 2.1.1	1.3.1.1	ALL-MDP-FS	23	591.90	2.1.1.1	ALL-MDP-FS	21	679.0	
		1.3.1.2	ALL-MDP-FH	4	46.70	2.1.1.2	ALL-MDP-FH	4	56.8	
		1.3.1.3	ALL-MDP-RH	11	141.50	2.1.1.4	ALL-MDP-RH	11	160.5	
		1.3.1.4	ALL-MDP-FHRH	15	188.20	2.1.1.3	ALL-MDP-FHRH	15	217.3	This rule includes data for standby MDP Fail-to-Run
						2.1.1.5	ALL-MDP-FR-NR	9	354.2	Add a new rule for Normally Running MDP Fail-to-Run
						2.1.1.6	ALL-MDP-FS-NS	21	428.2	New CCF rule
						2.1.1.7	ALL-MDP-FS-NR	0	247.8	New CCF rule
	1.3.2 Pooled Pump Volutes -> 2.1.2	1.3.2.1	ALL-PMP-FR	3	109.50	2.1.2.1	ALL-PMP-FR	2	92.1	
	1.3.3 Pooled Clean System MDPs -> 2.1.3	1.3.3.1	CLN-MDP-FS	15	405.50	2.1.3.1	CLN-MDP-FS	13	464.6	
		1.3.3.2	CLN-MDP-FH	3	26.10	2.1.3.2	CLN-MDP-FH	3	32.1	
		1.3.3.3	CLN-MDP-FHRH	11	272.00	2.1.3.3	CLN-MDP-FHRH	7	89.6	The 2012 Report result included Fail-to-Run failure mode.
		1.3.3.4	CLN-MDP-RH	4	48.90	2.1.3.4	CLN-MDP-RH	4	57.5	
	1.3.4 PWR Containment Spray MDPs -> 2.1.4	1.3.4.1	CSS-MDP-FS	3	30.00	2.1.4.1	CSS-MDP-FS	3	37.0	
		1.3.4.2	CSS-MDP-FH	0	7.00	2.1.4.2	CSS-MDP-FH	0	8.0	
		1.3.4.3	CSS-MDP-FHRH	0	13.10	2.1.4.3	CSS-MDP-FHRH	0	14.1	
		1.3.4.4	CSS-MDP-RH	0	6.10	2.1.4.4	CSS-MDP-RH	0	6.1	
	1.3.5 BWR RHR MDPs -> 2.1.5	1.3.5.1	BWR-RHR-MDP-FS	2	32.00	2.1.5.1	BWR-RHR-MDP-FS	2	39.0	
		1.3.5.2	BWR-RHR-MDP-FH	0	5.00	2.1.5.2	BWR-RHR-MDP-FH	0	5.0	
		1.3.5.3	BWR-RHR-MDP-FHRH	0	12.50	2.1.5.3	BWR-RHR-MDP-FHRH	0	16.5	
		1.3.5.4	BWR-RHR-MDP-RH	0	7.50	2.1.5.4	BWR-RHR-MDP-RH	0	11.5	Not in SPAR 2012 Rules. Added to SPAR 2015 Rules
	1.3.6 AFW MDPs -> 2.1.6	1.3.6.1	AFW-MDP-FS	2	35.20	2.1.6.1	AFW-MDP-FS	2	44.7	
		1.3.6.2	AFW-MDP-FH	2	6.50	2.1.6.2	AFW-MDP-FH	2	8.5	
		1.3.6.3	AFW-MDP-FHRH	2	13.20	2.1.6.3	AFW-MDP-FHRH	2	18.2	
		1.3.6.4	AFW-MDP-RH	0	6.70	2.1.6.4	AFW-MDP-RH	0	9.7	

CCF Report		2012 Report / SPAR Rules 2012				2015 Report / SPAR Rules 2015A				Comments
Section Number (2012 Report -> 2015 Report)		Sub-Section	Rule Name	CCF Events	Ind. Events	Sub-Section	Rule Name	CCF Events	Ind. Events	
	1.3.7 AFW Pump Volutes -> 2.1.7	1.3.7	AFW-PMP-FR	0	17.10	2.1.7.1	AFW-PMP-FR	1	22.1	
	1.3.8 ESW MDPs -> 2.1.8 SW MDPs	1.3.8.1	SWN-MDP-FS	1	26.50	2.1.8.1	SWN-MDP-FS	0	30.5	
		1.3.8.2	SWN-MDP-FR	3	59.80	2.1.8.2	SWN-MDP-FR	3	71.0	
		1.3.8.3	SWS-MDP-FS	7	122.90	2.1.8.3	SSW-MDP-FS	8	152.9	Change Standby Service Water system designation from SWS to SSW.
		1.3.8.4	SWS-MDP-FR	0	3.00	2.1.8.4	SSW-MDP-FR	7	121.2	(1) Change Standby Service Water system designation from SWS to SSW. (2) 2012 Report used Fail -to-Run failure mode for Standby SW. Should have used Fail-to-Run-<1H and Fail-to-Run->1H which would have a result of 7/107.9.
		1.3.8.5	ESW-MDP-FS	8	148.40	2.1.8.5	SWS-MDP-FS	8	183.4	(1) Change All Service Water system designation from ESW to SWS. (2) The 2012 Rule excludes Extreme Environmental CCF cause. The EE cause is added to the 2015 Rule.
