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CCF Parameter Estimations, 2020 Update

November 2021

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ABSTRACT

This report documents the quantitative results of the common-cause failure (CCF) data collection effort (which included data through 2020) and summarizes the results of the parameter estimation quantification process performed on CCF data in the U.S. Nuclear Regulatory Commission (NRC) CCF database. This is the 2020 update to NUREG/CR-5497, updating data and parameter estimations for CCFs.

This release, CCF Parameter Estimation 2020, reflects the CCF data contained within the CCF database, https://rads.inl.gov/Pages/CCF.aspx, by executing (in August 2021) the CCF query rules in the folder *SPAR Rules 2020*. The data covers the period from 1/1/2006 to 12/31/2020, the most recent 15-year period in which data are available. The use of the most recent rolling 15-year data in parameter estimation differs from previous updates, in which 1/1/1997 was used as the starting date (e.g., 1/1/1997 to 12/31/2015 for the 2015 update, 1/1/1997 to 12/31/2012 for the 2012 update). The new date range (i.e., the most recent 15-year period), was selected for this CCF update so as to be consistent with the date range chosen for the component reliability parameter estimation, and with the effort to include sufficient data for analysis while simultaneously reflecting the most recent industry performance.

These results are appropriate for use in probabilistic risk assessment (PRA) studies, including the Standardized Plant Analysis Risk (SPAR) models of commercial nuclear power plants (NPPs) in the U.S.

This update may be referred as: U.S. Nuclear Regulatory Commission, "CCF Parameter Estimations, 2020 Update," https://nrcoe.inl.gov/publicdocs/CCF/ccfparamest2020.pdf, November 2021.

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ACRONYMS

ACP	ac power
AFW	auxiliary feedwater
ANS	American Nuclear Society
AOV	air-operated valve
ASME	American Society of Mechanical Engineers
BAT	battery
BCH	battery charger
BWR	boiling water reactor
CC	fail to open
CCCG	common-cause component group
CCF	common-cause failure
CCW	component cooling water
CKV	check valve
CLN	clean
CRB	circuit breaker
CS	containment spray
CSS	containment spray system
CWS	circulating water system
DCP	dc power
EE	extreme environmental
EDG	emergency diesel generator
EPIX	Equipment Performance and Information Exchange
EPS	emergency power supply
FC	fail to control
FH	first hour
FHRH	first hour remaining hours
FR	fail to run
FS	fail to start
FTC	fail to close
FTCL	fail to close after passing liquid
FTFR	failure to transfer
FTLR	fail to load and run
FTO	fail to open
FTOC	fail to open or close
FTOP	fail to operate
FTR>1H	fail to run after 1 hour of operation
FTR≤1H	fail to run for 1 hour of operation
FTS	fail to start
HCI	high-pressure coolant injection

HPI	high-pressure safety injection
HTX	heat exchanger
ICES	INPO Consolidated Events Database
INL	Idaho National Laboratory
INPO	Institute of Nuclear Power Operations
IRIS	Industry Reporting and Information System
LCI	low-pressure coolant injection
LCS	low-pressure core spray
LER	licensee event report
LK	leakage
LPI	low-pressure injection
LR	fail to load and run
MDC	motor-driven air compressor
MDP	motor-driven pump
MFW	main feedwater
MOV	motor-operated valve
MSIV	main steam isolation valve
MSS	main steam system
MSSV	main steam stop valve
NE	non-extreme environment
NPP	nuclear power plant
NPRDS	Nuclear Plant Reliability Database System
NR	normally running
NRC	U.S. Nuclear Regulatory Commission
NUCLARR	Nuclear Computerized Library for Assessing Reactor Reliability
OO	fail to close
OOS	out of specification
OpE	operating experience
PDP	positive displacement pump
PG	plug
PMP	pump volute
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PWR	pressurized water reactor
RADS	Reliability and Availability Database System
RCI	reactor core isolation cooling
RCIC	reactor core isolation cooling
RCS	reactor coolant system
RH	remaining hours
RHR	residual heat removal
RPS	reactor protection system

RTB	reactor trip breaker
SCSS	Sequence Coding and Search System
SLC	standby liquid control
SMP	sump
SO	spurious operation
SPAR	standardized plant analysis risk
SRV	safety relief valve (dual actuation)
SSW	standby service water system
STR	strainer
SVV	safety valve (single acting)
SW	service water
SWN	normally running service water system
SWS	service water system
TDP	turbine-driven pump
TSA	traveling screen assembly
VAC	vacuum breaker
UA	unavailability

CCF Parameter Estimations, 2020 Update

1. SUMMARY

1.1 Introduction

1.1.1 General CCF Information

A general conclusion from probabilistic risk assessments (PRAs) of commercial nuclear power plants (NPPs) is that common-cause failures (CCFs) are significant contributors to the loss of functions of safety systems. CCF is defined in the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) Standard ASME/ANS RA-Sa-2009 [1] as "a failure of two or more components during a short period of time as a result of a single shared cause." In the CCF database and analysis system (see NUREG/CR-6268, Revision 1, "Common Cause Failure Database and Analysis System, Event Data Collection, Classification, and Coding" [2]), 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 failure of equipment outside the established component boundary.

Since the 1980s, a series of U.S. Nuclear Regulatory Commission (NRC) reports have been published to provide guidelines for performing CCF modeling in PRA, and for performing CCF event data analysis (e.g., NUREG/CR-4780, "Procedures for Treating Common Cause Failures in Safety and Reliability Studies" [3], and NUREG/CR-5485, "Guidelines on Modeling Common-Cause Failures in Probabilistic Risk Assessment" [4]). For CCF data collection and analysis, Idaho National Laboratory (INL) and NRC's Office of Nuclear Regulatory Research have developed and maintained a CCF database system that stores coded CCF events, and a CCF software program that uses an impact vector and mapping method to estimate CCF parameters for the events stored in the CCF database [2]. The data collection effort encompasses CCF events from as far back as 1980 for use in CCF analyses. The current data collection effort has separated the data by nuclear plant system. The principal products of this CCF data collection and analysis system (CCF database) are a method of identifying and classifying CCF events, a CCF database containing both CCF events and independent failure counts, and CCF parameter estimation software.

Historically, three data sources have been used to select the 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 Institute of Nuclear Power Operations (INPO) Industry Reporting and Information System (IRIS)—formerly the INPO Consolidated Events Database (ICES) and the Equipment Performance and Information Exchange (EPIX)—which contains component failure information going back as far as 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. The CCF database can be accessed by NRC/INL staff and INPO members through the NRC Reliability and Availability Database System (RADS), https://rads.inl.gov/Pages/CCF.aspx.

1.1.2 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 across systems. The second level is the industry-wide component-specific distribution that is specific to system or system group. Then there are CCF parameter estimations for generic demand or rate failures.

It is up to the user to decide the level of pooling appropriate for the intended use. If sufficient data exist at the system/component level most appropriate for the intended use, it is recommended that the more specific data be used. Otherwise, it is recommended that the industry-level pooled component data be used. If no listed pooled components are appropriate for the intended use, the use of the No Data (Prior Only), Generic Demand, or Generic Rate pooled distribution in Section 3 of this report may be appropriate.

1.2 CCF Parameter Estimation History

1.2.1 Earlier History

The first CCF parameter estimations are documented in NUREG/CR-5497, "Common-Cause Failure Parameter Estimations" [5], with the data covering the time period of 1980–1995. A series of updates were conducted on the parameter estimations in the following years:

- CCF Parameter Estimations, 2003 Update [6] reflects the version of the CCF database that contains data from 1980 to 2003, though a starting date of 1/1/1985 was used to estimate CCF parameters in order to avoid using the large number of CCF events from the 1980–1984 period, as the trend is seen to decrease significantly from 1980 to 1985. The analysis also found that the previously recommended value of 0.85 for the mapping up factor, rho, was very conservative. A recommended rho value of 0.50 was used in the 2003 Update.
- CCF Parameter Estimations, 2005 Update [7] reflects the version of the CCF database that contains data from 1980 to 2005. A starting date of 1/1/1991 was used to avoid using the large number of CCF events from the 1980–1990 period, as the trend is seen to decrease significantly from 1980 to 1991.
- CCF Parameter Estimations, 2007 Update [8] reflects the version of the CCF database that contains data from 1980 to 2007. A starting date of 1/1/1991 was again used to avoid using the large number of CCF events from the 1980–1990 period.
- CCF Parameter Estimations, 2009 Update [9] reflects the version of the revamped CCF database that contains data from 1997 to 2009. The starting date is 1/1/1997. The large number of CCF events from the 1980–1996 period is excluded from the analysis (and subsequent analyses), as the trend is seen to decrease significantly from 1980 to 1997.
- CCF Parameter Estimations, 2010 Update [10] reflects the version of the CCF database that contains data from 1997 to 2010. The starting date is 1/1/1997.
- CCF Parameter Estimations, 2012 Update [11] reflects the version of the CCF database that contains data from 1997 to 2012. The starting date is 1/1/1997.

All the related NRC CCF parameter estimation reports can be located at the NRC operating experience (OpE) results website: https://nrcoe.inl.gov/ccf_pe/.

1.2.2 2015 Update

CCF Parameter Estimations, 2015 Update [12] reflects the version of the CCF database that contains data from 1997 to 2015 by executing (in October 2016) the query rules included under the folder *SPAR Rules 2015A* within the CCF database, https://rads.inl.gov/Pages/CCF.aspx. The 2015 Update [12] and the CCF rule folder *SPAR Rules 2015A* (and *SPAR Rules 2015*) have mostly adopted the 2012 Update [11] and *SPAR Rules 2012*, respectively. The folder *SPAR Rules 2015* has the same CCF rules as *SPAR Rules 2012*, while *SPAR Rules 2015A* includes a few new CCF rules requested by the Standardized Plant Analysis Risk (SPAR) model developers. The main changes in the 2015 Update are as follows:

- The Date Range was changed from "1997 to 2012" to "1997 to 2015."
- For the CCF event type under the CCF rules, "CCF Events Only" rather than "All Events" was selected in order to exclude those explicitly modeled events from the query results.
- The failure mode for unavailability (UA) was excluded from the CCF parameter estimation process. The events with UA included no equipment failure, as the equipment was under maintenance or was out of service due to the state of another component.
- A few new rules were created and added to the CCF rule folder *SPAR Rules 2015A* and the 2015 Update, due to one of the following reasons:
  - The SPAR modelers requested the additions, e.g., ALL-MOV-LK for motor-operated valves (MOVs) leakage (LK) failure, ALL-AOV-SO for air-operated valves (AOVs) spurious operations (SO), and ACP-CRB-4160-FTOC for 4160V circuit breakers (CRB) fail to open/close (FTOC).
  - The CCF failure data and parameters could support different levels of the pooled distributions, e.g., ALL-MDP-NR-FR for normally running (NR) motor-driven pump (MDP) fail-to-run (FTR), as the results are significantly different from those of the standby MDP FTR.
  - Other adjustments were needed, e.g., the previous rule CCW-HTX-HT was actually for non-extreme environmental (NE) failure causes and should be named CCW-HTX-HT-NE.
- The designations of various service water (SW) systems (normally running, standby, or both) were revised to be consistent with the SPAR models and conventions: SWN for normally running SW systems, SSW for standby SW, and SWS for all SW.
- The sections for the strainers and traveling screens were re-arranged to better present the results of different systems (pooled, service water, and circulating water).

1.3 Current Update: 2020 Update

This report, "CCF Parameter Estimations, 2020 Update," is the 2020 update to NUREG/CR-5497, updating the data and parameter estimations for CCF. It documents the quantitative results of the CCF data collection effort (with data through 2020) and summarizes the results of the parameter estimation quantification process performed on CCF data in the NRC CCF database.

This report reflects the CCF data contained within the CCF database (https://rads.inl.gov/Pages/CCF.aspx) by executing (in August 2021) the CCF query rules in the folder *SPAR Rules 2020*. The data covers the time period from 1/1/2006 to 12/31/2020, the most recent 15-year period in which data are available. The results are appropriate for use in PRA studies, including SPAR models of commercial NPPs in the U.S.

The main changes in the 2020 Update are as follows:

1. This update covers data from 1/1/2006 to 12/31/2020, the most recent 15-year period in which the data are available. This differs from previous updates, in which 1/1/1997 was used as the starting date (e.g., 1/1/1997 to 12/31/2015 for the 2015 update, 1/1/1997 to 12/31/2012 for the 2012 update). The new date range (i.e., the latest 15-year period) was selected for this CCF update so as to be consistent with the date range chosen for the component reliability parameter estimation, and with the effort to include sufficient data for analysis while simultaneously reflecting the most recent industry performance.

2. The new CCF priors developed in [13, 14] using data from 1997 to 2015 were applied in this update. The old CCF prior using data from 1991 to 2005 was used in previous CCF parameter estimation updates such as [12]. The table below compares the new 2015 prior distributions (mean, α, and β parameters) with the old 2005 prior distributions for common-cause component group (CCCG) sizes ranging from 2 to 4. The mean values of the common-cause alpha factors (α2 in a group size of 2; α2 and α3 in a group size of 3; and α2, α3, and α4 in a group size of 4) in the new 2015 priors are around or nearly 50 percent of those in the old 2005 priors—a significant decrease between the periods. The results imply that the probability of the redundant components in a group size of two failing simultaneously as a direct result of a shared cause is about 0.02, as per the 1997–2015 operating experience (a drop from the 0.04 value based on the 1991–2005 data). The possibility of all three components in a group size of three failing simultaneously as a direct result of a shared cause is about 0.005, as per the 1997–2015 operating experience (a drop from the value of about 0.009 based on the 1991–2005 data).

Table 1-1. Comparison between the 2015 and 2005 priors.

CCCG	Alpha Factor	Old 2005 Priors (1991--2005)			New 2015 Priors (1997--2015)			Δ(Mean)%
		Mean	α	β	Mean	α	β	
2	α1	9.59E-01	1.02E+01	4.35E-01	9.80E-01	2.24E+01	4.69E-01	2%
	α2	**4.07E-02**	**4.35E-01**	**1.02E+01**	**2.05E-02**	**4.69E-01**	**2.24E+01**	**-50%**
3	α1	9.64E-01	2.96E+01	1.10E+00	9.81E-01	5.80E+01	1.13E+00	2%
	α2	2.72E-02	8.34E-01	2.98E+01	1.44E-02	8.51E-01	5.83E+01	-47%
	α3	**8.72E-03**	**2.67E-01**	**3.04E+01**	**4.68E-03**	**2.77E-01**	**5.88E+01**	**-46%**
4	α1	9.61E-01	4.61E+01	1.86E+00	9.80E-01	9.07E+01	1.89E+00	2%
	α2	2.56E-02	1.23E+00	4.68E+01	1.36E-02	1.26E+00	9.13E+01	-47%
	α3	8.42E-03	4.04E-01	4.76E+01	4.35E-03	4.02E-01	9.22E+01	-48%
	α4	**4.64E-03**	**2.23E-01**	**4.78E+01**	**2.50E-03**	**2.31E-01**	**9.23E+01**	**-46%**

3. With using the most recent 15-year time period in this update, many templates in the 2015 Update [12] will now have zero CCF events and zero or one independent event. Most of them are system-specific templates such as SLC-MDP-FHRH, ISO-MOV-FTOC, ISO-AOV-FTOC, BWR-RHR-CKV-CC or OO, HPI-CKV-CC or OO, and CCW-HTX-EE-HT. The Bayesian update results, if conducted, would be the same or very close to those in Section 3.1.3.1 CCF (No Data), which represents the 2015 generic priors. These templates are thus removed from this update (refer to Appendix A for the removed 2015 templates, with Note 1).

4. As requested by the SPAR model developers, the Maximum Redundancy Range (or group size) was revised to eight for all CCF templates in this update. Previously, while most CCF templates used the value of eight, a few templates used other values such as two, four, or six.
5. In previous updates such as [12], maximum likelihood estimate (MLE) values were provided in the tables under the "ALPHA FACTOR and MGL PARAMETERS" sub-section of each CCF template. This practice was changed by providing more meaningful mean values instead of MLEs for alpha factors and MGL parameters in this update.
6. The RADS CCF rules used for the 2015 Update were copied and revised for use in this update. During review, a few errors were identified and corrected in the CCF rules:
    a. A criterion of "Centrifugal" was added to all MDP-related templates in order to be consistent with the usage of MDP in the component reliability analysis. Section 2.1 of the 2015 Parameter Estimation Update [15] states that "The motor-driven pump component data in this section includes only centrifugal type pumps."
    b. Made sure that all boiling-water reactor (BWR) plants were selected for BWR-specific CCF rules. In the previous version, a few BWR-specific CCF rules such as BWR-RHR-MOV-FTOC overlooked one BWR plant.
    c. The "High dP" failure mode is not included in the strainer reliability analysis (refer to Section 6 of [15]). To be consistent with the component reliability analysis, the "High dP" failure mode was removed from associated CCF rules such as SWS-STR-PG.
    d. Some CCF rule descriptions were revised for consistency with the criteria applied to the rules.

1.4 General Insights from the 2020 Update

The CCF study uses operating experience to characterize component failure data from operating U.S. commercial NPPs. This 2020 Update is based on the operating experience from 2006 through 2020 using the NRC CCF database and the RADS web application (https://rads.inl.gov/Pages/CCF.aspx). The CCF database is a rich source of information on various aspects of CCF. Exploring the full potential of the database merits a dedicated activity and is outside the scope of the current effort. Nevertheless, some general observations were made regarding the character of CCF events, including the CCF parameter results, causes and shared cause factors, and frequency of occurrence. This section documents these observations and insights.

CCF events are collected and entered into the CCF database according to the system, component type, and failure mode (these are referred as "CCF templates" in SPAR models or "CCF rules" in RADS). Appendix A shows the CCF templates included in the 2020 Update, as well as the differences from the 2015 Update. Appendix B provides a comparison of the CCF parameter results between the 2020 Update and the 2015 Update. Table 1-2 highlights the top 10 CCF templates that feature the highest CCF parameters ($\alpha 2$ in a group size of 2, $\alpha 3$ in a group size of 3, and $\alpha 4$ in a group size of 4), which range from 3.65E-2 to 1.53E-1 for $\alpha 2$ (CCCG = 2), from 1.31E-2 to 6.10E-2 for $\alpha 3$ (CCCG = 3), and from 5.12E-3 to 2.53E-2 for $\alpha 4$ (CCCG = 4). and relate to the travelling screens, strainers, air-operated valves (AOVs), MOVs, MDPs, and power-operated relief valves (PORVs).

It should be noted that the insights in this section are solely based on the numbers of either all CCF events or complete CCF events. These insights should not be used as bases to guess or compare CCF parameters (e.g., causal CCF parameters). Impact vectors, instead of the counts of

CCF events, are used in CCF parameter estimations. After applying component degradation value, timing factor, and shared cause factor, the impact vector of a specific CCF event could vary significantly. For example, a CCF event with a CCCG size of 3 could have an impact vector of [0, 0, 1] (for a complete CCF event with all three components in the group failed simultaneously due to a shared cause), [0, 1, 0] (two of the three components in the group failed simultaneously due to a shared cause), or [0.81, 0.18, 0.01] (the three components are degraded instead of failed with the timing factor and/or shared cause factor may or may not be 1.0).[1] Refer to NUREG/CR-6268, Rev. 1 for more details on the defining of impact vectors).

Table 1-2. The 10 CCF templates with the largest CCF parameters.

2020 Section	CCF Template	Description	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)
2.6.1.2	ALL-TSA-PG-EE	TRAVELLING SCREENS PLUG DUE TO EXTREME ENVIRONMENTAL STRESS, ALL SYSTEMS	1.53E-01	6.10E-02	2.53E-02
2.6.3.1	CWS-TSA-PG-EE	CIRCULATING WATER SYSTEM TRAVELLING SCREENS PLUG DUE TO EXTREME ENVIRONMENTAL STRESS	1.53E-01	6.10E-02	2.53E-02
2.6.1.1	ALL-TSA-PG	TRAVELLING SCREENS PLUG, ALL SYSTEMS	1.46E-01	5.89E-02	2.45E-02
2.6.2.3	SWS-STR-PG-EE	SERVICE WATER STRAINERS PLUG ENVIRONMENTAL	8.51E-02	1.82E-02	6.90E-03
2.6.2.2	SWS-STR-PG	SERVICE WATER STRAINERS PLUG POOLED CAUSES	7.00E-02	1.58E-02	5.87E-03
2.4.2.2	AFW-AOV-CC	AUXILIARY FEEDWATER SYSTEM AIR-OPERATED VALVES FAIL TO OPEN	4.80E-02	1.30E-02	5.55E-03
2.6.2.1	SWS-TSA-FO-NE	SERVICE WATER TRAVELLING SCREENS FAIL TO OPEN NON ENVIRONMENTAL	4.69E-02	1.08E-02	4.39E-03
2.6.1.4	ALL-TSA-FO-NE	ALL TRAVELLING SCREENS FAIL TO OPEN NON ENVIRONMENTAL	3.88E-02	8.63E-03	3.62E-03
2.3.1.4	ALL-MOV-CO	MOTOR-OPERATED VALVES SPURIOUS OPERATION, ALL SYSTEMS	3.68E-02	1.52E-02	9.81E-03
2.1.6.1	AFW-MDP-FS	AUXILIARY FEEDWATER SYSTEM	3.65E-02	1.51E-02	5.79E-03

[1] The impact vectors used in this example has a format of [F1, F2, … Fm] for a component group size of m. So [1, 0, 0] means one and only one component failed; [0, 1, 0] means two components failed due to a shared cause; [0, 0, 1] means all three components failed due to a shared cause.