		1.3.8.6	ESW-MDP-FR	1	61.70	2.1.8.6	SWS-MDP-FR	11	198.7	(1) Change All Service Water system designation from ESW to SWS. (2) The 2012 Rule excludes Extreme Environmental CCF cause. The EE cause is added to the 2015 Rule. (3) Add Fail-to-run<1H and Fail-to-run>1H to the 2015 Rule as it includes standby SW system.
						2.1.8.7	SWS-MDP-FR-EE	2	6.1	New CCF rule
		1.3.9.1	HPI-MDP-FS	1	157.10	2.1.9.1	HPI-MDP-FS	1	162.7	

CCF Report		2012 Report / SPAR Rules 2012				2015 Report / SPAR Rules 2015A				Comments
Section Number (2012 Report -> 2015 Report)		Sub-Section	Rule Name	CCF Events	Ind. Events	Sub-Section	Rule Name	CCF Events	Ind. Events	
	1.3.9 PWR HPSI MDPs -> 2.1.9	1.3.9.2	HPI-MDP-FH	0	2.50	2.1.9.2	HPI-MDP-FH	0	2.5	
		1.3.9.3	HPI-MDP-FHRH	5	149.90	2.1.9.3	HPI-MDP-FHRH	8	146.4	New CCF 285-2013-0463
		1.3.9.4	HPI-MDP-RH	5	147.40	2.1.9.4	HPI-MDP-RH	8	143.9	
	1.3.10 PWR RHR MDPs -> 2.1.10	1.3.10.1	PWR-RHR-MDP-FS	3	33.50	2.1.10.1	PWR-RHR-MDP-FS	3	34.5	
		1.3.10.2	PWR-RHR-MDP-FH	1	3.00	2.1.10.2	PWR-RHR-MDP-FH	1	5.0	
		1.3.10.3	PWR-RHR-MDP-FHRH	1	12.90	2.1.10.3	PWR-RHR-MDP-FHRH	1	15.4	
		1.3.10.4	PWR-RHR-MDP-RH	0	9.90	2.1.10.4	PWR-RHR-MDP-RH	0	10.4	
	1.3.11 BWR SLC Pump -> 2.1.11	1.3.11.1	SLC-MDP-FS	1	14.50	2.1.11.1	SLC-MDP-FS	1	18.5	
						2.1.11.2	SLC-MDP-FH	0	2.0	The 2012 Report does not include the results for this rule
		1.3.11.2	SLC-MDP-FHRH	1	12.90	2.1.11.3	SLC-MDP-FHRH	0	4.2	The 2012 Report used the results for RHR system incorrectly
		1.3.11.3	SLC-MDP-RH	0	2.20	2.1.11.4	SLC-MDP-RH	0	2.2	
	1.3.12 CCW Pump -> 2.1.12	1.3.12.1	CCW-MDP-FS	0	84.70	2.1.12.1	CCW-MDP-FS	0	92.7	
		1.3.12.2	CCW-MDP-FR	2	59.50	2.1.12.2	CCW-MDP-FR	1	72.1	
	1.3.13 PDPs -> 2.1.13	1.3.13.1	ALL-PDP-FS	1	99.60	2.1.13.1	ALL-PDP-FS	1	112.6	
		1.3.13.2	ALL-PDP-FR	2	97.30	2.1.13.2	ALL-PDP-FR	4	99.4	
1.4 TDPs -> 2.2	1.4.1 Pooled TDPs -> 2.2.1	1.4.1.1	ALL-TDP-FS	1	183.90	2.2.1.1	ALL-TDP-FS	1	213.0	
		1.4.1.2	ALL-TDP-FH	0	66.10	2.2.1.2	ALL-TDP-FH	0	69.6	
		1.4.1.3	ALL-TDP-FHRH	0	154.10	2.2.1.3	ALL-TDP-FHRH	0	91.0	The 2012 Report result included Fail-to-Run failure mode. Remove FTR failure mode from this rule
		1.4.1.4	ALL-TDP-RH	0	88.00	2.2.1.4	ALL-TDP-RH	0	21.4	The 2012 Report result included Fail-to-Run failure mode. Remove FTR failure mode from this rule
						2.2.1.5	ALL-TDP-FR-NR	0	98.2	Add a new rule for Normal Running TDP Fail-to-Run
	1.4.2 AFW TDPs -> 2.2.2	1.4.2.1	AFW-TDP-FS	0	73.90	2.2.2.1	AFW-TDP-FS	0	89.0	
		1.4.2.2	AFW-TDP-FH	0	41.50	2.2.2.2	AFW-TDP-FH	0	44.0	

CCF Report		2012 Report / SPAR Rules 2012				2015 Report / SPAR Rules 2015A				Comments
Section Number (2012 Report -> 2015 Report)		Sub-Section	Rule Name	CCF Events	Ind. Events	Sub-Section	Rule Name	CCF Events	Ind. Events	
		1.4.2.3	AFW-TDP-FHRH	0	53.50	2.2.2.3	AFW-TDP-FHRH	0	59.3	
		1.4.2.4	AFW-TDP-RH	0	12.00	2.2.2.4	AFW-TDP-RH	0	15.3	
	1.4.3 BWR HPCI/RCIC TDPs -> 2.2.3	1.4.3.1	HCI-RCI-TDP-FS	1	96.00	2.2.3.1	HCI-RCI-TDP-FS	1	108.0	