2020 Section	CCF Template	Description	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)
		MOTOR-DRIVEN PUMPS FAIL TO START			
2.9.2.1	PWR-MSS-PRV-CC	PWR MAIN STEAM SYSTEM POWER-OPERATED RELIEF VALVES FAIL TO OPEN	3.44E-02	1.43E-02	5.51E-03
2.9.1.1	ALL-PORV-CC	POWER-OPERATED RELIEF VALVES FAIL TO OPEN, ALL SYSTEMS	3.08E-02	1.31E-02	5.12E-03

1.4.1 CCF Event Occurrence by Year

Figure 1-1 and Figure 1-2 show the number of all CCF events and complete CCF events that occurred, by year, from 1997 to 2020, respectively. "All" CCF events include both completed CCF events and partial CCF events. A "complete" CCF is a CCF in which all components in the CCCG have a component degradation value equal to 1.0 (a complete failure), and both the timing factor and shared cause factor of the CCF are equal to 1.0. If the timing factor, shared cause factor, or component degradation values are not 1.0, the CCF is a partial CCF.

Both figures show a steady and significant reduction in CCF event occurrences over the years. Table 1-3 further displays this reduction in numbers over multi-year periods within the timeframe of 1997–2020 (five-year period except the last one which is a four-year period of 2017–2020): from more than 30 CCFs yearly in the 1st five-year period (1997–2001) to about 20 yearly in the 2nd period (2002–2006), and about 15 yearly during 2007–2011, less than 10 during 2012–2016, and less than five during 2017–2020. The same reduction exists in the number of complete CCF events: from five events yearly during 1997–2001 to one or less per year during the last two multi-year periods.

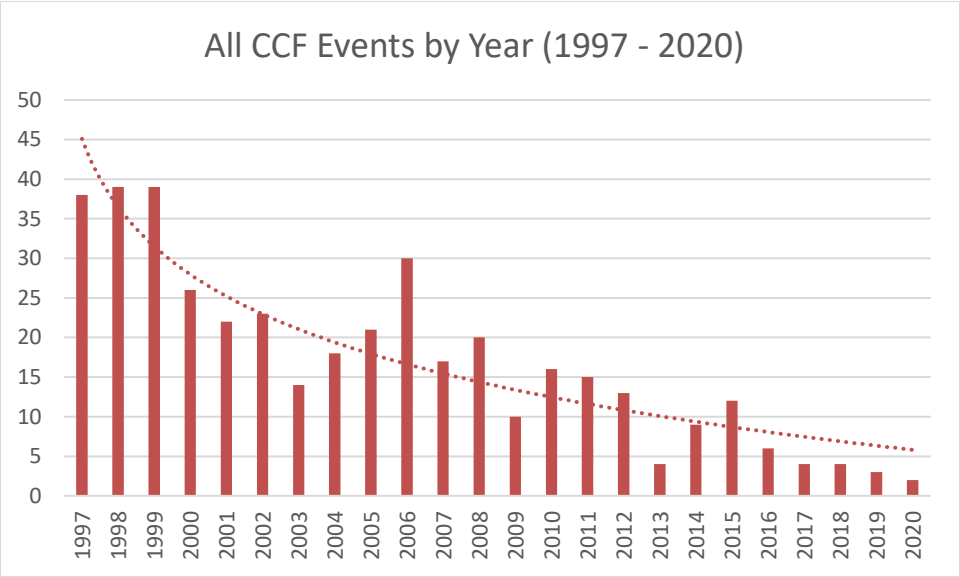

Figure 1-1. All CCF events by year (1997–2020).

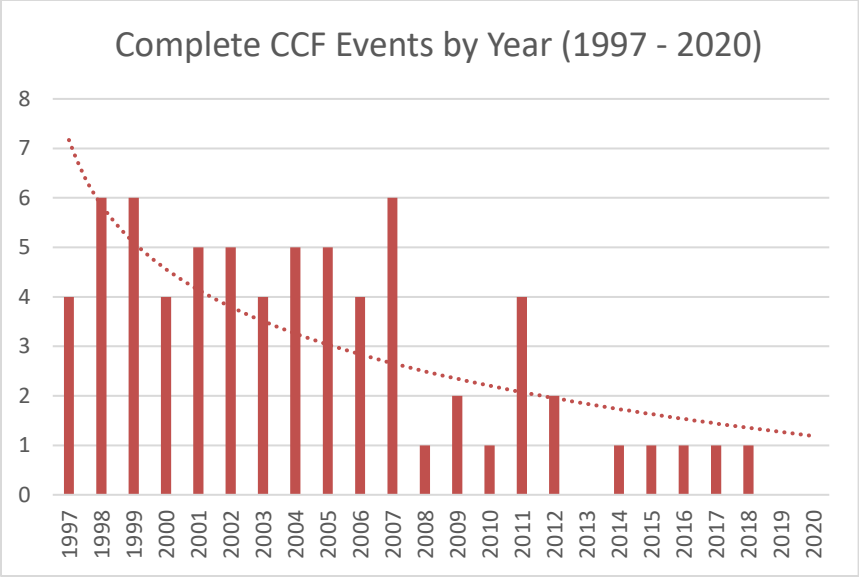

Figure 1-2. Complete CCF events by year (1997–2020).

Table 1-3. CCF events by multi-year period (1997–2020).

	1997–2001		2002–2006		2007–2011		2012–2016		2017–2020	
5–Year Period	Total	Per Year	Total	Per Year	Total	Per Year	Total	Per Year	Total	Per Year
All CCF Events	164	32.8	106	21.2	78	15.6	44	8.8	13	3.3
Complete CCF	25	5.0	23	4.6	14	2.8	5	1.0	2	0.5

1.4.2 Distribution of CCF Events by Cause and Coupling Factor

Figure 1-3 and Figure 1-4 show the distribution for all CCF events and complete CCF events, by proximate causes, during the 1997–2020 and 2006–2020 periods, respectively. Figure 1-5 and Figure 1-6 show the distribution of all CCF events and complete CCF events, by coupling factors, during the 1997–2020 and 2006–2020 periods, respectively. These figures provide a general picture of the types of events that may be expected to occur, and what type of features might be most susceptible to CCF events. The figures also display the different characteristics of all CCF events and complete CCF events.

It should be noted, however, that the cause and coupling factor associated observations in this section are solely based on the numbers of either all CCF events or complete CCF events. Using different characterizations (including the timing factor, shared cause factor, and component degradation) for each CCF event, or applications of the mapping methodology in CCF parameter estimations, would void the observations provided above so that, in those instances, they should not be used as the basis to compare the CCF causal alpha factors among different cause groups. Rather, a study reporting on CCF causal alpha factor parameter estimations will be published in the near future.

Figure 1-3 shows design to be the dominant cause group when considering the number of all CCF events for both the 1997–2020 and 2006–2020 periods. Human, component, and environment are the 2nd , 3rd, and 4th leading cause groups during the 1997–2020 period. However, for the 2006–2020 period, environment and component cause groups switch their places in the number of all CCF events, while human remains the 2nd leading cause group.

In considering complete CCF events only, Figure 1-4 shows close similarity between environment, human, and design with these categories ranking 1st, 2nd, and 3rd, respectively. Component is 4th, and other/unknown ranks last. This order applies to both the 1997–2020 and 2006–2020 periods, though the 2006–2020 period has much fewer CCF events.

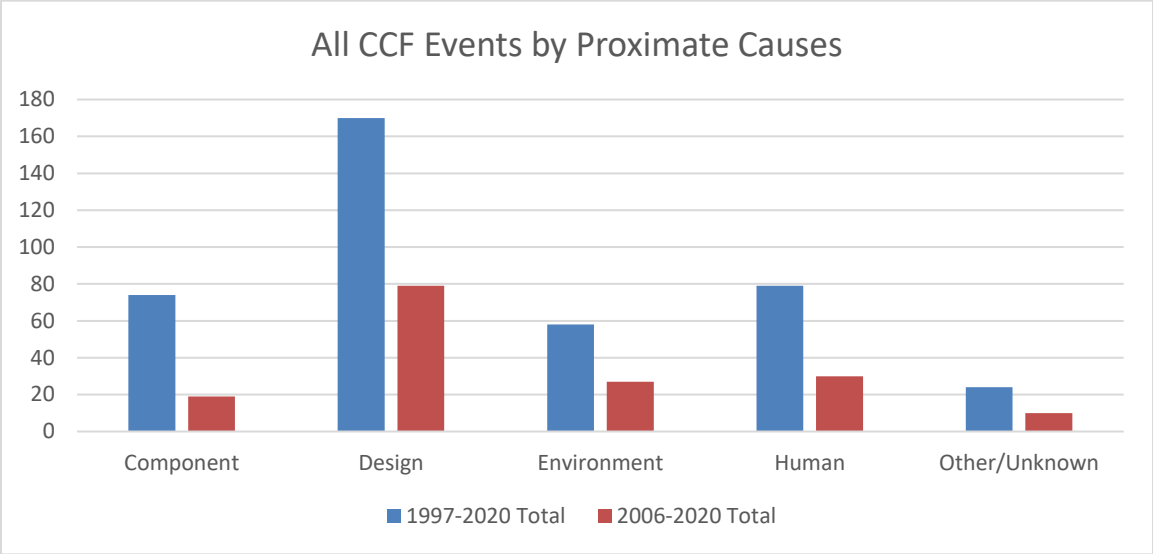

Figure 1-3. Distributions of all CCF events by proximate cause (1997–2020 and 2006–2020).

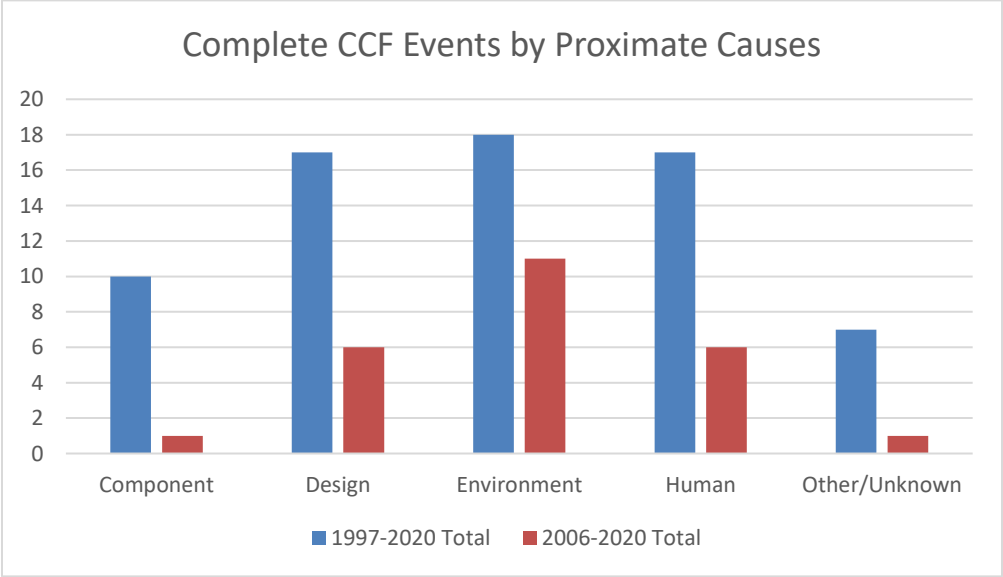

Figure 1-4. Distributions of complete CCF events by proximate cause (1997–2020 and 2006–2020).

Figure 1-5 shows that when considering all CCF events, design is the dominant coupling factor, maintenance is the 2nd leading coupling factor, environment is 3rd, and hardware and operational coupling factors show very small susceptibility to CCF. These observations apply to both the 1997–2020 and 2006–2020 periods, though the 2006–2020 period has much fewer CCF events.

Figure 1-6 shows that design is still the leading coupling factor when only considering complete CCF events during the 1997–2020 period. However, environment is now 2nd and maintenance 3rd. For the 2006–2020 period, environment became the leading coupling factor, while design was 2nd and maintenance, 3rd. Hardware and operational coupling factors still have very small susceptibility to complete CCF events in both periods.

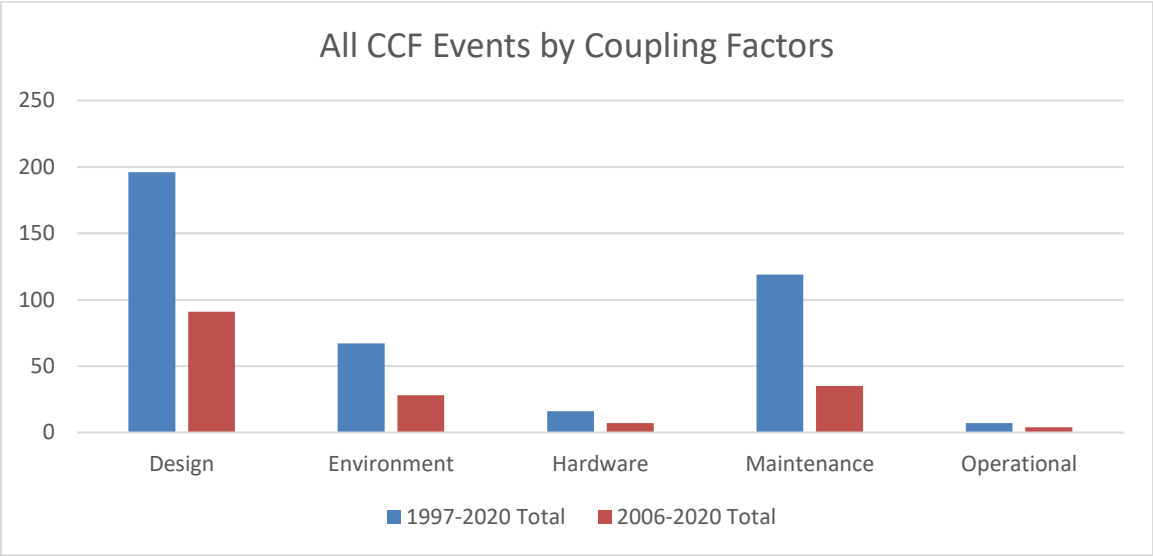

Figure 1-5. Distributions of all CCF events by coupling factor (1997–2020 and 2006–2020).

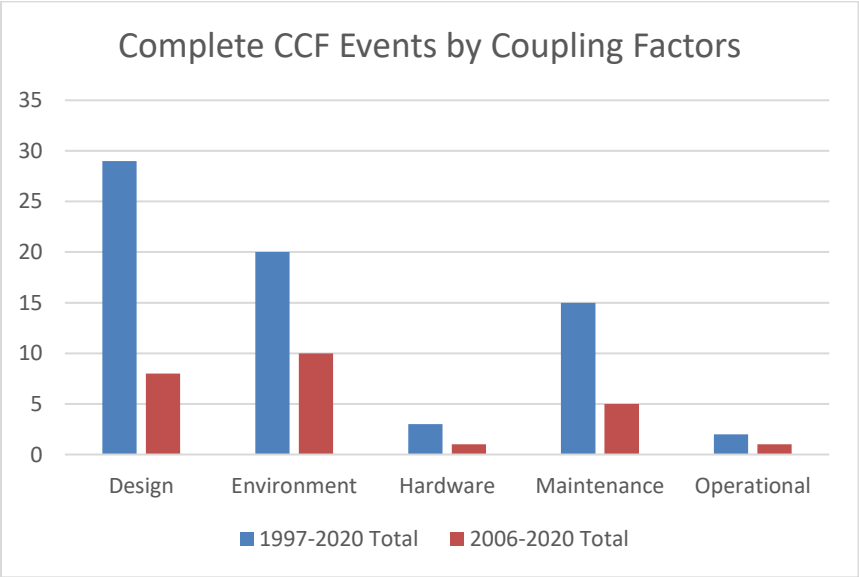

Figure 1-6. Distributions of complete CCF events by coupling factor (1997–2020 and 2006–2020).

1.4.3 Distribution of CCF Events by Defense

Figure 1-7 and Figure 1-8 show that different defense strategies could be applied to prevent the occurrence of CCF events.

Figure 1-7 shows that Maintenance (or maintenance program modification), function (or functional and/or physical interconnections modification), monitoring (or increased monitoring,

surveillance, or personnel training), and diversity (or increased diversity in types of equipment, procedures, equipment functions or manufacturers) are the top four defense strategies for preventing CCF when considering all CCF events during both the 1997–2020 and 2006–2020 periods.

Figure 1-8 shows that Maintenance is still the leading defense strategy when considering complete CCF for both the 1997–2020 and 2006–2020 periods. However, monitoring becomes the 2nd defense strategy and diversity 3rd. Function is the 4th during the 1997–2020 period but was not identified during the 2006–2020 period.

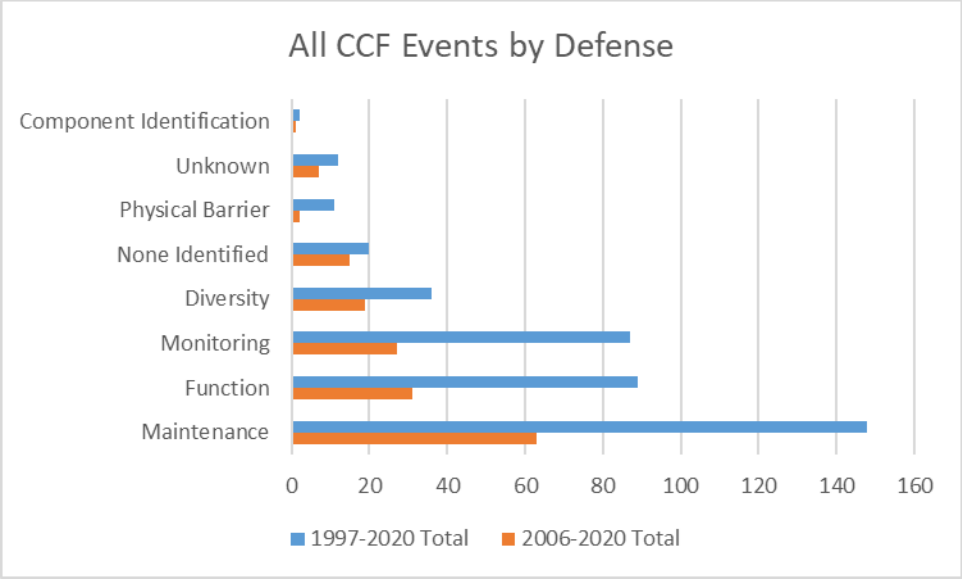

Figure 1-7. Distributions of all CCF events by defense (1997–2020 and 2006–2020).

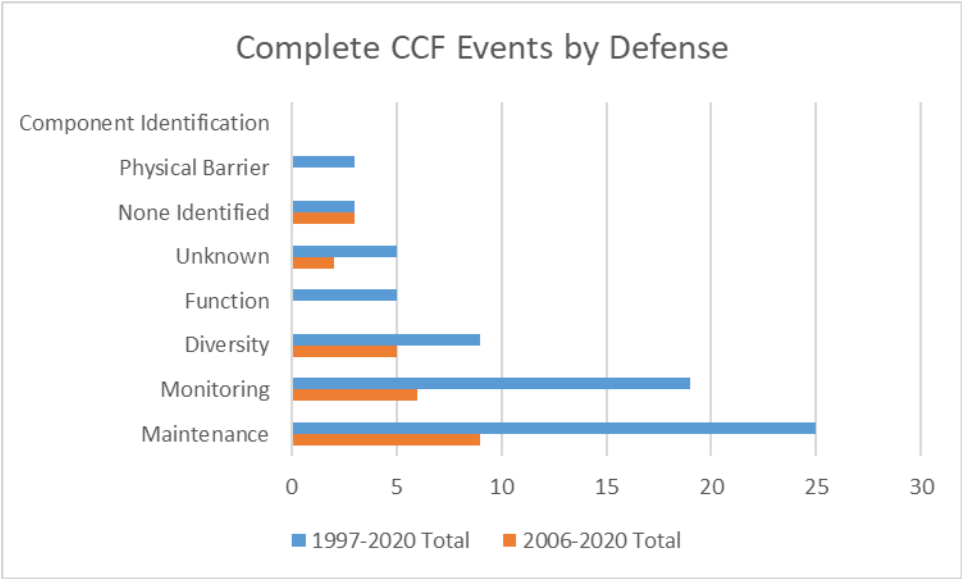

Figure 1-8. Distributions of complete CCF events by defense (1997–2020 and 2006–2020).

1.4.4 Distributions of CCF Events by System

Figure 1-9 and Figure 1-10 show the distribution of all CCF events and complete CCF events, by system, during the 1997–2020 and 2006–2020 periods, respectively. When considering all CCF events (Figure 1-9), Main Steam System (MSS) is the dominant category of CCFs, while Circulating Water System (CWS) ranks 2nd. Residual Heat Removal (RHR), Auxiliary Feedwater (AFW), Standby Service Water (SSW), Emergency Power Supply (EPS), Service Water Normally Running (SWN), AC Power, DC Power, Main Feedwater (MFW), and Reactor Coolant System (RCS) also show comparatively high numbers of CCFs.

When considering complete CCF events only (Figure 1-10), the profile is quite different, with CWS and RHR being the top two categories of CCFs. AFW, SWN, MSS, EPS, RCS, MFW, Instrument Air, and Containment Spray Recirculation also show comparatively high numbers of CCFs.