		1.4.3.2	HCI-RCI-TDP-FH	0	24.60	2.2.3.2	HCI-RCI-TDP-FH	0	25.6	
		1.4.3.3	HCI-RCI-TDP-FHRH	0	28.60	2.2.3.3	HCI-RCI-TDP-FHRH	0	31.7	
		1.4.3.4	HCI-RCI-TDP-RH	0	4.00	2.2.3.4	HCI-RCI-TDP-RH	0	6.1	
1.5 MOVs -> 2.3	1.5.1 Pooled MOVs -> 2.3.1	1.5.1.1	ALL-MOV-FTOC	9	528.60	2.3.1.1	ALL-MOV-FTOC	9	625.7	
		1.5.1.2	ALL-MOV-CC	4	299.80	2.3.1.2	ALL-MOV-CC	4	356.9	
		1.5.1.3	ALL-MOV-OO	5	208.80	2.3.1.3	ALL-MOV-OO	5	239.3	
		1.5.1.4	ALL-MOV-CO	1	29.00	2.3.1.4	ALL-MOV-CO	1	43.0	
						2.3.1.5	ALL-MOV-LK	3	67.1	New CCF rule
	1.5.2 PWR Containment Spray MOVs -> 2.3.2	1.5.2.1	CSS-MOV-FTOC	0	28.50	2.3.2.1	CSS-MOV-FTOC	0	38.0	
		1.5.2.2	CSS-MOV-CC	0	18.50	2.3.2.2	CSS-MOV-CC	0	24.0	
		1.5.2.3	CSS-MOV-OO	0	10.00	2.3.2.3	CSS-MOV-OO	0	14.0	
	1.5.3 BWR RHR MOVs -> 2.3.3	1.5.3.1	BWR-RHR-MOV-FTOC	2	127.50	2.3.3.1	BWR-RHR-MOV-FTOC	2	143.0	
		1.5.3.2	BWR-RHR-MOV-CC	1	77.20	2.3.3.2	BWR-RHR-MOV-CC	1	87.2	
		1.5.3.3	BWR-RHR-MOV-OO	1	47.30	2.3.3.3	BWR-RHR-MOV-OO	1	52.8	
	1.5.4 BWR Isolation Condenser MOVs -> 2.3.4	1.5.4.1	ISO-MOV-FTOC	0	8.10	2.3.4.1	ISO-MOV-FTOC	0	8.1	
		1.5.4.2	ISO-MOV-CC	0	6.10	2.3.4.2	ISO-MOV-CC	0	6.1	
		1.5.4.3	ISO-MOV-OO	0	2.00	2.3.4.3	ISO-MOV-OO	0	2.0	
	1.5.5 PWR AFW MOVs -> 2.3.5	1.5.5.1	AFW-MOV-FTOC	3	63.80	2.3.5.1	AFW-MOV-FTOC	3	84.8	
		1.5.5.2	AFW-MOV-CC	1	34.20	2.3.5.2	AFW-MOV-CC	1	44.2	
		1.5.5.3	AFW-MOV-OO	2	28.60	2.3.5.3	AFW-MOV-OO	2	37.6	
	1.5.6 PWR HPSI MOVs -> 2.3.6	1.5.6.1	HPI-MOV-FTOC	0	64.60	2.3.6.1	HPI-MOV-FTOC	0	72.6	
		1.5.6.2	HPI-MOV-CC	0	30.60	2.3.6.2	HPI-MOV-CC	0	36.1	
		1.5.6.3	HPI-MOV-OO	0	30.00	2.3.6.3	HPI-MOV-OO	0	32.0	
	1.5.7 PWR RHR MOVs -> 2.3.7	1.5.7.1	PWR-RHR-MOV-FTOC	1	87.70	2.3.7.1	PWR-RHR-MOV-FTOC	1	103.7	
		1.5.7.2	PWR-RHR-MOV-CC	1	57.10	2.3.7.2	PWR-RHR-MOV-CC	1	65.6	

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		1.5.7.3	PWR-RHR-MOV-OO	0	28.60	2.3.7.3	PWR-RHR-MOV-OO	0	32.1	
	1.5.8 BWR HPCI/RCIC MOVs -> 2.3.8	1.5.8.1	HCI-RCI-MOV-FTOC	2	80.80	2.3.8.1	HCI-RCI-MOV-FTOC	2	94.4	
		1.5.8.2	HCI-RCI-MOV-CC	1	41.00	2.3.8.2	HCI-RCI-MOV-CC	1	50.1	
		1.5.8.3	HCI-RCI-MOV-OO	1	34.80	2.3.8.3	HCI-RCI-MOV-OO	1	38.3	
	1.5.9 Pressurizer PORV Block MOVs -> 2.3.9	1.5.9.1	PWR-RCS-MOV-CC	0	5.00	2.3.9.1	PWR-RCS-MOV-CC	0	7.0	
		1.5.9.2	PWR-RCS-MOV-OO	0	5.00	2.3.9.2	PWR-RCS-MOV-OO	0	7.0	
1.6 AOVs -> 2.4	1.6.1 Pooled AOVs -> 2.4.1	1.6.1.1	ALL-AOV-FTOC	12	234.10	2.4.1.1	ALL-AOV-FTOC	14	266.2	New CCF 285-2015-0509
		1.6.1.2	ALL-AOV-CC	5	135.20	2.4.1.2	ALL-AOV-CC	6	156.8	
		1.6.1.3	ALL-AOV-OO	7	93.40	2.4.1.3	ALL-AOV-OO	7	98.4	
						2.4.1.4	ALL-AOV-SO	1	56.1	New CCF rule
	1.6.2 BWR Isolation Condenser AOVs -> 2.4.2	1.6.2.1	ISO-AOV-FTOC	1	1.00	2.4.2.1	ISO-AOV-FTOC	1	1.0	
		1.6.2.2	ISO-AOV-CC	0	1.00	2.4.2.2	ISO-AOV-CC	0	1.0	
		1.6.2.3	ISO-AOV-OO	1	0.00	2.4.2.3	ISO-AOV-OO	1	0.0	
	1.6.3 PWR AFW AOVs -> 2.4.3	1.6.3.1	AFW-AOV-FTOC	12	234.10	2.4.3.1	AFW-AOV-FTOC	6	65.1	AFW system was missed from the 2012 Rule and 2012 Report incorrectly.