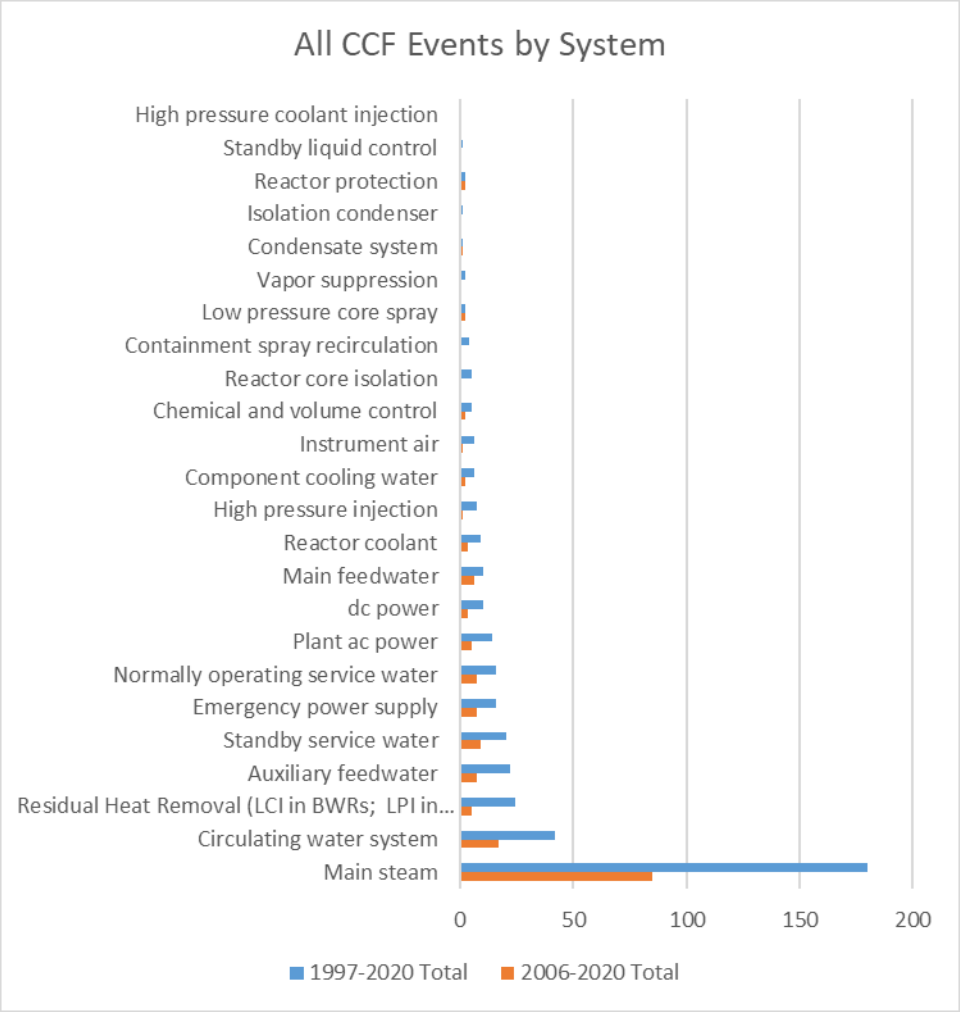

Figure 1-9. Distributions of all CCF events by system (1997–2020 and 2006–2020).

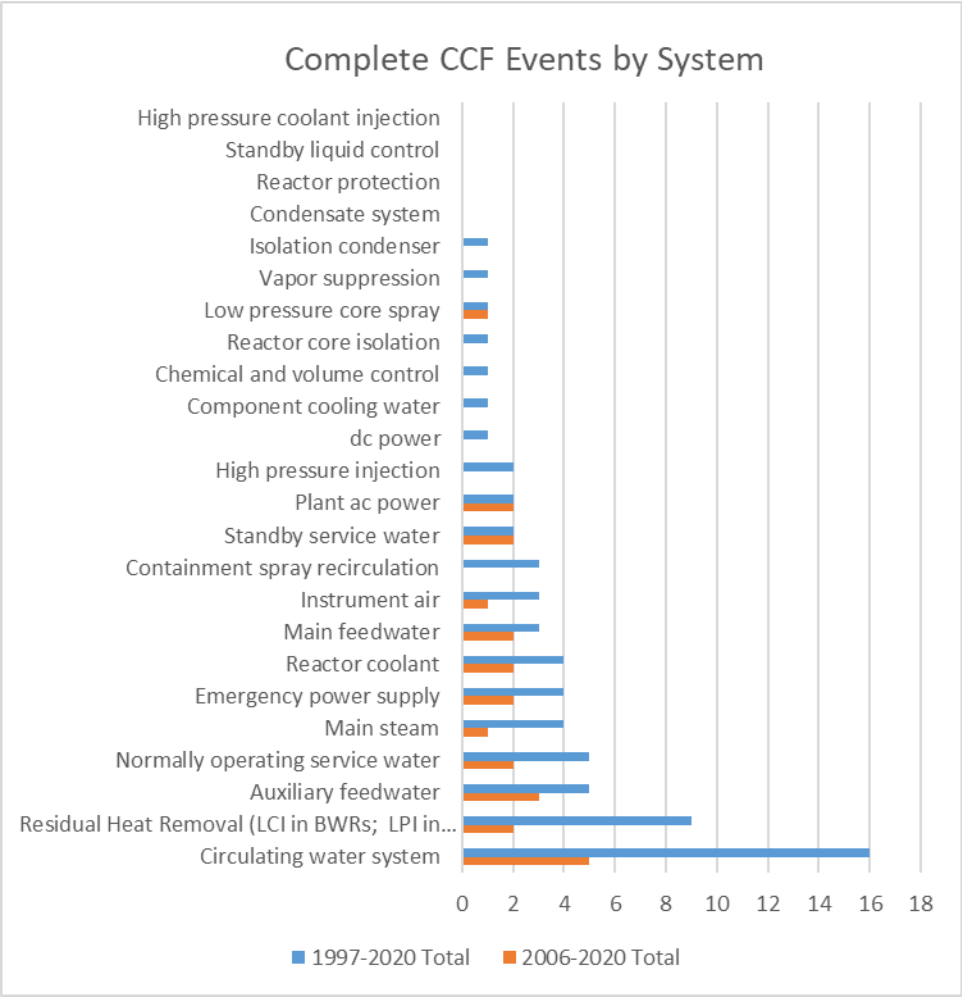

Figure 1-10. Distributions of complete CCF events by system (1997–2020 and 2006–2020).

1.4.5 Distributions of CCF Events by Component Type

Figure 1-11 and Figure 1-12 show distributions for all CCF events and complete CCF events, by component type, during the 1997–2020 and 2006–2020 periods, respectively. When considering all CCF events (Figure 1-11), safety relief valve (SRV) (dual actuation), MDP, strainer, safety valve (SVV) (single acting), main steam stop valve (MSSV), PORV, AOV, generator, MOV, circuit breaker, and check valve are the component types for which the most CCF events occurred during the 1997–2020 period. For the 2006–2020 period, SRV, strainer, SVV, MDP, MSSV, PORV, AOV, and generator are the top component types for CCF.

When considering complete CCF events only (Figure 1-12), the profile changes, as strainer and MDP stand out as the top two component types featuring CCFs during the 1997–2020 period. The PORV, generator, check valve, AOV, low-capacity relief valve, MOV, and compressor featured multiple complete CCF events during the 1997–2020 period. During the 2006–2020 period, only the strainer, generator, MDP, PORV, AOV, low-capacity relief valve, and MOV featured multiple complete CCF events.

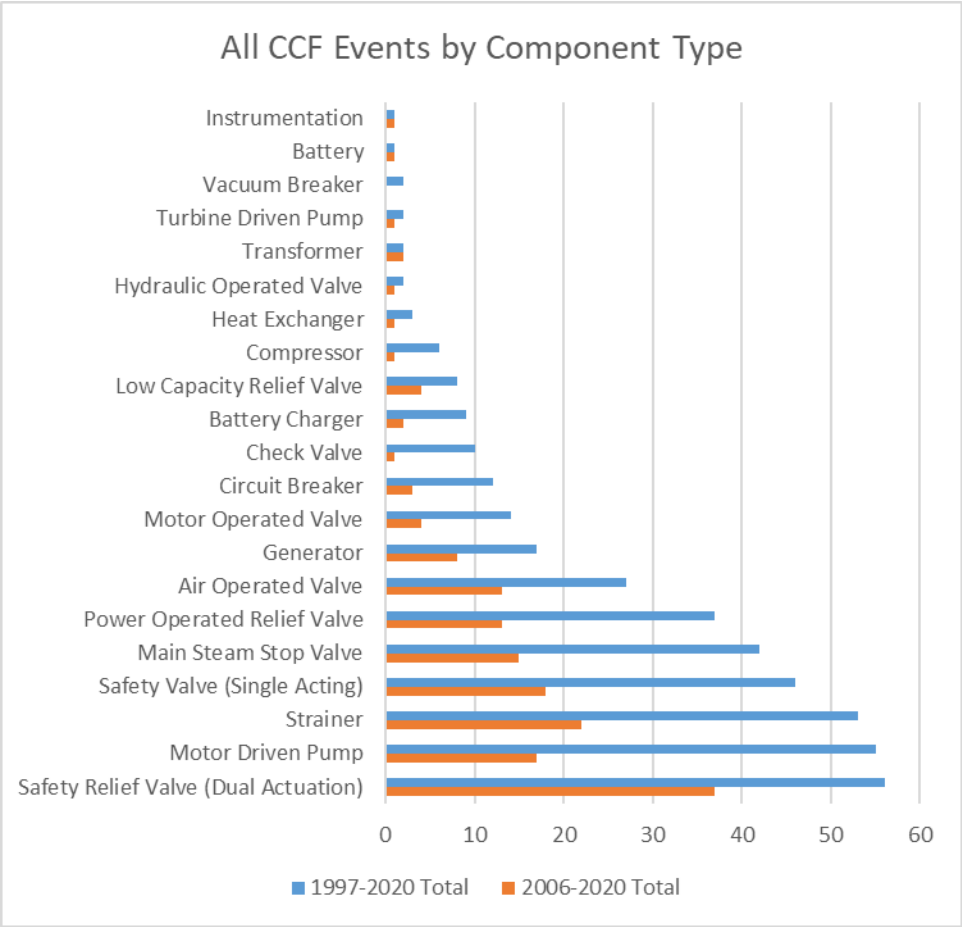

Figure 1-11. Distributions of all CCF events by component type (1997–2020 and 2006–2020).

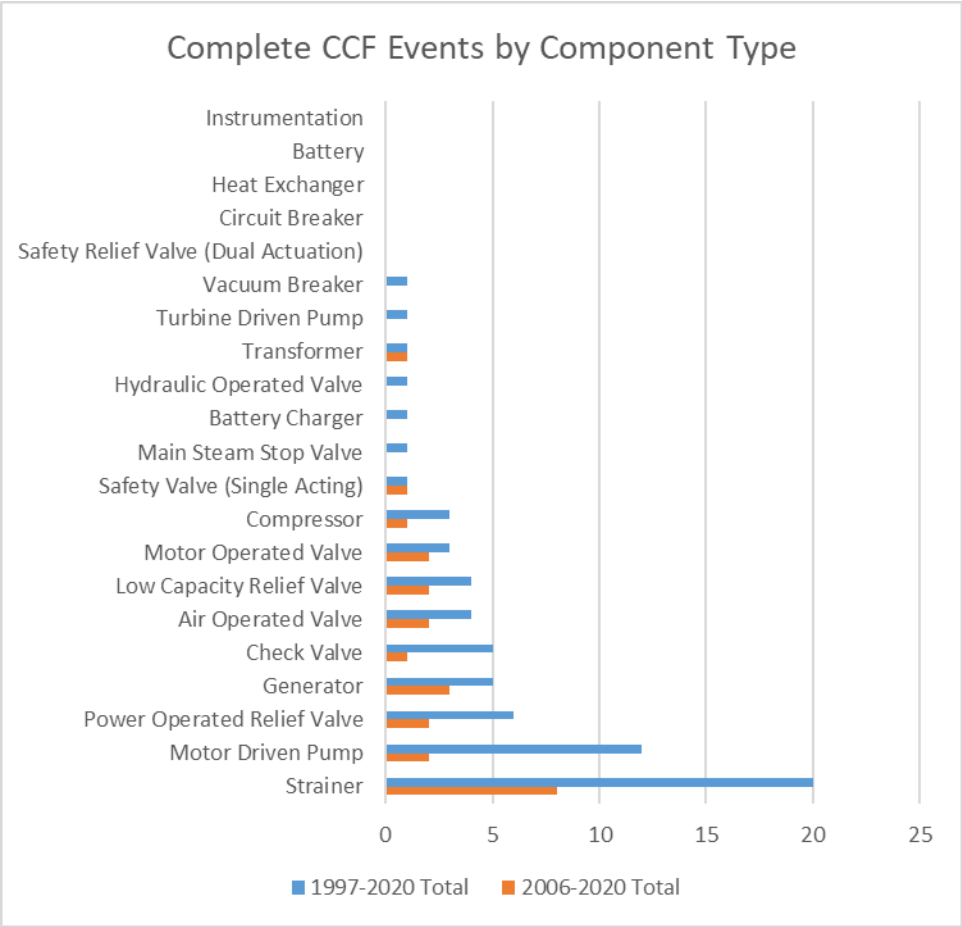

Figure 1-12. Distributions of complete CCF events by component type (1997–2020 and 2006–2020).

1.4.6 Distributions of CCF Events by Failure Mode

Figure 1-13 and Figure 1-14 show distributions for all CCF events and complete CCF events, by failure mode, during the 1997–2020 and 2006–2020 periods, respectively. When considering all CCF events (Figure 1-13), setpoint out of specification (OOS), fail to open (FTO), fail to remain closed, fail to operate (FTOP), fail to close (FTC), fail to start (FTS), no flow/plugged, FTR for NR equipment, and fail to run > 1 hour (FTR > 1 H) for standby (NS) equipment are the top failure modes for CCFs that occurred during the 1997–2020 period. Setpoint OOS, FTO, FTOP, FTC, no flow/plugged, and FTR are the top failure modes for the 2006–2020 period. Note that the setpoint OOS failure mode is not included in the CCF parameter estimation process.

When considering complete CCF events only (Figure 1-14), FTOP, FTS, no flow/plugged, FTO, FTR for NR equipment, and fail to remain closed are the top failure modes for CCFs that occurred during the 1997–2020 period. no flow/plugged, FTOP, FTS, FTO, FTR for NR equipment, and setpoint OOS are the only failure modes for which multiple CCFs occurred during the 2006–2020 period.

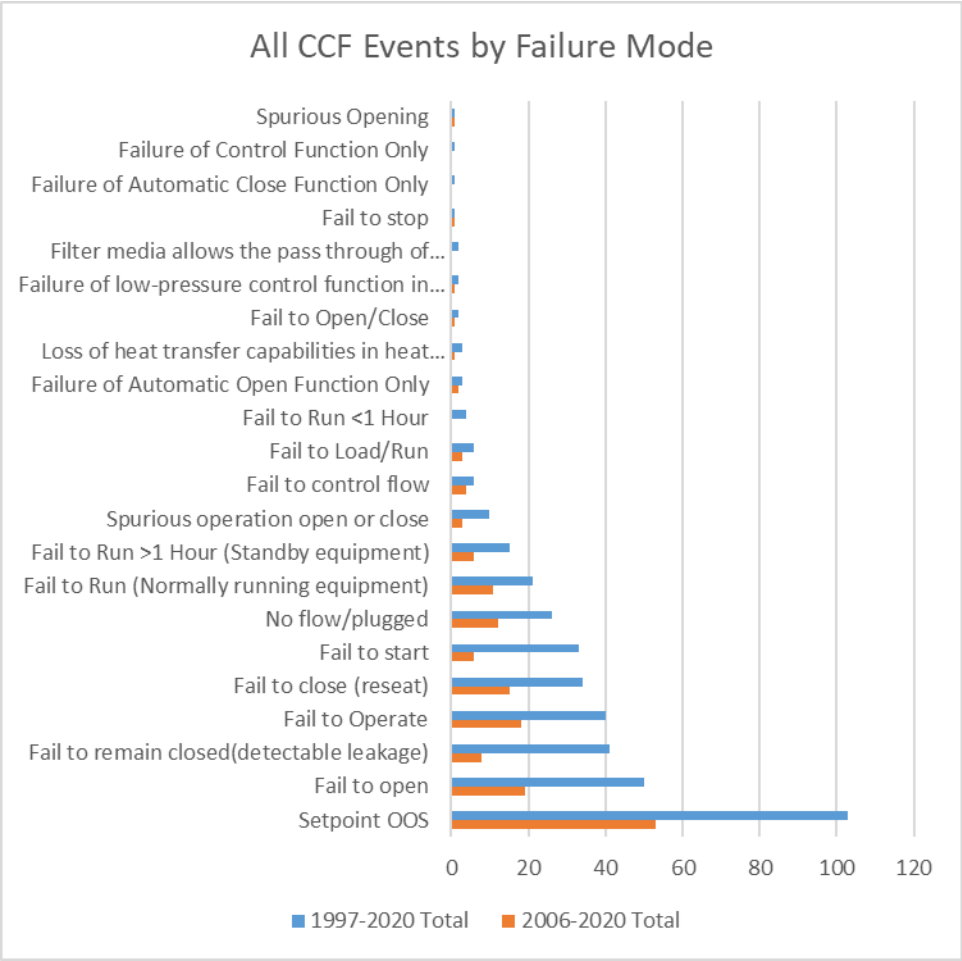

Figure 1-13. Distributions of all CCF events by failure mode (1997–2020 and 2006–2020).

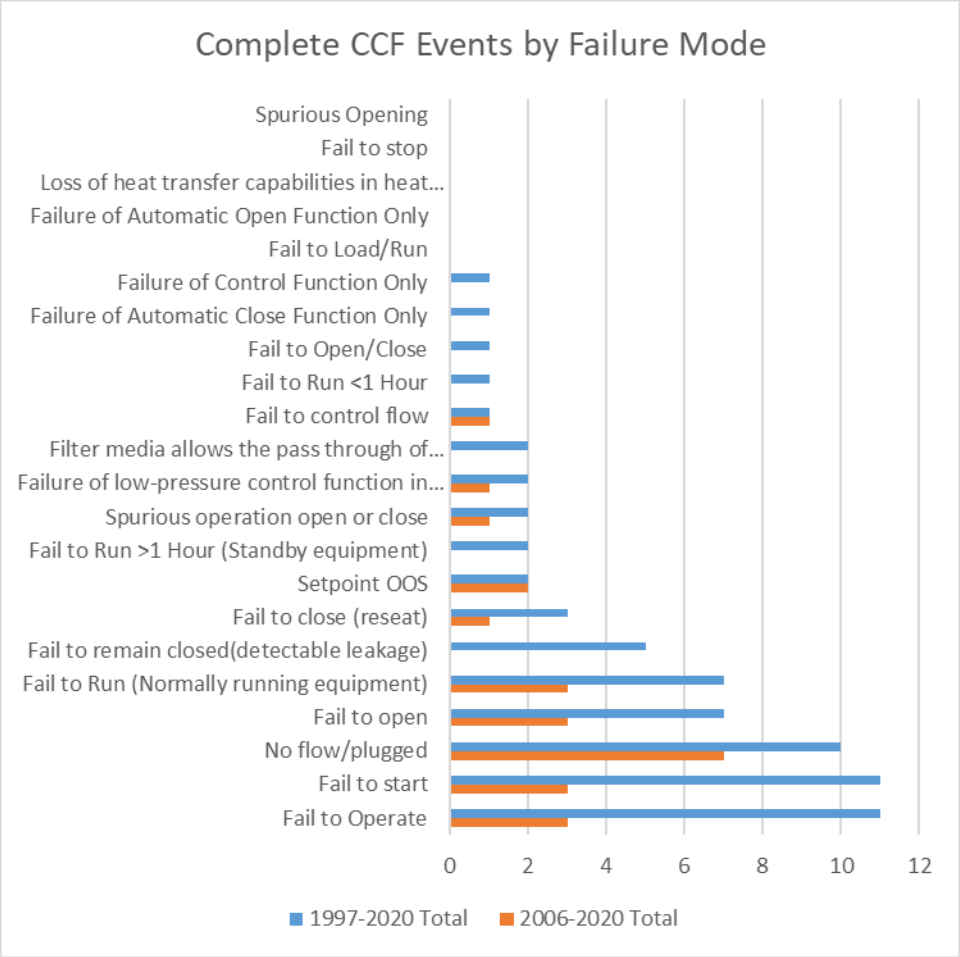

Figure 1-14. Distributions of complete CCF events by failure mode (1997–2020 and 2006–2020).