		1.6.3.2	AFW-AOV-CC	3	30.60	2.4.3.2	AFW-AOV-CC	3	35.1	
		1.6.3.3	AFW-AOV-OO	2	24.50	2.4.3.3	AFW-AOV-OO	2	28.0	
	1.6.4 HPCI/RCIC AOVs -> 2.4.4	1.6.4.1	HCI-RCI-AOV-FTOC	0	4.00	2.4.4.1	HCI-RCI-AOV-FTOC	0	5.0	
		1.6.4.2	HCI-RCI-AOV-CC	0	3.00	2.4.4.2	HCI-RCI-AOV-CC	0	4.0	
		1.6.4.3	HCI-RCI-AOV-OO	0	1.00	2.4.4.3	HCI-RCI-AOV-OO	0	1.0	
1.7 CKVs -> 2.5	1.7.1 Pooled CKVs -> 2.5.1	1.7.1.1	ALL-CKV-CC	0	9.00	2.5.1.1	ALL-CKV-CC	0	10.0	
		1.7.1.2	ALL-CKV-OO	2	40.00	2.5.1.2	ALL-CKV-OO	2	49.1	
		1.7.1.3	ALL-CKV-CO	0	0.00	2.5.1.3	ALL-CKV-CO	0	0.0	
		1.7.1.4	ALL-CKV-LK	7	48.10	2.5.1.4	ALL-CKV-LK	7	53.1	
	1.7.2 BWR RHR CKVs -> 2.5.2	1.7.2.1	BWR-RHR-CKV-CC	0	2.00	2.5.2.1	BWR-RHR-CKV-CC	0	2.0	
		1.7.2.2	BWR-RHR-CKV-OO	0	6.00	2.5.2.2	BWR-RHR-CKV-OO	0	6.0	
	1.7.3 PWR AFW CKVs -> 2.5.3	1.7.3.1	AFW-CKV-CC	0	2.00	2.5.3.1	AFW-CKV-CC	0	2.0	
		1.7.3.2	AFW-CKV-OO	1	6.00	2.5.3.2	AFW-CKV-OO	1	6.6	
		1.7.4.1	HPI-CKV-CC	0	3.00	2.5.4.1	HPI-CKV-CC	0	3.0	

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	1.7.4 PWR HPSI CKVs -> 2.5.4	1.7.4.2	HPI-CKV-OO	0	8.50	2.5.4.2	HPI-CKV-OO	0	8.5	
	1.7.5 PWR RHR CKVs -> 2.5.5	1.7.5.1	PWR-RHR-CKV-CC	0	0.00	2.5.5.1	PWR-RHR-CKV-CC	0	0.0	
		1.7.5.2	PWR-RHR-CKV-OO	0	7.50	2.5.5.2	PWR-RHR-CKV-OO	0	8.5	
	1.7.6 BWR HPCI/RCIC CKVs -> 2.5.6	1.7.6.1	HCI-RCI-CKV-CC	0	1.00	2.5.6.1	HCI-RCI-CKV-CC	0	1.0	
		1.7.6.2	HCI-RCI-CKV-OO	0	4.00	2.5.6.2	HCI-RCI-CKV-OO	0	6.0	
1.8 STR/TSA/SMP -> 2.6	1.8.1 Pooled Strainers (Non-ESW) -> 2.6.1 Pooled Strainers					2.6.1.1	ALL-TSA-PG	18	40.0	New CCF rule
						2.6.1.2	ALL-TSA-PG-EE	18	31.0	Copy 2012 Rule ESW-TSA-EE-PG to ALL-TSA-PG-EE for this pool distribution subsection.
						2.6.1.3	ALL-TSA-PG -> ALL-TSA-PG-NE	0	9.0	2012 Rule ALL-TSA-PG should be ALL-TSA-PG-NE. Re-run 2012 rule and got 0/9.0. Add to this subsection for pool distribution.
						2.6.1.4	ALL-TSA-FO-NE	13	79.0	Copy 2012 Rule ESW-TSA-FO to ALL-TSA-NE-FO for this pool distribution subsection.
		1.8.1.1	CLN-STR-PG	0	0.00	2.6.1.5	CLN-STR-PG	0	0.0	
	1.8.2 ESW Strainers -> 2.6.2 SW Strainers	1.8.2.1	ESW-TSA-FO	2	30.00	2.6.2.1	SWS-TSA-FO-NE	3	32.0	(1) The section (1.8.2 or 2.6.2) title is changed from "Emergency Service Water Strainers" to "Service Water Strainers". (2) The 2012 Rule includes CWS, which would be ALL-TSA-NE-FO (run for 2012 and got 12/74.0). Add ALL-TSA-NE-FO to previous subsection 2.6.1. (3) Remove CWS from the rule and rename the rule by adding NE. Run the rule for 2012 and got 3/30.0.