2. INDUSTRY COMPONENT CCF DISTRIBUTIONS

2.1 Motor-Driven Pumps

2.1.1 Pooled Motor-Driven Pumps

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

Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 339.9

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738293	0.9892417	0.9910988	0.9982971	0.9907620	1.673E+02	1.820E+00
α_2	1.70E-03	1.08E-02	8.90E-03	2.62E-02	9.24E-03	1.820E+00	1.673E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9777785	0.9894395	0.9905939	0.9971620	0.9917455	2.747E+02	2.932E+00
α_2	6.70E-04	5.51E-03	4.38E-03	1.42E-02	3.11E-03	1.530E+00	2.761E+02
α_3	5.30E-04	5.05E-03	3.92E-03	1.34E-02	5.15E-03	1.402E+00	2.762E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9791443	0.9890683	0.9899052	0.9961308	0.9921027	3.789E+02	4.188E+00
α_2	1.20E-03	5.85E-03	5.02E-03	1.34E-02	3.38E-03	2.242E+00	3.809E+02
α_3	2.15E-04	3.01E-03	2.20E-03	8.56E-03	2.58E-03	1.152E+00	3.820E+02
α_4	5.55E-05	2.07E-03	1.30E-03	6.73E-03	1.94E-03	7.940E-01	3.823E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9809605	0.9890628	0.9896446	0.9951795	0.9926691	5.507E+02	6.090E+00
α_2	1.47E-03	5.39E-03	4.81E-03	1.13E-02	2.96E-03	2.999E+00	5.538E+02
α_3	4.33E-04	3.04E-03	2.47E-03	7.60E-03	1.78E-03	1.695E+00	5.551E+02
α_4	1.05E-04	1.87E-03	1.31E-03	5.51E-03	1.81E-03	1.038E+00	5.558E+02
α_5	3.02E-07	6.43E-04	2.04E-04	2.77E-03	7.76E-04	3.580E-01	5.565E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9825351	0.9897006	0.9901857	0.9951997	0.9930975	6.567E+02	6.834E+00
α_2	1.13E-03	4.32E-03	3.83E-03	9.16E-03	2.67E-03	2.863E+00	6.606E+02
α_3	4.26E-04	2.73E-03	2.25E-03	6.68E-03	1.39E-03	1.811E+00	6.617E+02
α_4	1.48E-04	1.84E-03	1.37E-03	5.13E-03	1.43E-03	1.219E+00	6.623E+02
α_5	1.71E-05	1.04E-03	6.00E-04	3.56E-03	1.08E-03	6.898E-01	6.628E+02
α_6	6.49E-09	3.77E-04	6.62E-05	1.83E-03	3.24E-04	2.504E-01	6.633E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9836016	0.9897338	0.9900979	0.9946131	0.9934300	8.748E+02	9.074E+00
α_2	1.23E-03	3.97E-03	3.60E-03	7.96E-03	2.49E-03	3.506E+00	8.803E+02
α_3	5.04E-04	2.51E-03	2.14E-03	5.75E-03	1.16E-03	2.214E+00	8.816E+02
α_4	2.53E-04	1.86E-03	1.50E-03	4.70E-03	1.11E-03	1.646E+00	8.822E+02
α_5	8.18E-05	1.25E-03	9.02E-04	3.62E-03	1.07E-03	1.107E+00	8.827E+02
α_6	2.12E-06	5.61E-04	2.54E-04	2.16E-03	6.02E-04	4.963E-01	8.834E+02
α_7	2.89E-16	1.19E-04	9.45E-07	6.88E-04	1.39E-04	1.051E-01	8.837E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9847281	0.9903753	0.9907070	0.9948882	0.9936906	9.645E+02	9.373E+00
α_2	1.06E-03	3.49E-03	3.16E-03	7.06E-03	2.39E-03	3.399E+00	9.705E+02
α_3	3.52E-04	2.02E-03	1.69E-03	4.81E-03	1.00E-03	1.968E+00	9.719E+02
α_4	2.02E-04	1.61E-03	1.28E-03	4.13E-03	8.72E-04	1.566E+00	9.723E+02
α_5	1.06E-04	1.28E-03	9.55E-04	3.54E-03	9.34E-04	1.242E+00	9.726E+02
α_6	1.94E-05	7.93E-04	4.88E-04	2.60E-03	7.30E-04	7.720E-01	9.731E+02
α_7	2.81E-08	3.03E-04	7.21E-05	1.39E-03	3.24E-04	2.953E-01	9.736E+02
α_8	6.09E-14	1.33E-04	3.07E-06	7.53E-04	6.08E-05	1.298E-01	9.737E+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	9.89E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.90E-01
α_2	1.08E-02	5.51E-03	5.85E-03	5.39E-03	4.32E-03	3.97E-03	3.49E-03
α_3		5.05E-03	3.01E-03	3.04E-03	2.73E-03	2.51E-03	2.02E-03
α_4			2.07E-03	1.87E-03	1.84E-03	1.86E-03	1.61E-03
α_5				6.43E-04	1.04E-03	1.25E-03	1.28E-03
α_6					3.77E-04	5.61E-04	7.93E-04
α_7						1.19E-04	3.03E-04
α_8							1.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.89E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.90E-01
Beta	1.08E-02	1.06E-02	1.09E-02	1.09E-02	1.03E-02	1.03E-02	9.62E-03
Gamma		4.78E-01	4.65E-01	5.08E-01	5.81E-01	6.14E-01	6.37E-01
Delta			4.08E-01	4.52E-01	5.44E-01	6.02E-01	6.71E-01
Epsilon				2.56E-01	4.35E-01	5.09E-01	6.09E-01

Mu					2.66E-01	3.52E-01	4.91E-01
Omega						1.75E-01	3.55E-01
Sigma							3.05E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	143.12	214.67	286.23	357.79	429.35	500.91	572.46
N_1	1.7976	2.0179	2.0357	2.0908	2.0997	2.0674	1.9958
N_2	1.3512	0.6786	0.9821	1.0744	1.1620	1.2624	1.3810
N_3		1.1250	0.7500	0.6458	0.6042	0.5848	0.5779
N_4			0.5625	0.6563	0.6233	0.5628	0.5040
N_5				0.2813	0.4688	0.5414	0.5397
N_6					0.1406	0.3047	0.4223
N_7						0.0703	0.1875
N_8							0.0352

2.1.1.2 MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: ALL-MDP-FH

Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 32.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668559	0.9915400	0.9963349	0.9999742	1.0000000	5.491E+01	4.685E-01
α_2	2.36E-05	8.46E-03	3.67E-03	3.31E-02	0.00E+00	4.685E-01	5.491E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648534	0.9876861	0.9910135	0.9991501	1.0000000	9.048E+01	1.128E+00
α_2	3.11E-04	9.29E-03	6.05E-03	2.93E-02	0.00E+00	8.512E-01	9.076E+01
α_3	1.51E-07	3.02E-03	6.46E-04	1.42E-02	0.00E+00	2.768E-01	9.133E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9637070	0.9848595	0.9873604	0.9974691	1.0000000	1.232E+02	1.894E+00
α_2	8.70E-04	1.01E-02	7.61E-03	2.77E-02	0.00E+00	1.260E+00	1.238E+02
α_3	3.49E-06	3.22E-03	1.18E-03	1.33E-02	0.00E+00	4.024E-01	1.247E+02
α_4	1.28E-08	1.85E-03	2.76E-04	9.17E-03	0.00E+00	2.315E-01	1.248E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9695918	0.9848651	0.9862698	0.9953525	1.0000000	2.233E+02	3.432E+00
α_2	1.44E-03	8.49E-03	7.09E-03	2.03E-02	0.00E+00	1.924E+00	2.248E+02
α_3	2.68E-04	4.63E-03	3.28E-03	1.36E-02	0.00E+00	1.049E+00	2.257E+02
α_4	1.28E-06	1.69E-03	5.81E-04	7.11E-03	0.00E+00	3.822E-01	2.264E+02
α_5	2.94E-20	3.38E-04	3.15E-07	1.97E-03	0.00E+00	7.674E-02	2.267E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9714029	0.9853380	0.9865598	0.9951077	1.0000000	2.577E+02	3.835E+00
α_2	9.32E-04	6.50E-03	5.30E-03	1.62E-02	0.00E+00	1.701E+00	2.599E+02
α_3	3.64E-04	4.61E-03	3.43E-03	1.29E-02	0.00E+00	1.207E+00	2.603E+02
α_4	2.09E-05	2.28E-03	1.20E-03	8.21E-03	0.00E+00	5.960E-01	2.610E+02
α_5	3.31E-09	8.45E-04	1.13E-04	4.24E-03	0.00E+00	2.211E-01	2.613E+02

α_6	3.30E-15	4.20E-04	4.25E-06	2.42E-03	0.00E+00	1.098E-01	2.614E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752931	0.9859837	0.9867644	0.9940027	1.0000000	4.043E+02	5.747E+00
α_2	1.12E-03	5.47E-03	4.69E-03	1.25E-02	0.00E+00	2.243E+00	4.078E+02
α_3	5.33E-04	3.97E-03	3.20E-03	1.01E-02	0.00E+00	1.630E+00	4.084E+02
α_4	1.64E-04	2.64E-03	1.89E-03	7.68E-03	0.00E+00	1.083E+00	4.090E+02
α_5	9.97E-06	1.38E-03	6.95E-04	5.07E-03	0.00E+00	5.654E-01	4.095E+02
α_6	2.57E-10	4.67E-04	4.32E-05	2.43E-03	0.00E+00	1.916E-01	4.099E+02
α_7	5.81E-41	8.49E-05	3.16E-12	3.72E-04	0.00E+00	3.480E-02	4.100E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9764071	0.9866302	0.9873836	0.9942927	1.0000000	4.225E+02	5.726E+00
α_2	8.49E-04	4.71E-03	3.97E-03	1.11E-02	0.00E+00	2.018E+00	4.262E+02
α_3	3.35E-04	3.25E-03	2.51E-03	8.66E-03	0.00E+00	1.391E+00	4.269E+02
α_4	1.48E-04	2.48E-03	1.76E-03	7.26E-03	0.00E+00	1.062E+00	4.272E+02
α_5	2.90E-05	1.64E-03	9.58E-04	5.57E-03	0.00E+00	7.026E-01	4.275E+02
α_6	3.21E-07	8.17E-04	2.51E-04	3.55E-03	0.00E+00	3.497E-01	4.279E+02
α_7	1.23E-15	2.52E-04	2.31E-06	1.45E-03	0.00E+00	1.078E-01	4.281E+02
α_8	2.57E-17	2.21E-04	9.37E-07	1.29E-03	0.00E+00	9.469E-02	4.282E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	8.46E-03	9.29E-03	1.01E-02	8.49E-03	6.50E-03	5.47E-03	4.71E-03
α_3		3.02E-03	3.22E-03	4.63E-03	4.61E-03	3.97E-03	3.25E-03
α_4			1.85E-03	1.69E-03	2.28E-03	2.64E-03	2.48E-03
α_5				3.38E-04	8.45E-04	1.38E-03	1.64E-03
α_6					4.20E-04	4.67E-04	8.17E-04
α_7						8.49E-05	2.52E-04
α_8							2.21E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	8.46E-03	1.23E-02	1.51E-02	1.51E-02	1.47E-02	1.40E-02	1.34E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	32.50	32.50	32.50	32.50	32.50	32.50	32.50
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

2.1.1.3 MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: ALL-MDP-FHRH

Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run >1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 127.5

Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9573939	0.9837830	0.9872775	0.9982240	0.9852776	8.666E+01	1.429E+00
α_2	1.77E-03	1.62E-02	1.27E-02	4.26E-02	1.47E-02	1.429E+00	8.666E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9574832	0.9790953	0.9811087	0.9938186	0.9779834	1.526E+02	3.258E+00
α_2	4.03E-03	1.67E-02	1.47E-02	3.63E-02	1.81E-02	2.606E+00	1.532E+02
α_3	5.57E-05	4.18E-03	2.34E-03	1.46E-02	3.88E-03	6.518E-01	1.552E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9597858	0.9780574	0.9794851	0.9914446	0.9769825	2.157E+02	4.840E+00
α_2	3.49E-03	1.31E-02	1.17E-02	2.77E-02	1.28E-02	2.893E+00	2.177E+02
α_3	1.03E-03	7.49E-03	6.07E-03	1.88E-02	9.77E-03	1.653E+00	2.189E+02
α_4	1.19E-07	1.33E-03	3.15E-04	6.14E-03	4.88E-04	2.940E-01	2.203E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678798	0.9811158	0.9820140	0.9912772	0.9796304	3.468E+02	6.675E+00
α_2	2.82E-03	9.43E-03	8.52E-03	1.91E-02	8.84E-03	3.332E+00	3.501E+02
α_3	1.04E-03	5.74E-03	4.84E-03	1.35E-02	6.16E-03	2.030E+00	3.514E+02
α_4	2.68E-04	3.41E-03	2.53E-03	9.55E-03	5.17E-03	1.205E+00	3.523E+02
α_5	1.55E-15	3.06E-04	2.83E-06	1.76E-03	1.96E-04	1.080E-01	3.534E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9707485	0.9824281	0.9831871	0.9915081	0.9814300	4.120E+02	7.369E+00
α_2	1.98E-03	7.20E-03	6.44E-03	1.50E-02	6.93E-03	3.021E+00	4.164E+02
α_3	9.26E-04	4.95E-03	4.19E-03	1.16E-02	4.58E-03	2.078E+00	4.173E+02

α_4	3.39E-04	3.30E-03	2.56E-03	8.83E-03	4.15E-03	1.386E+00	4.180E+02
α_5	4.19E-05	1.81E-03	1.11E-03	5.98E-03	2.83E-03	7.593E-01	4.186E+02
α_6	6.24E-14	2.99E-04	5.89E-06	1.70E-03	8.21E-05	1.254E-01	4.193E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749734	0.9841728	0.9847060	0.9915431	0.9831426	5.895E+02	9.480E+00
α_2	1.76E-03	5.75E-03	5.21E-03	1.16E-02	5.41E-03	3.442E+00	5.955E+02
α_3	9.13E-04	4.08E-03	3.54E-03	9.07E-03	3.67E-03	2.441E+00	5.965E+02
α_4	4.66E-04	3.01E-03	2.48E-03	7.37E-03	3.24E-03	1.801E+00	5.972E+02
α_5	1.60E-04	2.02E-03	1.50E-03	5.66E-03	2.92E-03	1.211E+00	5.978E+02
α_6	5.39E-06	9.06E-04	4.42E-04	3.38E-03	1.59E-03	5.426E-01	5.984E+02
α_7	2.86E-34	7.11E-05	8.38E-11	3.53E-04	3.53E-05	4.261E-02	5.989E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9765457	0.9851154	0.9856090	0.9919968	0.9844622	6.386E+02	9.649E+00
α_2	1.40E-03	4.88E-03	4.39E-03	1.01E-02	4.55E-03	3.166E+00	6.451E+02
α_3	6.31E-04	3.28E-03	2.79E-03	7.63E-03	2.92E-03	2.128E+00	6.461E+02
α_4	3.94E-04	2.68E-03	2.19E-03	6.64E-03	2.67E-03	1.736E+00	6.465E+02
α_5	1.90E-04	2.03E-03	1.55E-03	5.52E-03	2.43E-03	1.316E+00	6.469E+02
α_6	4.67E-05	1.34E-03	8.72E-04	4.21E-03	2.05E-03	8.665E-01	6.474E+02
α_7	1.50E-07	5.19E-04	1.51E-04	2.29E-03	9.06E-04	3.366E-01	6.479E+02
α_8	5.97E-17	1.52E-04	8.29E-07	8.84E-04	1.55E-05	9.860E-02	6.482E+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	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
α_2	1.62E-02	1.67E-02	1.31E-02	9.43E-03	7.20E-03	5.75E-03	4.88E-03
α_3		4.18E-03	7.49E-03	5.74E-03	4.95E-03	4.08E-03	3.28E-03
α_4			1.33E-03	3.41E-03	3.30E-03	3.01E-03	2.68E-03
α_5				3.06E-04	1.81E-03	2.02E-03	2.03E-03
α_6					2.99E-04	9.06E-04	1.34E-03
α_7						7.11E-05	5.19E-04
α_8							1.52E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
Beta	1.62E-02	2.09E-02	2.19E-02	1.89E-02	1.76E-02	1.58E-02	1.49E-02
Gamma		2.00E-01	4.02E-01	5.01E-01	5.90E-01	6.37E-01	6.72E-01
Delta			1.51E-01	3.93E-01	5.22E-01	5.96E-01	6.72E-01
Epsilon				8.22E-02	3.90E-01	4.99E-01	6.01E-01
Mu					1.42E-01	3.26E-01	4.97E-01
Omega						7.28E-02	3.34E-01
Sigma							2.27E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	61.20	91.80	122.40	153.00	183.60	214.20	244.80
N_1	3.0467	2.8150	2.6647	2.9603	3.2024	3.5048	3.7876
N_2	0.9600	1.7550	1.6335	1.4081	1.3199	1.1988	1.1482
N_3		0.3750	1.2505	0.9806	0.8708	0.8116	0.7380
N_4			0.0625	0.8229	0.7900	0.7181	0.6740
N_5				0.0313	0.5382	0.6455	0.6138
N_6					0.0156	0.3510	0.5168
N_7						0.0078	0.2288
N_8							0.0039

2.1.1.4 MOTOR-DRIVEN PUMPS FAIL TO RUN >1H ALL SYSTEMS: ALL-MDP-RH

Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run >1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 95.0

Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483128	0.9802929	0.9845146	0.9978348	0.9806478	7.106E+01	1.429E+00
α_2	2.16E-03	1.97E-02	1.55E-02	5.17E-02	1.94E-02	1.429E+00	7.106E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9500366	0.9754021	0.9777594	0.9927186	0.9709592	1.292E+02	3.258E+00
α_2	4.76E-03	1.97E-02	1.73E-02	4.27E-02	2.39E-02	2.606E+00	1.298E+02
α_3	6.56E-05	4.92E-03	2.75E-03	1.71E-02	5.11E-03	6.518E-01	1.318E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9532224	0.9744424	0.9760981	0.9900205	0.9695645	1.845E+02	4.840E+00
α_2	4.06E-03	1.53E-02	1.36E-02	3.22E-02	1.69E-02	2.893E+00	1.865E+02
α_3	1.20E-03	8.73E-03	7.07E-03	2.19E-02	1.29E-02	1.653E+00	1.877E+02
α_4	1.38E-07	1.55E-03	3.67E-04	7.15E-03	6.46E-04	2.940E-01	1.891E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9639211	0.9787739	0.9797793	0.9901863	0.9730215	3.078E+02	6.675E+00
α_2	3.17E-03	1.06E-02	9.58E-03	2.15E-02	1.17E-02	3.332E+00	3.111E+02
α_3	1.17E-03	6.45E-03	5.44E-03	1.52E-02	8.16E-03	2.030E+00	3.124E+02
α_4	3.01E-04	3.83E-03	2.85E-03	1.07E-02	6.85E-03	1.205E+00	3.133E+02
α_5	1.75E-15	3.43E-04	3.18E-06	1.98E-03	2.60E-04	1.080E-01	3.144E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670930	0.9802210	0.9810722	0.9904344	0.9753752	3.652E+02	7.369E+00
α_2	2.23E-03	8.11E-03	7.25E-03	1.69E-02	9.20E-03	3.021E+00	3.696E+02
α_3	1.04E-03	5.58E-03	4.72E-03	1.30E-02	6.07E-03	2.078E+00	3.705E+02
α_4	3.82E-04	3.72E-03	2.88E-03	9.93E-03	5.50E-03	1.386E+00	3.712E+02

α_5	4.72E-05	2.04E-03	1.24E-03	6.73E-03	3.75E-03	7.593E-01	3.718E+02
α_6	7.02E-14	3.37E-04	6.63E-06	1.91E-03	1.09E-04	1.254E-01	3.725E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724749	0.9825854	0.9831705	0.9906910	0.9776257	5.349E+02	9.480E+00
α_2	1.94E-03	6.32E-03	5.73E-03	1.27E-02	7.19E-03	3.442E+00	5.409E+02
α_3	1.00E-03	4.48E-03	3.89E-03	9.98E-03	4.86E-03	2.441E+00	5.419E+02
α_4	5.13E-04	3.31E-03	2.72E-03	8.10E-03	4.30E-03	1.801E+00	5.426E+02
α_5	1.76E-04	2.22E-03	1.65E-03	6.23E-03	3.87E-03	1.211E+00	5.432E+02
α_6	5.93E-06	9.97E-04	4.86E-04	3.72E-03	2.10E-03	5.426E-01	5.438E+02
α_7	3.15E-34	7.83E-05	9.22E-11	3.89E-04	4.68E-05	4.261E-02	5.443E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740516	0.9835300	0.9840745	0.9911410	0.9793622	5.762E+02	9.649E+00
α_2	1.55E-03	5.40E-03	4.85E-03	1.11E-02	6.04E-03	3.166E+00	5.827E+02
α_3	6.98E-04	3.63E-03	3.09E-03	8.44E-03	3.88E-03	2.128E+00	5.837E+02
α_4	4.36E-04	2.96E-03	2.42E-03	7.35E-03	3.55E-03	1.736E+00	5.841E+02
α_5	2.10E-04	2.25E-03	1.71E-03	6.11E-03	3.23E-03	1.316E+00	5.845E+02
α_6	5.17E-05	1.48E-03	9.65E-04	4.66E-03	2.72E-03	8.665E-01	5.850E+02
α_7	1.66E-07	5.75E-04	1.67E-04	2.53E-03	1.20E-03	3.366E-01	5.855E+02
α_8	6.61E-17	1.68E-04	9.17E-07	9.78E-04	2.05E-05	9.860E-02	5.858E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.75E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
α_2	1.97E-02	1.97E-02	1.53E-02	1.06E-02	8.11E-03	6.32E-03	5.40E-03
α_3		4.92E-03	8.73E-03	6.45E-03	5.58E-03	4.48E-03	3.63E-03
α_4			1.55E-03	3.83E-03	3.72E-03	3.31E-03	2.96E-03
α_5				3.43E-04	2.04E-03	2.22E-03	2.25E-03
α_6					3.37E-04	9.97E-04	1.48E-03
α_7						7.83E-05	5.75E-04
α_8							1.68E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.75E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
Beta	1.97E-02	2.46E-02	2.56E-02	2.12E-02	1.98E-02	1.74E-02	1.65E-02
Gamma		2.00E-01	4.02E-01	5.01E-01	5.90E-01	6.37E-01	6.72E-01
Delta			1.51E-01	3.93E-01	5.22E-01	5.96E-01	6.72E-01
Epsilon				8.22E-02	3.90E-01	4.99E-01	6.01E-01
Mu					1.42E-01	3.26E-01	4.97E-01
Omega						7.28E-02	3.34E-01
Sigma							2.27E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	45.60	68.40	91.20	114.00	136.80	159.60	182.40
N_1	3.0467	2.8150	2.6647	2.9603	3.2024	3.5048	3.7876
N_2	0.9600	1.7550	1.6335	1.4081	1.3199	1.1988	1.1482
N_3		0.3750	1.2505	0.9806	0.8708	0.8116	0.7380
N_4			0.0625	0.8229	0.7900	0.7181	0.6740
N_5				0.0313	0.5382	0.6455	0.6138
N_6					0.0156	0.3510	0.5168
N_7						0.0078	0.2288
N_8							0.0039

2.1.1.5 MOTOR-DRIVEN PUMPS FAIL TO RUN NORMALLY RUNNING SYSTEMS: ALL-MDP-FR-NR

Components/Pump/Motor-Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 134.5

Total Number of Common-Cause Failure Events: 5

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9537872	0.9794679	0.9822507	0.9956415	0.9794537	1.098E+02	2.302E+00
α_2	4.36E-03	2.05E-02	1.78E-02	4.62E-02	2.05E-02	2.302E+00	1.098E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9551773	0.9757949	0.9774387	0.9908073	0.9735037	1.866E+02	4.628E+00
α_2	5.29E-03	1.75E-02	1.59E-02	3.54E-02	1.89E-02	3.351E+00	1.878E+02
α_3	5.90E-04	6.68E-03	5.06E-03	1.83E-02	7.57E-03	1.277E+00	1.899E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9589648	0.9760713	0.9772528	0.9891471	0.9742305	2.608E+02	6.394E+00
α_2	5.17E-03	1.50E-02	1.38E-02	2.89E-02	1.57E-02	4.010E+00	2.632E+02
α_3	8.49E-04	6.18E-03	5.00E-03	1.56E-02	7.16E-03	1.652E+00	2.655E+02
α_4	5.58E-05	2.74E-03	1.64E-03	9.16E-03	2.86E-03	7.315E-01	2.665E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668479	0.9794989	0.9802695	0.9895121	0.9769618	4.029E+02	8.432E+00
α_2	3.74E-03	1.04E-02	9.62E-03	1.97E-02	1.08E-02	4.278E+00	4.070E+02
α_3	1.55E-03	6.40E-03	5.62E-03	1.39E-02	7.30E-03	2.632E+00	4.087E+02
α_4	2.24E-04	2.90E-03	2.15E-03	8.16E-03	3.74E-03	1.195E+00	4.101E+02
α_5	1.80E-07	7.94E-04	2.21E-04	3.53E-03	1.15E-03	3.267E-01	4.110E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9697949	0.9809506	0.9816012	0.9898827	0.9789131	4.791E+02	9.304E+00
α_2	2.59E-03	7.82E-03	7.16E-03	1.53E-02	8.16E-03	3.817E+00	4.846E+02
α_3	1.56E-03	5.91E-03	5.25E-03	1.25E-02	6.47E-03	2.886E+00	4.855E+02
α_4	4.47E-04	3.34E-03	2.69E-03	8.44E-03	3.98E-03	1.629E+00	4.868E+02

α_5	3.15E-05	1.51E-03	9.06E-04	5.04E-03	1.99E-03	7.367E-01	4.877E+02
α_6	3.94E-09	4.81E-04	7.36E-05	2.37E-03	4.82E-04	2.348E-01	4.882E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9739485	0.9828635	0.9833325	0.9901632	0.9804678	6.675E+02	1.164E+01
α_2	2.18E-03	6.16E-03	5.68E-03	1.18E-02	6.44E-03	4.184E+00	6.749E+02
α_3	1.46E-03	4.89E-03	4.42E-03	9.96E-03	5.62E-03	3.324E+00	6.758E+02
α_4	6.74E-04	3.30E-03	2.83E-03	7.55E-03	3.85E-03	2.243E+00	6.769E+02
α_5	1.68E-04	1.89E-03	1.43E-03	5.18E-03	2.38E-03	1.282E+00	6.779E+02
α_6	3.20E-06	7.48E-04	3.45E-04	2.86E-03	1.05E-03	5.080E-01	6.786E+02
α_7	3.80E-17	1.43E-04	7.20E-07	8.33E-04	2.07E-04	9.730E-02	6.790E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754878	0.9837931	0.9842243	0.9906114	0.9817911	7.275E+02	1.199E+01
α_2	1.70E-03	5.14E-03	4.70E-03	1.01E-02	5.19E-03	3.803E+00	7.357E+02
α_3	1.16E-03	4.15E-03	3.72E-03	8.64E-03	4.89E-03	3.072E+00	7.364E+02
α_4	6.51E-04	3.10E-03	2.67E-03	7.04E-03	3.59E-03	2.296E+00	7.372E+02
α_5	2.58E-04	2.09E-03	1.66E-03	5.38E-03	2.45E-03	1.545E+00	7.380E+02
α_6	3.75E-05	1.15E-03	7.40E-04	3.64E-03	1.45E-03	8.474E-01	7.387E+02
α_7	3.83E-08	4.01E-04	9.58E-05	1.84E-03	5.48E-04	2.963E-01	7.392E+02
α_8	3.91E-14	1.70E-04	3.42E-06	9.66E-04	9.09E-05	1.259E-01	7.394E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.79E-01	9.76E-01	9.76E-01	9.79E-01	9.81E-01	9.83E-01	9.84E-01
α_2	2.05E-02	1.75E-02	1.50E-02	1.04E-02	7.82E-03	6.16E-03	5.14E-03
α_3		6.68E-03	6.18E-03	6.40E-03	5.91E-03	4.89E-03	4.15E-03
α_4			2.74E-03	2.90E-03	3.34E-03	3.30E-03	3.10E-03
α_5				7.94E-04	1.51E-03	1.89E-03	2.09E-03
α_6					4.81E-04	7.48E-04	1.15E-03
α_7						1.43E-04	4.01E-04
α_8							1.70E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.79E-01	9.76E-01	9.76E-01	9.79E-01	9.81E-01	9.83E-01	9.84E-01
Beta	2.05E-02	2.42E-02	2.39E-02	2.05E-02	1.90E-02	1.71E-02	1.62E-02
Gamma		2.76E-01	3.73E-01	4.93E-01	5.90E-01	6.40E-01	6.83E-01
Delta			3.07E-01	3.66E-01	4.74E-01	5.54E-01	6.25E-01
Epsilon				2.15E-01	3.74E-01	4.57E-01	5.51E-01
Mu					2.42E-01	3.21E-01	4.51E-01
Omega						1.61E-01	3.33E-01
Sigma							2.98E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	84.06	126.09	168.13	210.16	252.19	294.22	336.25
N_1	3.3333	2.5000	2.0000	1.8750	1.6875	1.4766	1.2656
N_2	1.8333	2.5000	2.7500	2.3542	2.1163	1.9408	1.7844
N_3		1.0000	1.2500	1.5833	1.6788	1.6944	1.6812
N_4			0.5000	0.8125	1.0330	1.1597	1.2338
N_5				0.2500	0.5156	0.7167	0.8429
N_6					0.1250	0.3164	0.4977
N_7						0.0625	0.1885
N_8							0.0313

2.1.1.6 MOTOR-DRIVEN PUMPS FAIL TO START STANDBY SYSTEMS: ALL-MDP-FS-NS

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/Centrifugal
Failure Modes/Fail to Start (Normally standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 254.8

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668339	0.9863502	0.9886941	0.9978390	0.9877646	1.315E+02	1.820E+00
α_2	2.16E-03	1.36E-02	1.13E-02	3.32E-02	1.22E-02	1.820E+00	1.315E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724770	0.9869040	0.9883264	0.9964800	0.9890525	2.209E+02	2.932E+00
α_2	8.32E-04	6.83E-03	5.43E-03	1.76E-02	4.12E-03	1.530E+00	2.223E+02
α_3	6.58E-04	6.26E-03	4.87E-03	1.66E-02	6.83E-03	1.402E+00	2.225E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743630	0.9865532	0.9875831	0.9952289	0.9895173	3.073E+02	4.188E+00
α_2	1.47E-03	7.20E-03	6.17E-03	1.64E-02	4.49E-03	2.242E+00	3.092E+02
α_3	2.65E-04	3.70E-03	2.71E-03	1.05E-02	3.43E-03	1.152E+00	3.103E+02
α_4	6.83E-05	2.55E-03	1.59E-03	8.28E-03	2.57E-03	7.940E-01	3.107E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9773305	0.9869659	0.9876575	0.9942562	0.9902632	4.611E+02	6.090E+00
α_2	1.75E-03	6.42E-03	5.73E-03	1.34E-02	3.94E-03	2.999E+00	4.642E+02
α_3	5.16E-04	3.63E-03	2.95E-03	9.06E-03	2.37E-03	1.695E+00	4.655E+02
α_4	1.25E-04	2.22E-03	1.57E-03	6.56E-03	2.40E-03	1.038E+00	4.662E+02
α_5	3.60E-07	7.66E-04	2.43E-04	3.31E-03	1.03E-03	3.580E-01	4.669E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9791645	0.9877093	0.9882918	0.9942746	0.9908281	5.492E+02	6.834E+00
α_2	1.35E-03	5.15E-03	4.57E-03	1.09E-02	3.55E-03	2.863E+00	5.531E+02
α_3	5.09E-04	3.26E-03	2.68E-03	7.96E-03	1.85E-03	1.811E+00	5.542E+02
α_4	1.76E-04	2.19E-03	1.63E-03	6.12E-03	1.91E-03	1.219E+00	5.548E+02
α_5	2.05E-05	1.24E-03	7.17E-04	4.24E-03	1.43E-03	6.898E-01	5.553E+02
α_6	7.75E-09	4.50E-04	7.90E-05	2.18E-03	4.30E-04	2.504E-01	5.558E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9809033	0.9880362	0.9884649	0.9937189	0.9912668	7.494E+02	9.074E+00
α_2	1.44E-03	4.62E-03	4.19E-03	9.27E-03	3.31E-03	3.506E+00	7.549E+02
α_3	5.87E-04	2.92E-03	2.50E-03	6.70E-03	1.54E-03	2.214E+00	7.562E+02
α_4	2.95E-04	2.17E-03	1.75E-03	5.48E-03	1.48E-03	1.646E+00	7.568E+02
α_5	9.53E-05	1.46E-03	1.05E-03	4.22E-03	1.42E-03	1.107E+00	7.573E+02
α_6	2.48E-06	6.54E-04	2.96E-04	2.52E-03	8.00E-04	4.963E-01	7.579E+02
α_7	3.37E-16	1.39E-04	1.10E-06	8.02E-04	1.85E-04	1.051E-01	7.583E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9820983	0.9887143	0.9891016	0.9940042	0.9916107	8.212E+02	9.373E+00
α_2	1.24E-03	4.09E-03	3.70E-03	8.28E-03	3.18E-03	3.399E+00	8.271E+02
α_3	4.13E-04	2.37E-03	1.98E-03	5.64E-03	1.33E-03	1.968E+00	8.286E+02
α_4	2.37E-04	1.89E-03	1.50E-03	4.84E-03	1.16E-03	1.566E+00	8.290E+02
α_5	1.25E-04	1.50E-03	1.12E-03	4.15E-03	1.24E-03	1.242E+00	8.293E+02
α_6	2.27E-05	9.30E-04	5.72E-04	3.05E-03	9.71E-04	7.720E-01	8.298E+02
α_7	3.30E-08	3.56E-04	8.45E-05	1.63E-03	4.31E-04	2.953E-01	8.302E+02
α_8	7.15E-14	1.56E-04	3.60E-06	8.83E-04	8.09E-05	1.298E-01	8.304E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.86E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01	9.88E-01	9.89E-01
α_2	1.36E-02	6.83E-03	7.20E-03	6.42E-03	5.15E-03	4.62E-03	4.09E-03
α_3		6.26E-03	3.70E-03	3.63E-03	3.26E-03	2.92E-03	2.37E-03
α_4			2.55E-03	2.22E-03	2.19E-03	2.17E-03	1.89E-03
α_5				7.66E-04	1.24E-03	1.46E-03	1.50E-03
α_6					4.50E-04	6.54E-04	9.30E-04

α_7						1.39E-04	3.56E-04
α_8							1.56E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01	9.88E-01	9.89E-01
Beta	1.36E-02	1.31E-02	1.34E-02	1.30E-02	1.23E-02	1.20E-02	1.13E-02
Gamma		4.78E-01	4.65E-01	5.08E-01	5.81E-01	6.14E-01	6.37E-01
Delta			4.08E-01	4.52E-01	5.44E-01	6.02E-01	6.71E-01
Epsilon				2.56E-01	4.35E-01	5.09E-01	6.09E-01
Mu					2.66E-01	3.52E-01	4.91E-01
Omega						1.75E-01	3.55E-01
Sigma							3.05E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	107.28	160.93	214.57	268.21	321.85	375.49	429.14
N_1	1.7976	2.0179	2.0357	2.0908	2.0997	2.0674	1.9958
N_2	1.3512	0.6786	0.9821	1.0744	1.1620	1.2624	1.3810
N_3		1.1250	0.7500	0.6458	0.6042	0.5848	0.5779
N_4			0.5625	0.6563	0.6233	0.5628	0.5040
N_5				0.2813	0.4688	0.5414	0.5397
N_6					0.1406	0.3047	0.4223
N_7						0.0703	0.1875
N_8							0.0352

2.1.1.7 MOTOR-DRIVEN PUMPS FAIL TO START NORMALLY RUNNING SYSTEMS: ALL-MDP-FS-NR

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/Centrifugal
Failure Modes/Fail to Start (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 191.1

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763295	0.9935245	0.9966986	0.9999536	0.9984456	8.741E+01	5.697E-01
α_2	4.88E-05	6.48E-03	3.30E-03	2.37E-02	1.55E-03	5.697E-01	8.741E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9759139	0.9908584	0.9928440	0.9990000	0.9968863	1.552E+02	1.432E+00
α_2	5.31E-04	7.37E-03	5.41E-03	2.09E-02	3.11E-03	1.155E+00	1.554E+02
α_3	8.79E-08	1.77E-03	3.77E-04	8.29E-03	0.00E+00	2.768E-01	1.563E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752140	0.9887537	0.9901846	0.9974073	0.9953222	2.199E+02	2.501E+00
α_2	1.37E-03	8.40E-03	6.97E-03	2.03E-02	4.68E-03	1.867E+00	2.205E+02
α_3	1.96E-06	1.81E-03	6.63E-04	7.50E-03	0.00E+00	4.024E-01	2.220E+02
α_4	7.20E-09	1.04E-03	1.55E-04	5.15E-03	0.00E+00	2.315E-01	2.221E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9772291	0.9879950	0.9888926	0.9956839	0.9947834	3.520E+02	4.277E+00
α_2	1.86E-03	7.54E-03	6.64E-03	1.63E-02	4.70E-03	2.686E+00	3.536E+02
α_3	2.19E-04	3.18E-03	2.31E-03	9.10E-03	5.14E-04	1.132E+00	3.552E+02

α_4	8.15E-07	1.07E-03	3.69E-04	4.53E-03	0.00E+00	3.822E-01	3.559E+02
α_5	1.87E-20	2.15E-04	2.00E-07	1.25E-03	0.00E+00	7.674E-02	3.562E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9786371	0.9883217	0.9890792	0.9954095	0.9942943	4.183E+02	4.943E+00
α_2	1.50E-03	6.21E-03	5.45E-03	1.35E-02	4.78E-03	2.629E+00	4.206E+02
α_3	3.28E-04	3.25E-03	2.50E-03	8.69E-03	8.58E-04	1.374E+00	4.219E+02
α_4	1.46E-05	1.44E-03	7.68E-04	5.15E-03	7.15E-05	6.098E-01	4.227E+02
α_5	2.04E-09	5.22E-04	6.98E-05	2.62E-03	0.00E+00	2.211E-01	4.230E+02
α_6	2.04E-15	2.59E-04	2.62E-06	1.50E-03	0.00E+00	1.098E-01	4.232E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9801603	0.9881830	0.9887197	0.9943811	0.9938640	5.968E+02	7.136E+00
α_2	1.66E-03	5.53E-03	5.00E-03	1.12E-02	4.85E-03	3.342E+00	6.006E+02
α_3	5.11E-04	3.11E-03	2.58E-03	7.52E-03	1.10E-03	1.878E+00	6.020E+02
α_4	1.25E-04	1.86E-03	1.35E-03	5.34E-03	1.74E-04	1.122E+00	6.028E+02
α_5	6.92E-06	9.40E-04	4.75E-04	3.45E-03	1.02E-05	5.677E-01	6.033E+02
α_6	1.74E-10	3.17E-04	2.93E-05	1.65E-03	0.00E+00	1.916E-01	6.037E+02
α_7	3.95E-41	5.76E-05	2.14E-12	2.53E-04	0.00E+00	3.480E-02	6.039E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9811337	0.9886758	0.9891675	0.9945299	0.9934893	6.468E+02	7.408E+00
α_2	1.49E-03	5.03E-03	4.53E-03	1.03E-02	4.92E-03	3.290E+00	6.509E+02
α_3	3.81E-04	2.63E-03	2.14E-03	6.53E-03	1.27E-03	1.718E+00	6.525E+02
α_4	1.20E-04	1.74E-03	1.26E-03	4.97E-03	2.87E-04	1.136E+00	6.531E+02
α_5	2.00E-05	1.09E-03	6.39E-04	3.68E-03	3.28E-05	7.111E-01	6.535E+02
α_6	2.12E-07	5.35E-04	1.64E-04	2.33E-03	1.49E-06	3.501E-01	6.538E+02
α_7	8.06E-16	1.65E-04	1.51E-06	9.52E-04	0.00E+00	1.078E-01	6.541E+02
α_8	1.68E-17	1.45E-04	6.13E-07	8.43E-04	0.00E+00	9.469E-02	6.541E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.91E-01	9.89E-01	9.88E-01	9.88E-01	9.88E-01	9.89E-01
α_2	6.48E-03	7.37E-03	8.40E-03	7.54E-03	6.21E-03	5.53E-03	5.03E-03
α_3		1.77E-03	1.81E-03	3.18E-03	3.25E-03	3.11E-03	2.63E-03
α_4			1.04E-03	1.07E-03	1.44E-03	1.86E-03	1.74E-03
α_5				2.15E-04	5.22E-04	9.40E-04	1.09E-03
α_6					2.59E-04	3.17E-04	5.35E-04
α_7						5.76E-05	1.65E-04
α_8							1.45E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.91E-01	9.89E-01	9.88E-01	9.88E-01	9.88E-01	9.89E-01
Beta	6.48E-03	9.14E-03	1.12E-02	1.20E-02	1.17E-02	1.18E-02	1.13E-02
Gamma		1.93E-01	2.53E-01	3.72E-01	4.68E-01	5.32E-01	5.56E-01
Delta			3.65E-01	2.88E-01	4.06E-01	5.05E-01	5.83E-01
Epsilon				1.67E-01	3.52E-01	4.14E-01	5.27E-01
Mu					3.32E-01	2.85E-01	4.37E-01
Omega						1.54E-01	3.66E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	63.70	95.55	127.40	159.25	191.10	222.95	254.80
N_1	1.2976	1.6429	1.7857	1.9345	2.0060	2.0127	1.9645
N_2	0.1012	0.3036	0.6071	0.7619	0.9276	1.0984	1.2716
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

2.1.2 Pooled Pump Volutes

2.1.2.1 CLEAN SYSTEM PUMP VOLUTES FAIL TO RUN: CLN-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: 2006 through 2020

Total Number of Independent Failure Events: 51.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751705	0.9936669	0.9972662	0.9999806	1.0000000	7.351E+01	4.685E-01
α_2	1.76E-05	6.33E-03	2.74E-03	2.48E-02	0.00E+00	4.685E-01	7.351E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9707595	0.9897644	0.9925337	0.9992943	1.0000000	1.091E+02	1.128E+00
α_2	2.58E-04	7.72E-03	5.02E-03	2.44E-02	0.00E+00	8.512E-01	1.094E+02
α_3	1.25E-07	2.51E-03	5.36E-04	1.18E-02	0.00E+00	2.768E-01	1.099E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9683782	0.9868196	0.9890001	0.9977995	1.0000000	1.418E+02	1.894E+00
α_2	7.56E-04	8.77E-03	6.62E-03	2.41E-02	0.00E+00	1.260E+00	1.424E+02
α_3	3.04E-06	2.80E-03	1.03E-03	1.16E-02	0.00E+00	4.024E-01	1.433E+02
α_4	1.12E-08	1.61E-03	2.40E-04	7.98E-03	0.00E+00	2.315E-01	1.434E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9718860	0.9860123	0.9873131	0.9957070	1.0000000	2.419E+02	3.432E+00
α_2	1.33E-03	7.84E-03	6.55E-03	1.88E-02	0.00E+00	1.924E+00	2.434E+02