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						2.6.2.2	SWS-TSA-PG	1	4.0	New CCF rule
						2.6.2.3	SWS-TSA-PG-EE	1	3.0	The rule was moved from previous EE Event Strainers Section (previously 1.8.6, currently 2.6.6)
		1.8.2.2	ESW-TSA-PG	0	10.00	2.6.2.4	SWS-TSA-PG-NE	0	1.0	(1) The 2012 Rule includes CWS, which would be ALL-TSA-NE-PG. Add ALL-TSA-NE-PG to previous subsection 2.6.1. (2) Remove CWS from the rule and rename the rule by adding NE (the 2010 Rule has a result of 0/1 with no CWS in the rule).
		1.8.2.3	ESW-STR-PG	1	32.00	2.6.2.7	SWS-STR-PG-NE	1	31.0	Rename the rule by adding NE.
		1.8.2.4	ESW-STR-POOL-PG	1	32.00	2.6.2.5	SWS-STR-PG	7	47.0	2012 Report has the same rule and results as the NE rule (Section 1.8.2.3). Revise the rule for all causes and rename the rule as SWS-STR-PG (run the rule with All causes from 1997 to 2012 is 7/45.5).
						2.6.2.6	SWS-STR-PG-EE	6	16.0	The rule was moved from previous EE Event Strainers Section (previously 1.8.6, currently 2.6.6)
	1.8.3 Pooled Sump Strainers -> 2.6.3	1.8.3.1	ALL-SMP-PG	0	1.50	2.6.3.1	ALL-SMP-PG	0	1.5	
	1.8.4 PWR Containment Sump Strainers -> 2.6.4	1.8.4.1	CSS-STR-PG	0	0.00	2.6.4.1	CSS-STR-PG	0	0.0	
	1.8.5 BWR Suppression Pool Strainers -> 2.6.5	1.8.5.1	BWR-RHR-STR-PG	0	0.00	2.6.5.1	BWR-RHR-STR-PG	0	0.0	
		1.8.6.1	CWS-TSA-EE-PG	16	23.00	2.6.6.1	CWS-TSA-PG-EE	17	28.0	

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	1.8.6 Extreme Environmental Event Strainers -> 2.6.6 CSW Strainers	1.8.6.2	CWS-TSA-PG -> CWS-TSA-NE-PG	0	9.00	2.6.6.2	CWS-TSA-PG -> CWS-TSA-PG-NE	0	8.0	Rename the rule by adding NE to be consistent with the rule criteria.
		1.8.6.3	ESW-STR-EE-PG	5	15.00	2.6.6.3 -> 2.6.2.6	SWS-STR-PG-EE	6	16.0	
		1.8.6.4	ESW-TSA-EE-PG	17	26.00	2.6.6.4 -> 2.6.2.3	SWS-TSA-PG-EE	18->1	31.00->3.0	2012 Rule includes CWS, which would be ALL-TSA-EE-PG (run for 2012 and got 18/29.0). Add ALL-TSA-EE-PG to previous subsection 2.6.1. Remove CWS from the ESW rule. Run the rule for 2012 and got 1/3.0
1.9 HTXs -> 2.7	1.9.1 PWR HTXs -> 2.7.2	1.9.1.1	PWR-RHR-HTX-HT	0	1.10	2.7.2.1	PWR-RHR-HTX-HT	0	1.1	
						2.7.1.1	ALL-HTX-HT	2	26.2	New CCF rule
						2.7.1.2	ALL-HTX-HT-EE	1	6.5	New CCF rule
	1.9.2 Pooled HTXs -> 2.7.1	1.9.2.1	ALL-HTX-HT	1	19.70	2.7.1.3	ALL-HTX-HT-NE	1	19.7	Rename the rule by adding NE to be consistent with the rule criteria.
	1.9.3 CS HTXs -> 2.7.3	1.9.3.1	CSS-HTX-HT	0	3.50	2.7.3.1	CSS-HTX-HT	0	3.5	
	1.9.4 BWR RHR HTXs -> 2.7.4	1.9.4.1	BWR-RHR-HTX-HT	0	2.00	2.7.4.1	BWR-RHR-HTX-HT	0	2.0	
	1.9.5 BWR IS HTXs -> 2.7.5	1.9.5.1	ISO-HTX-HT	0	0.00	2.7.5.1	ISO-HTX-HT-NE	0	0.0	Rename the rule by adding NE to be consistent with the rule criteria.
	1.9.6 CCW HTXs -> 2.7.6					2.7.6.1	CCW-HTX-HT	2	19.1	New CCF rule
						2.7.6.2	CCW-HTX-HT-EE	1	6.0	New CCF rule
		1.9.6.1	CCW-HTX-HT	1	11.60	2.7.6.3	CCW-HTX-HT-NE	1	13.1	Rename the rule by adding NE to be consistent with the rule criteria.