α_3	2.47E-04	4.28E-03	3.03E-03	1.26E-02	0.00E+00	1.049E+00	2.443E+02
α_4	1.18E-06	1.56E-03	5.37E-04	6.57E-03	0.00E+00	3.822E-01	2.450E+02
α_5	2.72E-20	3.13E-04	2.91E-07	1.82E-03	0.00E+00	7.674E-02	2.453E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9732972	0.9863114	0.9874540	0.9954300	1.0000000	2.763E+02	3.835E+00
α_2	8.70E-04	6.07E-03	4.94E-03	1.51E-02	0.00E+00	1.701E+00	2.785E+02
α_3	3.40E-04	4.31E-03	3.20E-03	1.21E-02	0.00E+00	1.207E+00	2.789E+02
α_4	1.95E-05	2.13E-03	1.12E-03	7.67E-03	0.00E+00	5.960E-01	2.796E+02
α_5	3.09E-09	7.89E-04	1.06E-04	3.96E-03	0.00E+00	2.211E-01	2.799E+02
α_6	3.08E-15	3.92E-04	3.97E-06	2.26E-03	0.00E+00	1.098E-01	2.800E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763605	0.9865919	0.9873446	0.9942644	1.0000000	4.229E+02	5.747E+00
α_2	1.07E-03	5.23E-03	4.49E-03	1.19E-02	0.00E+00	2.243E+00	4.264E+02
α_3	5.10E-04	3.80E-03	3.06E-03	9.62E-03	0.00E+00	1.630E+00	4.270E+02
α_4	1.57E-04	2.53E-03	1.81E-03	7.35E-03	0.00E+00	1.083E+00	4.276E+02
α_5	9.53E-06	1.32E-03	6.65E-04	4.85E-03	0.00E+00	5.654E-01	4.281E+02
α_6	2.45E-10	4.47E-04	4.13E-05	2.33E-03	0.00E+00	1.916E-01	4.285E+02
α_7	5.56E-41	8.12E-05	3.02E-12	3.56E-04	0.00E+00	3.480E-02	4.286E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9773904	0.9871867	0.9879092	0.9945258	1.0000000	4.411E+02	5.726E+00
α_2	8.14E-04	4.52E-03	3.80E-03	1.07E-02	0.00E+00	2.018E+00	4.448E+02
α_3	3.21E-04	3.11E-03	2.41E-03	8.30E-03	0.00E+00	1.391E+00	4.455E+02
α_4	1.41E-04	2.38E-03	1.69E-03	6.96E-03	0.00E+00	1.062E+00	4.458E+02
α_5	2.77E-05	1.57E-03	9.18E-04	5.34E-03	0.00E+00	7.026E-01	4.461E+02
α_6	3.07E-07	7.83E-04	2.40E-04	3.40E-03	0.00E+00	3.497E-01	4.465E+02
α_7	1.18E-15	2.41E-04	2.21E-06	1.39E-03	0.00E+00	1.078E-01	4.467E+02
α_8	2.47E-17	2.12E-04	8.98E-07	1.23E-03	0.00E+00	9.469E-02	4.468E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
α_2	6.33E-03	7.72E-03	8.77E-03	7.84E-03	6.07E-03	5.23E-03	4.52E-03
α_3		2.51E-03	2.80E-03	4.28E-03	4.31E-03	3.80E-03	3.11E-03
α_4			1.61E-03	1.56E-03	2.13E-03	2.53E-03	2.38E-03
α_5				3.13E-04	7.89E-04	1.32E-03	1.57E-03
α_6					3.92E-04	4.47E-04	7.83E-04
α_7						8.12E-05	2.41E-04
α_8							2.12E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
Beta	6.33E-03	1.02E-02	1.32E-02	1.40E-02	1.37E-02	1.34E-02	1.28E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	51.10	51.10	51.10	51.10	51.10	51.10	51.10
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

2.1.3 Pooled Clean System Motor-Driven Pumps

2.1.3.1 CLEAN SYSTEM MOTOR-DRIVEN PUMPS FAIL TO START: CLN-MDP-FS

Systems/Clean Water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 193.3

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9684996	0.9872785	0.9895902	0.9981389	0.9888599	1.334E+02	1.719E+00
α_2	1.86E-03	1.27E-02	1.04E-02	3.15E-02	1.11E-02	1.719E+00	1.334E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748246	0.9884058	0.9898117	0.9971898	0.9910480	2.240E+02	2.628E+00
α_2	4.41E-04	5.41E-03	4.04E-03	1.51E-02	2.24E-03	1.226E+00	2.254E+02
α_3	6.49E-04	6.18E-03	4.81E-03	1.64E-02	6.71E-03	1.402E+00	2.253E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9774180	0.9886466	0.9896651	0.9963998	0.9924277	3.118E+02	3.581E+00
α_2	6.99E-04	5.18E-03	4.18E-03	1.31E-02	1.68E-03	1.635E+00	3.138E+02
α_3	2.61E-04	3.65E-03	2.67E-03	1.04E-02	3.37E-03	1.152E+00	3.143E+02
α_4	6.75E-05	2.52E-03	1.57E-03	8.18E-03	2.52E-03	7.940E-01	3.146E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9799791	0.9888974	0.9895823	0.9954814	0.9934828	4.671E+02	5.245E+00
α_2	9.65E-04	4.73E-03	4.06E-03	1.08E-02	1.12E-03	2.237E+00	4.701E+02
α_3	4.50E-04	3.41E-03	2.74E-03	8.66E-03	2.02E-03	1.612E+00	4.708E+02
α_4	1.24E-04	2.20E-03	1.55E-03	6.49E-03	2.36E-03	1.038E+00	4.713E+02
α_5	3.56E-07	7.58E-04	2.40E-04	3.27E-03	1.01E-03	3.580E-01	4.720E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9820220	0.9898196	0.9903962	0.9956587	0.9943285	5.567E+02	5.726E+00
α_2	5.88E-04	3.44E-03	2.87E-03	8.24E-03	7.03E-04	1.935E+00	5.605E+02

α_3	3.97E-04	2.92E-03	2.36E-03	7.38E-03	1.31E-03	1.645E+00	5.608E+02
α_4	1.68E-04	2.14E-03	1.59E-03	6.01E-03	1.83E-03	1.205E+00	5.612E+02
α_5	2.02E-05	1.23E-03	7.08E-04	4.19E-03	1.41E-03	6.898E-01	5.617E+02
α_6	7.66E-09	4.45E-04	7.81E-05	2.15E-03	4.22E-04	2.504E-01	5.622E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9834150	0.9899694	0.9903950	0.9950789	0.9950141	7.585E+02	7.685E+00
α_2	6.93E-04	3.14E-03	2.72E-03	7.03E-03	4.22E-04	2.407E+00	7.637E+02
α_3	4.47E-04	2.57E-03	2.15E-03	6.11E-03	8.64E-04	1.965E+00	7.642E+02
α_4	2.75E-04	2.10E-03	1.68E-03	5.33E-03	1.35E-03	1.606E+00	7.645E+02
α_5	9.37E-05	1.44E-03	1.04E-03	4.17E-03	1.39E-03	1.104E+00	7.650E+02
α_6	2.45E-06	6.48E-04	2.93E-04	2.49E-03	7.84E-04	4.963E-01	7.656E+02
α_7	3.34E-16	1.37E-04	1.09E-06	7.94E-04	1.81E-04	1.051E-01	7.660E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9848533	0.9908401	0.9912244	0.9955071	0.9955729	8.319E+02	7.690E+00
α_2	4.86E-04	2.53E-03	2.15E-03	5.89E-03	2.46E-04	2.127E+00	8.374E+02
α_3	2.64E-04	1.95E-03	1.58E-03	4.94E-03	5.63E-04	1.641E+00	8.379E+02
α_4	2.07E-04	1.78E-03	1.40E-03	4.63E-03	9.68E-04	1.492E+00	8.381E+02
α_5	1.21E-04	1.47E-03	1.10E-03	4.09E-03	1.20E-03	1.234E+00	8.383E+02
α_6	2.24E-05	9.19E-04	5.66E-04	3.02E-03	9.51E-04	7.716E-01	8.388E+02
α_7	3.26E-08	3.52E-04	8.36E-05	1.62E-03	4.22E-04	2.953E-01	8.393E+02
α_8	7.07E-14	1.55E-04	3.56E-06	8.73E-04	7.92E-05	1.298E-01	8.394E+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	9.88E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.91E-01
α_2	1.27E-02	5.41E-03	5.18E-03	4.73E-03	3.44E-03	3.14E-03	2.53E-03
α_3		6.18E-03	3.65E-03	3.41E-03	2.92E-03	2.57E-03	1.95E-03
α_4			2.52E-03	2.20E-03	2.14E-03	2.10E-03	1.78E-03
α_5				7.58E-04	1.23E-03	1.44E-03	1.47E-03
α_6					4.45E-04	6.48E-04	9.19E-04
α_7						1.37E-04	3.52E-04
α_8							1.55E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.91E-01
Beta	1.27E-02	1.16E-02	1.14E-02	1.11E-02	1.02E-02	1.00E-02	9.16E-03
Gamma		5.33E-01	5.44E-01	5.74E-01	6.62E-01	6.87E-01	7.23E-01
Delta			4.08E-01	4.64E-01	5.66E-01	6.28E-01	7.05E-01
Epsilon				2.56E-01	4.38E-01	5.15E-01	6.20E-01
Mu					2.66E-01	3.53E-01	4.92E-01
Omega						1.75E-01	3.55E-01

Sigma							3.05E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	110.46	165.69	220.91	276.14	331.37	386.60	441.83
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	1.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		1.1250	0.7500	0.5625	0.4375	0.3359	0.2500
N_4			0.5625	0.6563	0.6094	0.5234	0.4297
N_5				0.2813	0.4688	0.5391	0.5313
N_6					0.1406	0.3047	0.4219
N_7						0.0703	0.1875
N_8							0.0352

2.1.3.2 CLEAN SYSTEM MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1 HOUR: CLN-MDP-FH

Systems/Clean Water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 15.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9517531	0.9876643	0.9946216	0.9999626	1.0000000	3.751E+01	4.685E-01
α_2	3.47E-05	1.23E-02	5.38E-03	4.82E-02	0.00E+00	4.685E-01	3.751E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9566767	0.9847987	0.9888814	0.9989494	1.0000000	7.308E+01	1.128E+00
α_2	3.84E-04	1.15E-02	7.48E-03	3.62E-02	0.00E+00	8.512E-01	7.336E+01
α_3	1.86E-07	3.73E-03	7.99E-04	1.75E-02	0.00E+00	2.768E-01	7.393E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9578837	0.9824127	0.9853053	0.9970552	1.0000000	1.058E+02	1.894E+00
α_2	1.01E-03	1.17E-02	8.84E-03	3.22E-02	0.00E+00	1.260E+00	1.064E+02
α_3	4.06E-06	3.74E-03	1.37E-03	1.55E-02	0.00E+00	4.024E-01	1.073E+02
α_4	1.49E-08	2.15E-03	3.20E-04	1.06E-02	0.00E+00	2.315E-01	1.074E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670800	0.9836073	0.9851200	0.9949630	1.0000000	2.059E+02	3.432E+00
α_2	1.56E-03	9.19E-03	7.68E-03	2.20E-02	0.00E+00	1.924E+00	2.074E+02
α_3	2.90E-04	5.01E-03	3.55E-03	1.47E-02	0.00E+00	1.049E+00	2.083E+02
α_4	1.39E-06	1.83E-03	6.29E-04	7.70E-03	0.00E+00	3.822E-01	2.090E+02
α_5	3.18E-20	3.67E-04	3.42E-07	2.13E-03	0.00E+00	7.674E-02	2.093E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693815	0.9842930	0.9855943	0.9947563	1.0000000	2.403E+02	3.835E+00
α_2	9.99E-04	6.97E-03	5.68E-03	1.74E-02	0.00E+00	1.701E+00	2.425E+02
α_3	3.90E-04	4.94E-03	3.67E-03	1.38E-02	0.00E+00	1.207E+00	2.429E+02

α_4	2.24E-05	2.44E-03	1.28E-03	8.79E-03	0.00E+00	5.960E-01	2.436E+02
α_5	3.55E-09	9.06E-04	1.21E-04	4.54E-03	0.00E+00	2.211E-01	2.439E+02
α_6	3.54E-15	4.50E-04	4.55E-06	2.59E-03	0.00E+00	1.098E-01	2.440E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742037	0.9853625	0.9861768	0.9937352	1.0000000	3.869E+02	5.747E+00
α_2	1.17E-03	5.71E-03	4.90E-03	1.30E-02	0.00E+00	2.243E+00	3.904E+02
α_3	5.57E-04	4.15E-03	3.34E-03	1.05E-02	0.00E+00	1.630E+00	3.910E+02
α_4	1.72E-04	2.76E-03	1.97E-03	8.02E-03	0.00E+00	1.083E+00	3.916E+02
α_5	1.04E-05	1.44E-03	7.26E-04	5.29E-03	0.00E+00	5.654E-01	3.921E+02
α_6	2.68E-10	4.88E-04	4.51E-05	2.54E-03	0.00E+00	1.916E-01	3.925E+02
α_7	6.07E-41	8.86E-05	3.30E-12	3.89E-04	0.00E+00	3.480E-02	3.926E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754121	0.9860640	0.9868433	0.9940433	1.0000000	4.051E+02	5.726E+00
α_2	8.86E-04	4.91E-03	4.14E-03	1.16E-02	0.00E+00	2.018E+00	4.088E+02
α_3	3.49E-04	3.38E-03	2.62E-03	9.03E-03	0.00E+00	1.391E+00	4.095E+02
α_4	1.54E-04	2.59E-03	1.84E-03	7.57E-03	0.00E+00	1.062E+00	4.098E+02
α_5	3.02E-05	1.71E-03	9.99E-04	5.81E-03	0.00E+00	7.026E-01	4.101E+02
α_6	3.34E-07	8.51E-04	2.61E-04	3.70E-03	0.00E+00	3.497E-01	4.105E+02
α_7	1.28E-15	2.62E-04	2.41E-06	1.52E-03	0.00E+00	1.078E-01	4.107E+02
α_8	2.68E-17	2.30E-04	9.76E-07	1.34E-03	0.00E+00	9.469E-02	4.108E+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	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.23E-02	1.15E-02	1.17E-02	9.19E-03	6.97E-03	5.71E-03	4.91E-03
α_3		3.73E-03	3.74E-03	5.01E-03	4.94E-03	4.15E-03	3.38E-03
α_4			2.15E-03	1.83E-03	2.44E-03	2.76E-03	2.59E-03
α_5				3.67E-04	9.06E-04	1.44E-03	1.71E-03
α_6					4.50E-04	4.88E-04	8.51E-04
α_7						8.86E-05	2.62E-04
α_8							2.30E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.23E-02	1.52E-02	1.76E-02	1.64E-02	1.57E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	15.10	15.10	15.10	15.10	15.10	15.10	15.10
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

2.1.3.3 CLEAN SYSTEM MDP- MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: CLN-MDP-FHRH

Systems/Clean Water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 46.6

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9604257	0.9881742	0.9929194	0.9997698	0.9933613	6.032E+01	7.219E-01
α_2	2.33E-04	1.18E-02	7.08E-03	3.96E-02	6.64E-03	7.219E-01	6.032E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9645387	0.9858902	0.9885670	0.9980749	0.9910503	1.145E+02	1.638E+00
α_2	8.86E-04	1.06E-02	8.00E-03	2.95E-02	6.76E-03	1.236E+00	1.149E+02
α_3	3.72E-06	3.46E-03	1.27E-03	1.43E-02	2.19E-03	4.018E-01	1.157E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9664095	0.9845520	0.9864301	0.9962872	0.9906726	1.657E+02	2.600E+00
α_2	1.35E-03	9.82E-03	7.96E-03	2.47E-02	5.20E-03	1.653E+00	1.667E+02
α_3	5.20E-05	3.88E-03	2.17E-03	1.35E-02	3.31E-03	6.529E-01	1.677E+02
α_4	1.55E-07	1.75E-03	4.13E-04	8.04E-03	8.25E-04	2.940E-01	1.680E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9719343	0.9851941	0.9862979	0.9946760	0.9910776	2.845E+02	4.275E+00
α_2	1.62E-03	7.85E-03	6.74E-03	1.78E-02	3.61E-03	2.266E+00	2.865E+02
α_3	4.71E-04	4.72E-03	3.64E-03	1.27E-02	3.32E-03	1.363E+00	2.874E+02
α_4	1.07E-05	1.87E-03	9.06E-04	6.97E-03	1.65E-03	5.385E-01	2.882E+02
α_5	1.90E-15	3.74E-04	3.46E-06	2.16E-03	3.31E-04	1.080E-01	2.886E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742985	0.9860636	0.9870025	0.9946275	0.9917425	3.375E+02	4.769E+00
α_2	1.01E-03	5.78E-03	4.85E-03	1.37E-02	2.43E-03	1.977E+00	3.403E+02

α_3	5.36E-04	4.45E-03	3.53E-03	1.15E-02	2.79E-03	1.522E+00	3.407E+02
α_4	7.48E-05	2.43E-03	1.55E-03	7.76E-03	2.07E-03	8.304E-01	3.414E+02
α_5	1.52E-07	9.20E-04	2.43E-04	4.14E-03	8.28E-04	3.148E-01	3.419E+02
α_6	7.64E-14	3.66E-04	7.22E-06	2.08E-03	1.38E-04	1.254E-01	3.421E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9775014	0.9867610	0.9873911	0.9938672	0.9924407	5.027E+02	6.744E+00
α_2	1.09E-03	4.83E-03	4.20E-03	1.07E-02	1.66E-03	2.462E+00	5.070E+02
α_3	6.28E-04	3.74E-03	3.12E-03	9.00E-03	2.11E-03	1.908E+00	5.075E+02
α_4	2.63E-04	2.66E-03	2.05E-03	7.17E-03	2.08E-03	1.357E+00	5.081E+02
α_5	2.89E-05	1.43E-03	8.55E-04	4.80E-03	1.24E-03	7.294E-01	5.087E+02
α_6	6.90E-09	4.83E-04	8.20E-05	2.35E-03	4.15E-04	2.463E-01	5.092E+02
α_7	3.36E-34	8.37E-05	9.85E-11	4.16E-04	5.92E-05	4.261E-02	5.094E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9789570	0.9876135	0.9882062	0.9942559	0.9930839	5.395E+02	6.767E+00
α_2	8.02E-04	4.02E-03	3.43E-03	9.24E-03	1.18E-03	2.196E+00	5.441E+02
α_3	3.92E-04	2.96E-03	2.38E-03	7.51E-03	1.50E-03	1.616E+00	5.447E+02
α_4	2.35E-04	2.45E-03	1.87E-03	6.62E-03	1.82E-03	1.336E+00	5.450E+02
α_5	7.00E-05	1.69E-03	1.13E-03	5.20E-03	1.45E-03	9.214E-01	5.454E+02
α_6	2.06E-06	8.40E-04	3.53E-04	3.33E-03	7.26E-04	4.591E-01	5.459E+02
α_7	5.07E-13	2.55E-04	7.88E-06	1.42E-03	2.08E-04	1.391E-01	5.462E+02
α_8	7.08E-17	1.80E-04	9.84E-07	1.05E-03	2.59E-05	9.860E-02	5.462E+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	9.86E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01
α_2	1.18E-02	1.06E-02	9.82E-03	7.85E-03	5.78E-03	4.83E-03	4.02E-03
α_3		3.46E-03	3.88E-03	4.72E-03	4.45E-03	3.74E-03	2.96E-03
α_4			1.75E-03	1.87E-03	2.43E-03	2.66E-03	2.45E-03
α_5				3.74E-04	9.20E-04	1.43E-03	1.69E-03
α_6					3.66E-04	4.83E-04	8.40E-04
α_7						8.37E-05	2.55E-04
α_8							1.80E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.86E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01
Beta	1.18E-02	1.41E-02	1.54E-02	1.48E-02	1.39E-02	1.32E-02	1.24E-02
Gamma		2.45E-01	3.64E-01	4.70E-01	5.86E-01	6.35E-01	6.75E-01
Delta			3.10E-01	3.22E-01	4.55E-01	5.55E-01	6.46E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01

Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	37.28	55.92	74.56	93.20	111.84	130.48	149.12
N_1	0.6267	0.5550	0.4780	0.4270	0.4024	0.3968	0.4027
N_2	0.2533	0.3850	0.3935	0.3415	0.2754	0.2185	0.1782
N_3		0.1250	0.2505	0.3139	0.3153	0.2781	0.2259
N_4			0.0625	0.1563	0.2345	0.2737	0.2739
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.1.3.4 CLEAN SYSTEM MOTOR-DRIVEN PUMPS FAIL TO RUN > 1 HOUR: CLN-MDP-RH

Systems/Clean Water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 31.5

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9507410	0.9852565	0.9911437	0.9997071	0.9902863	4.824E+01	7.219E-01
α_2	2.91E-04	1.47E-02	8.85E-03	4.93E-02	9.71E-03	7.219E-01	4.824E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9580280	0.9832805	0.9864434	0.9977195	0.9868777	9.633E+01	1.638E+00
α_2	1.05E-03	1.26E-02	9.49E-03	3.49E-02	9.91E-03	1.236E+00	9.674E+01
α_3	4.41E-06	4.10E-03	1.50E-03	1.70E-02	3.22E-03	4.018E-01	9.757E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9608214	0.9819629	0.9841453	0.9956582	0.9863040	1.416E+02	2.600E+00
α_2	1.58E-03	1.15E-02	9.30E-03	2.88E-02	7.63E-03	1.653E+00	1.425E+02
α_3	6.08E-05	4.53E-03	2.54E-03	1.58E-02	4.86E-03	6.529E-01	1.435E+02
α_4	1.82E-07	2.04E-03	4.83E-04	9.39E-03	1.21E-03	2.940E-01	1.439E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686792	0.9834647	0.9846933	0.9940447	0.9868850	2.543E+02	4.275E+00
α_2	1.82E-03	8.76E-03	7.53E-03	1.99E-02	5.31E-03	2.266E+00	2.563E+02
α_3	5.26E-04	5.27E-03	4.06E-03	1.41E-02	4.88E-03	1.363E+00	2.572E+02
α_4	1.20E-05	2.08E-03	1.01E-03	7.78E-03	2.43E-03	5.385E-01	2.580E+02
α_5	2.12E-15	4.18E-04	3.87E-06	2.41E-03	4.86E-04	1.080E-01	2.584E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712740	0.9844130	0.9854542	0.9939885	0.9878529	3.012E+02	4.769E+00
α_2	1.14E-03	6.46E-03	5.42E-03	1.53E-02	3.58E-03	1.977E+00	3.040E+02
α_3	6.00E-04	4.97E-03	3.95E-03	1.29E-02	4.10E-03	1.522E+00	3.045E+02
α_4	8.36E-05	2.71E-03	1.74E-03	8.67E-03	3.05E-03	8.304E-01	3.052E+02

α_5	1.70E-07	1.03E-03	2.71E-04	4.63E-03	1.22E-03	3.148E-01	3.057E+02
α_6	8.55E-14	4.10E-04	8.08E-06	2.33E-03	2.03E-04	1.254E-01	3.059E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754693	0.9855628	0.9862480	0.9933106	0.9888734	4.604E+02	6.744E+00
α_2	1.19E-03	5.27E-03	4.58E-03	1.17E-02	2.44E-03	2.462E+00	4.647E+02
α_3	6.85E-04	4.08E-03	3.40E-03	9.82E-03	3.10E-03	1.908E+00	4.652E+02
α_4	2.87E-04	2.90E-03	2.23E-03	7.81E-03	3.05E-03	1.357E+00	4.658E+02
α_5	3.15E-05	1.56E-03	9.32E-04	5.23E-03	1.83E-03	7.294E-01	4.664E+02
α_6	7.53E-09	5.27E-04	8.94E-05	2.56E-03	6.10E-04	2.463E-01	4.669E+02
α_7	3.67E-34	9.12E-05	1.07E-10	4.53E-04	8.72E-05	4.261E-02	4.671E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9769229	0.9864116	0.9870557	0.9936956	0.9898154	4.912E+02	6.767E+00
α_2	8.80E-04	4.41E-03	3.77E-03	1.01E-02	1.74E-03	2.196E+00	4.958E+02
α_3	4.30E-04	3.25E-03	2.61E-03	8.24E-03	2.21E-03	1.616E+00	4.964E+02
α_4	2.57E-04	2.68E-03	2.05E-03	7.26E-03	2.68E-03	1.336E+00	4.967E+02
α_5	7.68E-05	1.85E-03	1.24E-03	5.70E-03	2.14E-03	9.214E-01	4.971E+02
α_6	2.26E-06	9.22E-04	3.88E-04	3.65E-03	1.07E-03	4.591E-01	4.975E+02
α_7	5.56E-13	2.79E-04	8.64E-06	1.56E-03	3.06E-04	1.391E-01	4.979E+02
α_8	7.77E-17	1.98E-04	1.08E-06	1.15E-03	3.82E-05	9.860E-02	4.979E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.85E-01	9.83E-01	9.82E-01	9.83E-01	9.84E-01	9.86E-01	9.86E-01
α_2	1.47E-02	1.26E-02	1.15E-02	8.76E-03	6.46E-03	5.27E-03	4.41E-03
α_3		4.10E-03	4.53E-03	5.27E-03	4.97E-03	4.08E-03	3.25E-03
α_4			2.04E-03	2.08E-03	2.71E-03	2.90E-03	2.68E-03
α_5				4.18E-04	1.03E-03	1.56E-03	1.85E-03
α_6					4.10E-04	5.27E-04	9.22E-04
α_7						9.12E-05	2.79E-04
α_8							1.98E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.85E-01	9.83E-01	9.82E-01	9.83E-01	9.84E-01	9.86E-01	9.86E-01
Beta	1.47E-02	1.67E-02	1.80E-02	1.65E-02	1.56E-02	1.44E-02	1.36E-02
Gamma		2.45E-01	3.64E-01	4.70E-01	5.86E-01	6.35E-01	6.75E-01
Delta			3.10E-01	3.22E-01	4.55E-01	5.55E-01	6.46E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01
Sigma							4.15E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	25.20	37.80	50.40	63.00	75.60	88.20	100.80
N_1	0.6267	0.5550	0.4780	0.4270	0.4024	0.3968	0.4027
N_2	0.2533	0.3850	0.3935	0.3415	0.2754	0.2185	0.1782
N_3		0.1250	0.2505	0.3139	0.3153	0.2781	0.2259
N_4			0.0625	0.1563	0.2345	0.2737	0.2739
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.1.4 Containment Spray Pumps

2.1.4.1 CSS MOTOR-DRIVEN PUMPS FAIL TO START: CSS-MDP-FS

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 17.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9540397	0.9882520	0.9948824	0.9999643	1.0000000	3.941E+01	4.685E-01
α_2	3.30E-05	1.17E-02	5.11E-03	4.60E-02	0.00E+00	4.685E-01	3.941E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9577503	0.9851782	0.9891614	0.9989758	1.0000000	7.498E+01	1.128E+00
α_2	3.75E-04	1.12E-02	7.29E-03	3.53E-02	0.00E+00	8.512E-01	7.526E+01
α_3	1.82E-07	3.64E-03	7.79E-04	1.71E-02	0.00E+00	2.768E-01	7.583E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9586083	0.9827177	0.9855617	0.9971069	1.0000000	1.077E+02	1.894E+00
α_2	9.94E-04	1.15E-02	8.69E-03	3.16E-02	0.00E+00	1.260E+00	1.083E+02
α_3	3.99E-06	3.67E-03	1.35E-03	1.52E-02	0.00E+00	4.024E-01	1.092E+02
α_4	1.47E-08	2.11E-03	3.15E-04	1.05E-02	0.00E+00	2.315E-01	1.093E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9673743	0.9837547	0.9852543	0.9950087	1.0000000	2.078E+02	3.432E+00
α_2	1.55E-03	9.11E-03	7.61E-03	2.18E-02	0.00E+00	1.924E+00	2.093E+02
α_3	2.87E-04	4.97E-03	3.52E-03	1.46E-02	0.00E+00	1.049E+00	2.102E+02
α_4	1.38E-06	1.81E-03	6.24E-04	7.63E-03	0.00E+00	3.822E-01	2.109E+02
α_5	3.15E-20	3.63E-04	3.38E-07	2.11E-03	0.00E+00	7.674E-02	2.112E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696166	0.9844143	0.9857058	0.9947972	1.0000000	2.422E+02	3.835E+00
α_2	9.91E-04	6.91E-03	5.63E-03	1.72E-02	0.00E+00	1.701E+00	2.444E+02
α_3	3.87E-04	4.91E-03	3.65E-03	1.37E-02	0.00E+00	1.207E+00	2.448E+02

α_4	2.22E-05	2.42E-03	1.27E-03	8.73E-03	0.00E+00	5.960E-01	2.455E+02
α_5	3.52E-09	8.99E-04	1.20E-04	4.51E-03	0.00E+00	2.211E-01	2.458E+02
α_6	3.51E-15	4.46E-04	4.52E-06	2.57E-03	0.00E+00	1.098E-01	2.459E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743308	0.9854330	0.9862434	0.9937654	1.0000000	3.888E+02	5.747E+00
α_2	1.16E-03	5.69E-03	4.87E-03	1.30E-02	0.00E+00	2.243E+00	3.923E+02
α_3	5.54E-04	4.13E-03	3.33E-03	1.04E-02	0.00E+00	1.630E+00	3.929E+02
α_4	1.71E-04	2.74E-03	1.96E-03	7.98E-03	0.00E+00	1.083E+00	3.935E+02
α_5	1.04E-05	1.43E-03	7.23E-04	5.26E-03	0.00E+00	5.654E-01	3.940E+02
α_6	2.67E-10	4.86E-04	4.49E-05	2.53E-03	0.00E+00	1.916E-01	3.944E+02
α_7	6.04E-41	8.82E-05	3.28E-12	3.87E-04	0.00E+00	3.480E-02	3.945E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9755249	0.9861281	0.9869039	0.9940708	1.0000000	4.070E+02	5.726E+00
α_2	8.81E-04	4.89E-03	4.12E-03	1.15E-02	0.00E+00	2.018E+00	4.107E+02
α_3	3.48E-04	3.37E-03	2.61E-03	8.99E-03	0.00E+00	1.391E+00	4.114E+02
α_4	1.53E-04	2.57E-03	1.83E-03	7.54E-03	0.00E+00	1.062E+00	4.117E+02
α_5	3.00E-05	1.70E-03	9.94E-04	5.78E-03	0.00E+00	7.026E-01	4.120E+02
α_6	3.33E-07	8.47E-04	2.60E-04	3.68E-03	0.00E+00	3.497E-01	4.124E+02
α_7	1.28E-15	2.61E-04	2.40E-06	1.51E-03	0.00E+00	1.078E-01	4.126E+02
α_8	2.67E-17	2.29E-04	9.72E-07	1.34E-03	0.00E+00	9.469E-02	4.127E+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	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.17E-02	1.12E-02	1.15E-02	9.11E-03	6.91E-03	5.69E-03	4.89E-03
α_3		3.64E-03	3.67E-03	4.97E-03	4.91E-03	4.13E-03	3.37E-03
α_4			2.11E-03	1.81E-03	2.42E-03	2.74E-03	2.57E-03
α_5				3.63E-04	8.99E-04	1.43E-03	1.70E-03
α_6					4.46E-04	4.86E-04	8.47E-04
α_7						8.82E-05	2.61E-04
α_8							2.29E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.17E-02	1.48E-02	1.73E-02	1.62E-02	1.56E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	17.00	17.00	17.00	17.00	17.00	17.00	17.00
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

2.1.4.2 CSS MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1 HOUR: CSS-MDP-FH

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run < 1H
Date Range: 2006 through 2020

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	0.9293809	0.9818971	0.9920474	0.9999453	1.0000000	2.541E+01	4.685E-01
α_2	5.13E-05	1.81E-02	7.95E-03	7.06E-02	0.00E+00	4.685E-01	2.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483145	0.9818372	0.9866969	0.9987453	1.0000000	6.098E+01	1.128E+00
α_2	4.60E-04	1.37E-02	8.95E-03	4.32E-02	0.00E+00	8.512E-01	6.126E+01
α_3	2.23E-07	4.46E-03	9.56E-04	2.09E-02	0.00E+00	2.768E-01	6.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525994	0.9801860	0.9834318	0.9966772	1.0000000	9.368E+01	1.894E+00
α_2	1.14E-03	1.32E-02	9.97E-03	3.62E-02	0.00E+00	1.260E+00	9.431E+01
α_3	4.58E-06	4.21E-03	1.55E-03	1.74E-02	0.00E+00	4.024E-01	9.517E+01
α_4	1.68E-08	2.42E-03	3.61E-04	1.20E-02	0.00E+00	2.315E-01	9.534E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650736	0.9826018	0.9842043	0.9946508	1.0000000	1.938E+02	3.432E+00
α_2	1.66E-03	9.75E-03	8.15E-03	2.33E-02	0.00E+00	1.924E+00	1.953E+02
α_3	3.08E-04	5.32E-03	3.77E-03	1.56E-02	0.00E+00	1.049E+00	1.962E+02
α_4	1.47E-06	1.94E-03	6.68E-04	8.17E-03	0.00E+00	3.822E-01	1.969E+02
α_5	3.38E-20	3.89E-04	3.63E-07	2.26E-03	0.00E+00	7.674E-02	1.972E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677940	0.9834740	0.9848410	0.9944760	1.0000000	2.282E+02	3.835E+00
α_2	1.05E-03	7.33E-03	5.97E-03	1.83E-02	0.00E+00	1.701E+00	2.304E+02
α_3	4.10E-04	5.20E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.308E+02

α_4	2.35E-05	2.57E-03	1.35E-03	9.25E-03	0.00E+00	5.960E-01	2.315E+02
α_5	3.73E-09	9.53E-04	1.27E-04	4.78E-03	0.00E+00	2.211E-01	2.318E+02
α_6	3.72E-15	4.73E-04	4.79E-06	2.73E-03	0.00E+00	1.098E-01	2.319E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733872	0.9848971	0.9857364	0.9935299	1.0000000	3.748E+02	5.747E+00
α_2	1.21E-03	5.89E-03	5.05E-03	1.35E-02	0.00E+00	2.243E+00	3.783E+02
α_3	5.75E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.789E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.28E-03	0.00E+00	1.083E+00	3.795E+02
α_5	1.07E-05	1.49E-03	7.49E-04	5.46E-03	0.00E+00	5.654E-01	3.800E+02
α_6	2.76E-10	5.03E-04	4.65E-05	2.62E-03	0.00E+00	1.916E-01	3.804E+02
α_7	6.26E-41	9.14E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.805E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746696	0.9856411	0.9864433	0.9938665	1.0000000	3.930E+02	5.726E+00
α_2	9.13E-04	5.06E-03	4.26E-03	1.19E-02	0.00E+00	2.018E+00	3.967E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.30E-03	0.00E+00	1.391E+00	3.974E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.80E-03	0.00E+00	1.062E+00	3.977E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.98E-03	0.00E+00	7.026E-01	3.980E+02
α_6	3.44E-07	8.77E-04	2.69E-04	3.81E-03	0.00E+00	3.497E-01	3.984E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.986E+02
α_8	2.76E-17	2.37E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.987E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.81E-02	1.37E-02	1.32E-02	9.75E-03	7.33E-03	5.89E-03	5.06E-03
α_3		4.46E-03	4.21E-03	5.32E-03	5.20E-03	4.28E-03	3.49E-03
α_4			2.42E-03	1.94E-03	2.57E-03	2.85E-03	2.66E-03
α_5				3.89E-04	9.53E-04	1.49E-03	1.76E-03
α_6					4.73E-04	5.03E-04	8.77E-04
α_7						9.14E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.81E-02	1.82E-02	1.98E-02	1.74E-02	1.65E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	3.00	3.00	3.00	3.00	3.00	3.00	3.00
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

2.1.4.3 CSS MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: CSS-MDP-FHRH

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run < 1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

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	0.9344075	0.9831957	0.9926358	0.9999492	1.0000000	2.741E+01	4.685E-01
α_2	4.76E-05	1.68E-02	7.37E-03	6.56E-02	0.00E+00	4.685E-01	2.741E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9499123	0.9824038	0.9871113	0.9987856	1.0000000	6.298E+01	1.128E+00
α_2	4.46E-04	1.33E-02	8.67E-03	4.18E-02	0.00E+00	8.512E-01	6.326E+01
α_3	2.16E-07	4.32E-03	9.26E-04	2.03E-02	0.00E+00	2.768E-01	6.383E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9535624	0.9805921	0.9837738	0.9967462	1.0000000	9.568E+01	1.894E+00
α_2	1.12E-03	1.29E-02	9.77E-03	3.55E-02	0.00E+00	1.260E+00	9.631E+01
α_3	4.49E-06	4.12E-03	1.52E-03	1.71E-02	0.00E+00	4.024E-01	9.717E+01
α_4	1.65E-08	2.37E-03	3.54E-04	1.17E-02	0.00E+00	2.315E-01	9.734E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9654219	0.9827764	0.9843634	0.9947051	1.0000000	1.958E+02	3.432E+00
α_2	1.64E-03	9.66E-03	8.07E-03	2.31E-02	0.00E+00	1.924E+00	1.973E+02
α_3	3.05E-04	5.26E-03	3.73E-03	1.55E-02	0.00E+00	1.049E+00	1.982E+02
α_4	1.46E-06	1.92E-03	6.61E-04	8.09E-03	0.00E+00	3.822E-01	1.989E+02
α_5	3.35E-20	3.85E-04	3.59E-07	2.24E-03	0.00E+00	7.674E-02	1.992E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680677	0.9836153	0.9849709	0.9945233	1.0000000	2.302E+02	3.835E+00
α_2	1.04E-03	7.27E-03	5.92E-03	1.81E-02	0.00E+00	1.701E+00	2.324E+02

α_3	4.07E-04	5.16E-03	3.83E-03	1.44E-02	0.00E+00	1.207E+00	2.328E+02
α_4	2.33E-05	2.55E-03	1.34E-03	9.17E-03	0.00E+00	5.960E-01	2.335E+02
α_5	3.70E-09	9.45E-04	1.26E-04	4.74E-03	0.00E+00	2.211E-01	2.338E+02
α_6	3.69E-15	4.69E-04	4.75E-06	2.71E-03	0.00E+00	1.098E-01	2.339E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735302	0.9849761	0.9858111	0.9935639	1.0000000	3.768E+02	5.747E+00
α_2	1.20E-03	5.86E-03	5.03E-03	1.34E-02	0.00E+00	2.243E+00	3.803E+02
α_3	5.72E-04	4.26E-03	3.43E-03	1.08E-02	0.00E+00	1.630E+00	3.809E+02
α_4	1.76E-04	2.83E-03	2.03E-03	8.23E-03	0.00E+00	1.083E+00	3.815E+02
α_5	1.07E-05	1.48E-03	7.45E-04	5.43E-03	0.00E+00	5.654E-01	3.820E+02
α_6	2.75E-10	5.01E-04	4.63E-05	2.61E-03	0.00E+00	1.916E-01	3.824E+02
α_7	6.23E-41	9.10E-05	3.38E-12	3.99E-04	0.00E+00	3.480E-02	3.825E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747953	0.9857127	0.9865111	0.9938970	1.0000000	3.950E+02	5.726E+00
α_2	9.08E-04	5.04E-03	4.24E-03	1.19E-02	0.00E+00	2.018E+00	3.987E+02
α_3	3.58E-04	3.47E-03	2.69E-03	9.26E-03	0.00E+00	1.391E+00	3.994E+02
α_4	1.58E-04	2.65E-03	1.88E-03	7.76E-03	0.00E+00	1.062E+00	3.997E+02
α_5	3.09E-05	1.75E-03	1.02E-03	5.95E-03	0.00E+00	7.026E-01	4.000E+02
α_6	3.43E-07	8.73E-04	2.68E-04	3.80E-03	0.00E+00	3.497E-01	4.004E+02
α_7	1.32E-15	2.69E-04	2.47E-06	1.55E-03	0.00E+00	1.078E-01	4.006E+02
α_8	2.75E-17	2.36E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	4.007E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.68E-02	1.33E-02	1.29E-02	9.66E-03	7.27E-03	5.86E-03	5.04E-03
α_3		4.32E-03	4.12E-03	5.26E-03	5.16E-03	4.26E-03	3.47E-03
α_4			2.37E-03	1.92E-03	2.55E-03	2.83E-03	2.65E-03
α_5				3.85E-04	9.45E-04	1.48E-03	1.75E-03
α_6					4.69E-04	5.01E-04	8.73E-04
α_7						9.10E-05	2.69E-04
α_8							2.36E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.68E-02	1.76E-02	1.94E-02	1.72E-02	1.64E-02	1.50E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	5.00	5.00	5.00	5.00	5.00	5.00	5.00
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

2.1.4.4 CSS MOTOR-DRIVEN PUMPS FAIL TO RUN > 1 HOUR: CSS-MDP-RH

Systems/Clean Water/Containment spray recirculation
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

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	0.9265716	0.9811696	0.9917194	0.9999431	1.0000000	2.441E+01	4.685E-01
α_2	5.35E-05	1.88E-02	8.28E-03	7.34E-02	0.00E+00	4.685E-01	2.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474768	0.9815399	0.9864769	0.9987198	1.0000000	5.998E+01	1.128E+00
α_2	4.68E-04	1.39E-02	9.10E-03	4.39E-02	0.00E+00	8.512E-01	6.026E+01
α_3	2.27E-07	4.53E-03	9.72E-04	2.13E-02	0.00E+00	2.768E-01	6.083E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521027	0.9799764	0.9832554	0.9966416	1.0000000	9.268E+01	1.894E+00
α_2	1.15E-03	1.33E-02	1.01E-02	3.66E-02	0.00E+00	1.260E+00	9.331E+01
α_3	4.63E-06	4.26E-03	1.56E-03	1.76E-02	0.00E+00	4.024E-01	9.417E+01
α_4	1.70E-08	2.45E-03	3.65E-04	1.21E-02	0.00E+00	2.315E-01	9.434E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648968	0.9825131	0.9841236	0.9946232	1.0000000	1.928E+02	3.432E+00
α_2	1.67E-03	9.80E-03	8.20E-03	2.34E-02	0.00E+00	1.924E+00	1.943E+02
α_3	3.10E-04	5.34E-03	3.79E-03	1.57E-02	0.00E+00	1.049E+00	1.952E+02
α_4	1.48E-06	1.95E-03	6.71E-04	8.21E-03	0.00E+00	3.822E-01	1.959E+02
α_5	3.40E-20	3.91E-04	3.64E-07	2.27E-03	0.00E+00	7.674E-02	1.962E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676555	0.9834025	0.9847752	0.9944521	1.0000000	2.272E+02	3.835E+00
α_2	1.06E-03	7.36E-03	6.00E-03	1.83E-02	0.00E+00	1.701E+00	2.294E+02
α_3	4.12E-04	5.22E-03	3.88E-03	1.46E-02	0.00E+00	1.207E+00	2.298E+02
α_4	2.36E-05	2.58E-03	1.35E-03	9.29E-03	0.00E+00	5.960E-01	2.305E+02