1.10 SRVs -> 2.8	1.10.1 Pooled SVs -> 2.8.1	1.10.1.1	ALL-SVV-CC	3	3.50	2.8.1.1	ALL-SVV-CC	3	3.5	
		1.10.1.2	ALL-SVV-OO	1	7.00	2.8.1.2	ALL-SVV-OO	1	7.0	
	1.10.2 PWR SG SVs -> 2.8.2	1.10.2.1	PWR-MSS-SVV-CC	3	1.00	2.8.2.1	PWR-MSS-SVV-CC	3	1.0	
		1.10.2.2	PWR-MSS-SVV-OO	1	6.00	2.8.2.2	PWR-MSS-SVV-OO	1	6.0	
		1.10.3.1	BWR-MSS-SRV-CC	6	22.00	2.8.3.1	BWR-MSS-SRV-CC	7	29.6	New CCF 298-2015-0493

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	1.10.3 BWR SRVs -> 2.8.3	1.10.3.2	BWR-MSS-SRV-OO	0	7.10	2.8.3.2	BWR-MSS-SRV-OO	0	7.6	
						2.8.3.3	BWR-MSS-SRV-CO	1	11.0	New CCF rule
	1.10.4 PWR PZR SVs -> 2.8.4	1.10.4.1	PWR-RCS-SVV-CC	0	2.50	2.8.4.1	PWR-RCS-SVV-CC	0	2.5	
		1.10.4.2	PWR-RCS-SVV-OO	0	1.00	2.8.4.2	PWR-RCS-SVV-OO	0	1.0	
1.11 PORVs -> 2.9	1.11.1 Pooled PORVs -> 2.9.1	1.11.1.1	ALL-PORV-CC	9	103.30	2.9.1.1	ALL-PORV-CC	8	109.4	2012 result include Common Mode (explicitly modeled) Events
		1.11.1.2	ALL-PORV-OO	1	35.60	2.9.1.2	ALL-PORV-OO	1	40.1	
	1.11.2 PWR SG PORVs -> 2.9.2	1.11.2.1	PWR-MSS-PRV-CC	7	82.20	2.9.2.1	PWR-MSS-PRV-CC	6	86.7	2012 result include Common Mode (explicitly modeled) Events
		1.11.2.2	PWR-MSS-PRV-OO	1	29.50	2.9.2.2	PWR-MSS-PRV-OO	1	32.6	
	1.11.3 PWR PZR PORVs -> 2.9.3	1.11.3.1	PWR-RCS-PORV-CC	2	19.10	2.9.3.1	PWR-RCS-PORV-CC	2	20.6	
		1.11.3.2	PWR-RCS-PORV-OO	0	5.10	2.9.3.2	PWR-RCS-PORV-OO	0	5.5	
1.12 MSIVs -> 2.10	1.12.1 PWR MSIVs -> 2.10.1	1.12.1.1	PWR-MSS-MSV-CC	2	18.30	2.10.1.1	PWR-MSS-MSV-CC	2	21.9	
		1.12.1.2	PWR-MSS-MSV-OO	6	30.40	2.10.1.2	PWR-MSS-MSV-OO	6	35.3	
	1.12.2 BWR MSIVs -> 2.10.2	1.12.2.1	BWR-MSS-MSV-CC	1	4.10	2.10.2.1	BWR-MSS-MSV-CC	1	4.3	
		1.12.2.2	BWR-MSS-MSV-OO	2	8.90	2.10.2.2	BWR-MSS-MSV-OO	3	11.4	New CCF 366-2015-0494
1.13 Generators -> 2.11	1.13.1 EDGs -> 2.11.1	1.13.1.1	EPS-EDG-FS	4	231.40	2.11.1.1	EPS-EDG-FS	4	258.4	
		1.13.1.2	EPS-EDG-LR	3	239.60	2.11.1.2	EPS-EDG-LR	5	271.3	New CCFs 324-2015-0497 and 333-2013-0454
		1.13.1.3	EPS-EDG-FR	5	166.80	2.11.1.3	EPS-EDG-FR	6	222.0	New CCF 323-2014-0489
1.14 VACs -> 2.12	1.14.1 BWR Suppression VACs -> 2.12.1	1.14.1.1	CVR-VAC-CC	1	8.50	2.12.1.1	CVR-VAC-CC	1	9.5	
1.15 AC Breakers -> 2.13	1.15.1 480VAC Circuit Breakers -> 2.13.1	1.15.1.1	ACP-CRB-480-CC	3	25.20	2.13.1.1	ACP-CRB-480-CC	3	32.3	
		1.15.1.2	ACP-CRB-480-OO	1	55.20	2.13.1.2	ACP-CRB-480-OO	1	59.2	
		1.15.1.3	ACP-CRB-480-SA	0	56.20	2.13.1.3	ACP-CRB-480-SA	1	65.2	
						2.13.1.4	ACP-CRB-480-FTOC	4	92.5	New CCF rule
	1.15.2 4160VAC Circuit Breakers -> 2.13.2	1.15.2.1	ACP-CRB-4160-CC	2	15.10	2.13.2.1	ACP-CRB-4160-CC	2	17.6	
		1.15.2.2	ACP-CRB-4160-OO	0	64.30	2.13.2.2	ACP-CRB-4160-OO	0	78.3	
		1.15.2.3	ACP-CRB-4160-SA	3	38.50	2.13.2.3	ACP-CRB-4160-SA	3	44.5	2012 Report used -CO instead of -SA

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						2.13.2.4	ACP-CRB-4160-FTOC	2	103.4	New CCF rule
1.16 DC Systems -> 2.14	1.16.1 Batteries -> 2.14.1	1.16.1.1	DCP-BAT-NO	0	59.20	2.14.1.1	DCP-BAT-NO	1	32.1	Re-run 2012 rule and got 1/28.7. Failure mode UA (maintenance or out due to the state of another component) has been removed from the count of failures.
	1.16.2 Battery Chargers -> 2.14.2	1.16.2.1	DCP-BCH-FC	0	0.00	2.14.2.1	DCP-BCH-FC	9	319.0	Re-run 2012 rule and got 9/270.5
		1.16.2.2	DCP-BCH-LP	0	281.50					In 2012 Report but not in SPAR Rules. SPAR uses only one DCP-BCH rule now.
	1.16.3 Circuit Breakers -> 2.14.3	1.16.3.1	DCP-CRB-CC	0	1.50	2.14.3.1	DCP-CRB-CC	0	1.5	
		1.16.3.2	DCP-CRB-OO	0	11.00	2.14.3.2	DCP-CRB-OO	0	13.0	
		1.16.3.3	DCP-CRB-SA	0	14.50	2.14.3.3	DCP-CRB-SA	0	8.6	
						2.14.3.4	DCP-CRB-FTOC	0	14.5	New CCF rule
1.17 RPS Rx Trip Breakers -> 2.15 Rx Trip Breakers	1.17.1 Rx Trip Breakers -> 2.15.1 RPS Rx Trip Breakers	1.17.1.1	RPS-RTB-CC	0	7.00	2.15.1.1	RPS-RTB-CC	0	8.6	Change 1.17 title to "Reactor Trip Breakers" and change 1.17.1 title to "Rreactor Protection System Reactor Trip Breakers".
1.18 MDCs -> 2.16	1.18.1 Motor-Driven Air Compressors -> 2.16.1	1.18.1	ALL-MDC-FS	2	234.60	2.16.1.1	ALL-MDC-FS	2	297.2	
		1.18.2	ALL-MDC-FR	3	577.60	2.16.1.2	ALL-MDC-FR	4	729.7	Re-run 2012 rule also got 4 CCFs
2.2 Generic Distributions -> 3.1	2.2.1 Demand -> 3.1.1	2.2.1.1	CCF-DEM	102	3104.30	3.1.1.1	CCF-DEM	107	3598.9	Re-run 2012 Rule with "CCF Events Only" event type selected and got 101/3176.6. There are 6 new CCF after the year of 2012.
	2.2.2 Rate -> 3.1.2	2.2.2.1	CCF-RATE	108	2658.10	3.1.2.1	CCF-RATE	116	3224.0	Re-run 2012 Rule with "CCF Events Only" event type selected and got 111/2743.9. There are 5 new CCF after the year of 2012.

CCF Report		2012 Report / SPAR Rules 2012				2015 Report / SPAR Rules 2015A				Comments
Section Number (2012 Report -> 2015 Report)		Sub-Section	Rule Name	CCF Events	Ind. Events	Sub-Section	Rule Name	CCF Events	Ind. Events	
	2.2.3 CCF Prior -> 3.1.3	2.2.3.1	CCF ALL			3.1.3.1	CCF ALL			Use the same no data prior as in the 2012 Report.

Appendix B Matrix Between ZA Templates and CCF Rules

ZA Template Name	NROD Rule Name
ZA-AOV-FTOC	2.4.1.1 ALL-AOV-FTOC
ZA-AOV-FTOC-AFW	2.4.3.1 AFW-AOV-FTOC
ZA-AOV-SO	2.4.1.4 ALL-AOV-SO
ZA-ARV-CC-MSS	2.9.2.1 PWR-MSS-PRV-CC
ZA-BAT-LP	2.14.1.1 DCP-BAT-NO
ZA-BCH-LP	2.14.2.1 DCP-BCH-FC
ZA-CCF-ALL	3.1.3.1 CCF ALL
ZA-CCF-DEM	3.1.1.1 CCF-DEM
ZA-CCF-RATE	3.1.2.1 CCF-RATE
ZA-CKV-CC	2.5.1.1 ALL-CKV-CC
ZA-CKV-CO	2.5.1.3 ALL-CKV-CO
ZA-CKV-OO	2.5.1.2 ALL-CKV-OO
ZA-CRB-CO-4160	2.13.2.3 ACP-CRB-4160-SA
ZA-CRB-CO-480	2.13.1.3 ACP-CRB-480-SA
ZA-CRB-CO-DCP	2.14.3.3 DCP-CRB-SA
ZA-CRB-FTOC-4160	2.13.2.4 ACP-CRB-4160-FTOC
ZA-CRB-FTOC-480	2.13.1.4 ACP-CRB-480-FTOC
ZA-CRB-FTOC-DCP	2.14.3.4 DCP-CRB-FTOC
ZA-DGN-FR	2.11.1.3 EPS-EDG-FR
ZA-DGN-FS	2.11.1.1 EPS-EDG-FS
ZA-DGN-LR	2.11.1.2 EPS-EDG-LR
ZA-HTX-PE	2.7.1.2 ALL-HTX-HT-EE
ZA-HTX-PE-CCW	2.7.6.2 CCW-HTX-HT-EE
ZA-HTX-PG	2.7.1.1 ALL-HTX-HT
ZA-HTX-PG-CCW	2.7.6.1 CCW-HTX-HT
ZA-MDC-FR	2.16.1.2 ALL-MDC-FR
ZA-MDC-FS	2.16.1.1 ALL-MDC-FS
ZA-MDP-FE-SWS	2.1.8.7 SWS-MDP-FR-EE
ZA-MDP-FR	2.1.1.3 ALL-MDP-FHRH
ZA-MDP-FR-AFW	2.1.6.3 AFW-MDP-FHRH
ZA-MDP-FR-CCW	2.1.12.2 CCW-MDP-FR
ZA-MDP-FR-CSS	2.1.4.3 CSS-MDP-FHRH
ZA-MDP-FR-HPI-PWR	2.1.9.3 HPI-MDP-FHRH
ZA-MDP-FR-NR	2.1.1.5 ALL-MDP-FR-NR
ZA-MDP-FR-NR-SWS	2.1.8.2 SWN-MDP-FR
ZA-MDP-FR-NS	2.1.1.3 ALL-MDP-FHRH
ZA-MDP-FR-NS-SWS	2.1.8.4 SSW-MDP-FR
ZA-MDP-FR-RHR-BWR	2.1.5.3 BWR-RHR-MDP-FHRH
ZA-MDP-FR-RHR-PWR	2.1.10.3 PWR-RHR-MDP-FHRH
ZA-MDP-FS	2.1.1.1 ALL-MDP-FS
ZA-MDP-FS-AFW	2.1.6.1 AFW-MDP-FS
ZA-MDP-FS-CCW	2.1.12.1 CCW-MDP-FS
ZA-MDP-FS-CSS	2.1.4.1 CSS-MDP-FS
ZA-MDP-FS-HPI-PWR	2.1.9.1 HPI-MDP-FS
ZA-MDP-FS-NR	2.1.1.7 ALL-MDP-FS-NR
ZA-MDP-FS-NR-SWS	2.1.8.1 SWN-MDP-FS
ZA-MDP-FS-NS	2.1.1.6 ALL-MDP-FS-NS

ZA Template Name	NROD Rule Name
ZA-MDP-FS-NS-SWS	2.1.8.3 SSW-MDP-FS
ZA-MDP-FS-RHR-BWR	2.1.5.1 BWR-RHR-MDP-FS
ZA-MDP-FS-RHR-PWR	2.1.10.1 PWR-RHR-MDP-FS
ZA-MOV-FTOC	2.3.1.1 ALL-MOV-FTOC
ZA-MOV-FTOC-AFW	2.3.5.1 AFW-MOV-FTOC
ZA-MOV-FTOC-HCIRCI	2.3.8.1 HCI-RCI-MOV-FTOC
ZA-MOV-FTOC-HPI-P	2.3.6.1 HPI-MOV-FTOC
ZA-MOV-FTOC-RHR-B	2.3.3.1 BWR-RHR-MOV-FTOC
ZA-MOV-FTOC-RHR-P	2.3.7.1 PWR-RHR-MOV-FTOC
ZA-MOV-SO	2.3.1.4 ALL-MOV-CO
ZA-MSV-CC-BWR	2.10.2.1 BWR-MSS-MSV-CC
ZA-MSV-CC-PWR	2.10.1.1 PWR-MSS-MSV-CC
ZA-MSV-OO-BWR	2.10.2.2 BWR-MSS-MSV-OO
ZA-MSV-OO-PWR	2.10.1.2 PWR-MSS-MSV-OO
ZA-PDP-FR	2.1.13.2 ALL-PDP-FR
ZA-PDP-FS	2.1.13.1 ALL-PDP-FS
ZA-PMP-FR	2.1.2.1 ALL-PMP-FR
ZA-PMP-FR-AFW	2.1.7.1 AFW-PMP-FR
ZA-PRV-CC-PZR	2.9.3.1 PWR-RCS-PORV-CC
ZA-PRV-OO-PZR	2.9.3.2 PWR-RCS-PORV-OO
ZA-RTB-CC	2.15.1.1 RPS-RTB-CC
ZA-SMP-PG	2.6.3.1 ALL-SMP-PG
ZA-SRV-CC-BWR	2.8.3.1 BWR-MSS-SRV-CC
ZA-SRV-CO-BWR	2.8.3.3 BWR-MSS-SRV-CO
ZA-SRV-OO-BWR	2.8.3.2 BWR-MSS-SRV-OO
ZA-STR-PE-SWS	2.6.2.6 SWS-STR-PG-EE
ZA-STR-PG-SWS	2.6.2.5 SWS-STR-PG
ZA-SVV-CC-MSS	2.8.2.1 PWR-MSS-SVV-CC
ZA-SVV-CC-PZR	2.8.4.1 PWR-RCS-SVV-CC
ZA-TDP-FR	2.2.1.3 ALL-TDP-FHRH
ZA-TDP-FR-AFW	2.2.2.3 AFW-TDP-FHRH
ZA-TDP-FS	2.2.1.1 ALL-TDP-FS
ZA-TDP-FS-AFW	2.2.2.1 AFW-TDP-FS
ZA-TSA-PE-SWS	2.6.2.3 SWS-TSA-PG-EE
ZA-TSA-PG-SWS	2.6.2.2 SWS-TSA-PG