α_5	3.75E-09	9.57E-04	1.28E-04	4.80E-03	0.00E+00	2.211E-01	2.308E+02
α_6	3.74E-15	4.75E-04	4.81E-06	2.74E-03	0.00E+00	1.098E-01	2.309E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733172	0.9848573	0.9856988	0.9935127	1.0000000	3.738E+02	5.747E+00
α_2	1.21E-03	5.91E-03	5.07E-03	1.35E-02	0.00E+00	2.243E+00	3.773E+02
α_3	5.76E-04	4.29E-03	3.46E-03	1.09E-02	0.00E+00	1.630E+00	3.779E+02
α_4	1.78E-04	2.85E-03	2.04E-03	8.30E-03	0.00E+00	1.083E+00	3.785E+02
α_5	1.08E-05	1.49E-03	7.51E-04	5.47E-03	0.00E+00	5.654E-01	3.790E+02
α_6	2.77E-10	5.05E-04	4.66E-05	2.63E-03	0.00E+00	1.916E-01	3.794E+02
α_7	6.28E-41	9.17E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.795E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746063	0.9856050	0.9864091	0.9938511	1.0000000	3.920E+02	5.726E+00
α_2	9.15E-04	5.07E-03	4.27E-03	1.20E-02	0.00E+00	2.018E+00	3.957E+02
α_3	3.61E-04	3.50E-03	2.71E-03	9.33E-03	0.00E+00	1.391E+00	3.964E+02
α_4	1.59E-04	2.67E-03	1.90E-03	7.82E-03	0.00E+00	1.062E+00	3.967E+02
α_5	3.12E-05	1.77E-03	1.03E-03	6.00E-03	0.00E+00	7.026E-01	3.970E+02
α_6	3.45E-07	8.79E-04	2.70E-04	3.82E-03	0.00E+00	3.497E-01	3.974E+02
α_7	1.33E-15	2.71E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.976E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.977E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.88E-02	1.39E-02	1.33E-02	9.80E-03	7.36E-03	5.91E-03	5.07E-03
α_3		4.53E-03	4.26E-03	5.34E-03	5.22E-03	4.29E-03	3.50E-03
α_4			2.45E-03	1.95E-03	2.58E-03	2.85E-03	2.67E-03
α_5				3.91E-04	9.57E-04	1.49E-03	1.77E-03
α_6					4.75E-04	5.05E-04	8.79E-04
α_7						9.17E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.88E-02	1.85E-02	2.00E-02	1.75E-02	1.66E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	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

2.1.5 BWR Residual Heat Removal Pumps

2.1.5.1 BWR RHR MOTOR-DRIVEN PUMPS FAIL TO START: BWR-RHR-MDP-FS

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 23.7

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9324165	0.9797492	0.9878059	0.9996017	0.9801587	3.476E+01	7.185E-01
α_2	3.96E-04	2.03E-02	1.22E-02	6.76E-02	1.98E-02	7.185E-01	3.476E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474391	0.9790625	0.9830172	0.9971618	0.9731903	7.613E+01	1.628E+00
α_2	1.30E-03	1.58E-02	1.18E-02	4.37E-02	2.01E-02	1.226E+00	7.653E+01
α_3	5.57E-06	5.17E-03	1.90E-03	2.14E-02	6.70E-03	4.018E-01	7.736E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521352	0.9779781	0.9806412	0.9947239	0.9720954	1.146E+02	2.581E+00
α_2	1.89E-03	1.39E-02	1.13E-02	3.51E-02	1.52E-02	1.635E+00	1.156E+02
α_3	7.46E-05	5.57E-03	3.12E-03	1.94E-02	1.01E-02	6.524E-01	1.166E+02
α_4	2.24E-07	2.51E-03	5.94E-04	1.15E-02	2.54E-03	2.940E-01	1.169E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9642073	0.9811235	0.9825298	0.9932266	0.9734423	2.206E+02	4.245E+00
α_2	2.03E-03	9.95E-03	8.54E-03	2.27E-02	1.02E-02	2.237E+00	2.226E+02
α_3	6.03E-04	6.05E-03	4.67E-03	1.62E-02	1.02E-02	1.362E+00	2.235E+02
α_4	1.38E-05	2.39E-03	1.16E-03	8.95E-03	5.11E-03	5.385E-01	2.243E+02
α_5	2.44E-15	4.80E-04	4.45E-06	2.77E-03	1.02E-03	1.080E-01	2.248E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9671523	0.9822073	0.9834018	0.9931689	0.9756223	2.609E+02	4.726E+00
α_2	1.25E-03	7.29E-03	6.09E-03	1.74E-02	6.42E-03	1.935E+00	2.637E+02

α_3	6.88E-04	5.72E-03	4.54E-03	1.48E-02	8.55E-03	1.520E+00	2.641E+02
α_4	9.64E-05	3.13E-03	2.00E-03	9.99E-03	6.42E-03	8.303E-01	2.648E+02
α_5	1.96E-07	1.19E-03	3.13E-04	5.34E-03	2.57E-03	3.148E-01	2.653E+02
α_6	9.86E-14	4.72E-04	9.31E-06	2.68E-03	4.28E-04	1.254E-01	2.655E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9729142	0.9840842	0.9848441	0.9926517	0.9779241	4.133E+02	6.685E+00
α_2	1.27E-03	5.73E-03	4.97E-03	1.28E-02	3.86E-03	2.407E+00	4.176E+02
α_3	7.57E-04	4.53E-03	3.77E-03	1.09E-02	6.44E-03	1.903E+00	4.181E+02
α_4	3.19E-04	3.23E-03	2.48E-03	8.69E-03	6.44E-03	1.356E+00	4.187E+02
α_5	3.50E-05	1.74E-03	1.04E-03	5.82E-03	3.86E-03	7.294E-01	4.193E+02
α_6	8.37E-09	5.86E-04	9.95E-05	2.85E-03	1.29E-03	2.463E-01	4.198E+02
α_7	4.08E-34	1.01E-04	1.19E-10	5.04E-04	1.84E-04	4.261E-02	4.200E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743626	0.9849363	0.9856561	0.9930442	0.9800636	4.375E+02	6.690E+00
α_2	9.21E-04	4.79E-03	4.07E-03	1.11E-02	2.26E-03	2.127E+00	4.420E+02
α_3	4.77E-04	3.62E-03	2.91E-03	9.20E-03	4.52E-03	1.609E+00	4.425E+02
α_4	2.89E-04	3.01E-03	2.30E-03	8.13E-03	5.65E-03	1.336E+00	4.428E+02
α_5	8.61E-05	2.07E-03	1.39E-03	6.39E-03	4.52E-03	9.213E-01	4.432E+02
α_6	2.54E-06	1.03E-03	4.35E-04	4.09E-03	2.26E-03	4.591E-01	4.437E+02
α_7	6.24E-13	3.13E-04	9.69E-06	1.75E-03	6.46E-04	1.391E-01	4.440E+02
α_8	8.72E-17	2.22E-04	1.21E-06	1.29E-03	8.07E-05	9.860E-02	4.440E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
α_2	2.03E-02	1.58E-02	1.39E-02	9.95E-03	7.29E-03	5.73E-03	4.79E-03
α_3		5.17E-03	5.57E-03	6.05E-03	5.72E-03	4.53E-03	3.62E-03
α_4			2.51E-03	2.39E-03	3.13E-03	3.23E-03	3.01E-03
α_5				4.80E-04	1.19E-03	1.74E-03	2.07E-03
α_6					4.72E-04	5.86E-04	1.03E-03
α_7						1.01E-04	3.13E-04
α_8							2.22E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
Beta	2.03E-02	2.09E-02	2.20E-02	1.89E-02	1.78E-02	1.59E-02	1.51E-02
Gamma		2.47E-01	3.67E-01	4.73E-01	5.90E-01	6.40E-01	6.82E-01
Delta			3.11E-01	3.22E-01	4.55E-01	5.55E-01	6.47E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01

Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	11.85	17.78	23.70	29.63	35.55	41.48	47.40
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	0.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		0.1250	0.2500	0.3125	0.3125	0.2734	0.2188
N_4			0.0625	0.1563	0.2344	0.2734	0.2734
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.1.5.2 BWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: BWR-RHR-MDP-FH

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

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	0.9265716	0.9811696	0.9917194	0.9999431	1.0000000	2.441E+01	4.685E-01
α_2	5.35E-05	1.88E-02	8.28E-03	7.34E-02	0.00E+00	4.685E-01	2.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474768	0.9815399	0.9864769	0.9987198	1.0000000	5.998E+01	1.128E+00
α_2	4.68E-04	1.39E-02	9.10E-03	4.39E-02	0.00E+00	8.512E-01	6.026E+01
α_3	2.27E-07	4.53E-03	9.72E-04	2.13E-02	0.00E+00	2.768E-01	6.083E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521027	0.9799764	0.9832554	0.9966416	1.0000000	9.268E+01	1.894E+00
α_2	1.15E-03	1.33E-02	1.01E-02	3.66E-02	0.00E+00	1.260E+00	9.331E+01
α_3	4.63E-06	4.26E-03	1.56E-03	1.76E-02	0.00E+00	4.024E-01	9.417E+01
α_4	1.70E-08	2.45E-03	3.65E-04	1.21E-02	0.00E+00	2.315E-01	9.434E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648968	0.9825131	0.9841236	0.9946232	1.0000000	1.928E+02	3.432E+00
α_2	1.67E-03	9.80E-03	8.20E-03	2.34E-02	0.00E+00	1.924E+00	1.943E+02
α_3	3.10E-04	5.34E-03	3.79E-03	1.57E-02	0.00E+00	1.049E+00	1.952E+02
α_4	1.48E-06	1.95E-03	6.71E-04	8.21E-03	0.00E+00	3.822E-01	1.959E+02
α_5	3.40E-20	3.91E-04	3.64E-07	2.27E-03	0.00E+00	7.674E-02	1.962E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676555	0.9834025	0.9847752	0.9944521	1.0000000	2.272E+02	3.835E+00
α_2	1.06E-03	7.36E-03	6.00E-03	1.83E-02	0.00E+00	1.701E+00	2.294E+02
α_3	4.12E-04	5.22E-03	3.88E-03	1.46E-02	0.00E+00	1.207E+00	2.298E+02
α_4	2.36E-05	2.58E-03	1.35E-03	9.29E-03	0.00E+00	5.960E-01	2.305E+02
α_5	3.75E-09	9.57E-04	1.28E-04	4.80E-03	0.00E+00	2.211E-01	2.308E+02
α_6	3.74E-15	4.75E-04	4.81E-06	2.74E-03	0.00E+00	1.098E-01	2.309E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733172	0.9848573	0.9856988	0.9935127	1.0000000	3.738E+02	5.747E+00
α_2	1.21E-03	5.91E-03	5.07E-03	1.35E-02	0.00E+00	2.243E+00	3.773E+02
α_3	5.76E-04	4.29E-03	3.46E-03	1.09E-02	0.00E+00	1.630E+00	3.779E+02
α_4	1.78E-04	2.85E-03	2.04E-03	8.30E-03	0.00E+00	1.083E+00	3.785E+02
α_5	1.08E-05	1.49E-03	7.51E-04	5.47E-03	0.00E+00	5.654E-01	3.790E+02
α_6	2.77E-10	5.05E-04	4.66E-05	2.63E-03	0.00E+00	1.916E-01	3.794E+02
α_7	6.28E-41	9.17E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.795E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746063	0.9856050	0.9864091	0.9938511	1.0000000	3.920E+02	5.726E+00
α_2	9.15E-04	5.07E-03	4.27E-03	1.20E-02	0.00E+00	2.018E+00	3.957E+02
α_3	3.61E-04	3.50E-03	2.71E-03	9.33E-03	0.00E+00	1.391E+00	3.964E+02
α_4	1.59E-04	2.67E-03	1.90E-03	7.82E-03	0.00E+00	1.062E+00	3.967E+02
α_5	3.12E-05	1.77E-03	1.03E-03	6.00E-03	0.00E+00	7.026E-01	3.970E+02
α_6	3.45E-07	8.79E-04	2.70E-04	3.82E-03	0.00E+00	3.497E-01	3.974E+02
α_7	1.33E-15	2.71E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.976E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.977E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.88E-02	1.39E-02	1.33E-02	9.80E-03	7.36E-03	5.91E-03	5.07E-03
α_3		4.53E-03	4.26E-03	5.34E-03	5.22E-03	4.29E-03	3.50E-03
α_4			2.45E-03	1.95E-03	2.58E-03	2.85E-03	2.67E-03
α_5				3.91E-04	9.57E-04	1.49E-03	1.77E-03
α_6					4.75E-04	5.05E-04	8.79E-04
α_7						9.17E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.88E-02	1.85E-02	2.00E-02	1.75E-02	1.66E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

2.1.5.3 BWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: BWR-RHR-MDP-FHRH

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

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	0.9420768	0.9851358	0.9934600	0.9999533	0.9996239	3.127E+01	4.719E-01
α_2	4.36E-05	1.49E-02	6.54E-03	5.79E-02	3.76E-04	4.719E-01	3.127E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553486	0.9842806	0.9884647	0.9988973	0.9992476	7.126E+01	1.138E+00
α_2	4.13E-04	1.19E-02	7.80E-03	3.74E-02	7.52E-04	8.612E-01	7.154E+01
α_3	1.91E-07	3.82E-03	8.19E-04	1.79E-02	0.00E+00	2.768E-01	7.212E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9585961	0.9826572	0.9854837	0.9970584	0.9989274	1.084E+02	1.913E+00
α_2	1.03E-03	1.16E-02	8.80E-03	3.17E-02	1.04E-03	1.278E+00	1.090E+02
α_3	4.00E-06	3.65E-03	1.34E-03	1.51E-02	2.82E-05	4.029E-01	1.099E+02
α_4	1.46E-08	2.10E-03	3.13E-04	1.04E-02	0.00E+00	2.315E-01	1.101E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679412	0.9839998	0.9854647	0.9950506	0.9986277	2.129E+02	3.463E+00
α_2	1.57E-03	9.03E-03	7.56E-03	2.15E-02	1.31E-03	1.953E+00	2.145E+02
α_3	2.82E-04	4.85E-03	3.44E-03	1.43E-02	6.32E-05	1.050E+00	2.154E+02
α_4	1.34E-06	1.77E-03	6.09E-04	7.45E-03	0.00E+00	3.822E-01	2.160E+02
α_5	3.08E-20	3.55E-04	3.30E-07	2.06E-03	0.00E+00	7.674E-02	2.163E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9705020	0.9848249	0.9860693	0.9948939	0.9983453	2.517E+02	3.879E+00

α_2	1.01E-03	6.82E-03	5.58E-03	1.68E-02	1.55E-03	1.742E+00	2.539E+02
α_3	3.75E-04	4.73E-03	3.52E-03	1.32E-02	1.05E-04	1.210E+00	2.544E+02
α_4	2.14E-05	2.33E-03	1.22E-03	8.40E-03	3.53E-06	5.961E-01	2.550E+02
α_5	3.39E-09	8.65E-04	1.16E-04	4.34E-03	0.00E+00	2.211E-01	2.554E+02
α_6	3.38E-15	4.29E-04	4.35E-06	2.48E-03	0.00E+00	1.098E-01	2.555E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750062	0.9857858	0.9865691	0.9938834	0.9980831	4.027E+02	5.807E+00
α_2	1.18E-03	5.62E-03	4.84E-03	1.27E-02	1.76E-03	2.298E+00	4.062E+02
α_3	5.39E-04	4.00E-03	3.23E-03	1.01E-02	1.52E-04	1.634E+00	4.069E+02
α_4	1.65E-04	2.65E-03	1.90E-03	7.71E-03	7.36E-06	1.083E+00	4.074E+02
α_5	1.00E-05	1.38E-03	6.98E-04	5.08E-03	0.00E+00	5.654E-01	4.080E+02
α_6	2.58E-10	4.69E-04	4.33E-05	2.44E-03	0.00E+00	1.916E-01	4.083E+02
α_7	5.83E-41	8.52E-05	3.17E-12	3.74E-04	0.00E+00	3.480E-02	4.085E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763257	0.9865422	0.9872857	0.9942136	0.9978390	4.253E+02	5.802E+00
α_2	9.09E-04	4.84E-03	4.10E-03	1.13E-02	1.95E-03	2.087E+00	4.290E+02
α_3	3.38E-04	3.24E-03	2.51E-03	8.63E-03	2.03E-04	1.398E+00	4.297E+02
α_4	1.47E-04	2.46E-03	1.75E-03	7.22E-03	1.28E-05	1.063E+00	4.301E+02
α_5	2.88E-05	1.63E-03	9.52E-04	5.54E-03	0.00E+00	7.026E-01	4.304E+02
α_6	3.18E-07	8.11E-04	2.49E-04	3.53E-03	0.00E+00	3.497E-01	4.308E+02
α_7	1.22E-15	2.50E-04	2.30E-06	1.44E-03	0.00E+00	1.078E-01	4.310E+02
α_8	2.56E-17	2.20E-04	9.30E-07	1.28E-03	0.00E+00	9.469E-02	4.310E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.85E-01	9.84E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.87E-01
α_2	1.49E-02	1.19E-02	1.16E-02	9.03E-03	6.82E-03	5.62E-03	4.84E-03
α_3		3.82E-03	3.65E-03	4.85E-03	4.73E-03	4.00E-03	3.24E-03
α_4			2.10E-03	1.77E-03	2.33E-03	2.65E-03	2.46E-03
α_5				3.55E-04	8.65E-04	1.38E-03	1.63E-03
α_6					4.29E-04	4.69E-04	8.11E-04
α_7						8.52E-05	2.50E-04
α_8							2.20E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.85E-01	9.84E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.87E-01
Beta	1.49E-02	1.57E-02	1.73E-02	1.60E-02	1.52E-02	1.42E-02	1.35E-02
Gamma		2.43E-01	3.32E-01	4.36E-01	5.51E-01	6.04E-01	6.40E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.34E-01	6.24E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.41E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	8.73	13.10	17.47	21.83	26.20	30.57	34.93
N_1	0.1267	0.1800	0.2280	0.2708	0.3087	0.3421	0.3714
N_2	0.0033	0.0100	0.0185	0.0290	0.0411	0.0544	0.0688
N_3		0.0000	0.0005	0.0014	0.0028	0.0047	0.0072
N_4			0.0000	0.0000	0.0001	0.0002	0.0005
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

2.1.5.4 BWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN >1H: BWR-RHR-MDP-RH

Plants/BWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 11.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9395551	0.9844841	0.9931673	0.9999513	0.9995573	2.994E+01	4.719E-01
α_2	4.56E-05	1.55E-02	6.84E-03	6.04E-02	4.43E-04	4.719E-01	2.994E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9540904	0.9838340	0.9881339	0.9988651	0.9991143	6.926E+01	1.138E+00
α_2	4.25E-04	1.22E-02	8.02E-03	3.84E-02	8.86E-04	8.612E-01	6.954E+01
α_3	1.97E-07	3.93E-03	8.42E-04	1.84E-02	0.00E+00	2.768E-01	7.012E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9575784	0.9822275	0.9851218	0.9969846	0.9987373	1.057E+02	1.913E+00
α_2	1.06E-03	1.19E-02	9.02E-03	3.25E-02	1.23E-03	1.278E+00	1.063E+02
α_3	4.10E-06	3.74E-03	1.38E-03	1.55E-02	3.32E-05	4.029E-01	1.072E+02
α_4	1.49E-08	2.15E-03	3.21E-04	1.07E-02	0.00E+00	2.315E-01	1.074E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9674426	0.9837495	0.9852366	0.9949725	0.9983844	2.096E+02	3.463E+00
α_2	1.59E-03	9.17E-03	7.68E-03	2.18E-02	1.54E-03	1.953E+00	2.111E+02
α_3	2.86E-04	4.93E-03	3.49E-03	1.45E-02	7.45E-05	1.050E+00	2.120E+02
α_4	1.36E-06	1.79E-03	6.18E-04	7.57E-03	0.00E+00	3.822E-01	2.127E+02
α_5	3.13E-20	3.60E-04	3.36E-07	2.09E-03	0.00E+00	7.674E-02	2.130E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700357	0.9845837	0.9858473	0.9948121	0.9980518	2.477E+02	3.879E+00
α_2	1.03E-03	6.92E-03	5.67E-03	1.71E-02	1.82E-03	1.742E+00	2.499E+02

α_3	3.81E-04	4.81E-03	3.58E-03	1.34E-02	1.23E-04	1.210E+00	2.504E+02
α_4	2.17E-05	2.37E-03	1.24E-03	8.54E-03	4.16E-06	5.961E-01	2.510E+02
α_5	3.44E-09	8.79E-04	1.17E-04	4.41E-03	0.00E+00	2.211E-01	2.514E+02
α_6	3.43E-15	4.36E-04	4.42E-06	2.52E-03	0.00E+00	1.098E-01	2.515E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747190	0.9856215	0.9864137	0.9938129	0.9977429	3.980E+02	5.807E+00
α_2	1.20E-03	5.69E-03	4.90E-03	1.29E-02	2.07E-03	2.298E+00	4.016E+02
α_3	5.45E-04	4.05E-03	3.26E-03	1.02E-02	1.78E-04	1.634E+00	4.022E+02
α_4	1.67E-04	2.68E-03	1.92E-03	7.80E-03	8.67E-06	1.083E+00	4.028E+02
α_5	1.01E-05	1.40E-03	7.06E-04	5.14E-03	0.00E+00	5.654E-01	4.033E+02
α_6	2.61E-10	4.74E-04	4.38E-05	2.47E-03	0.00E+00	1.916E-01	4.037E+02
α_7	5.90E-41	8.62E-05	3.21E-12	3.78E-04	0.00E+00	3.480E-02	4.038E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9760356	0.9863736	0.9871262	0.9941363	0.9974555	4.200E+02	5.802E+00
α_2	9.21E-04	4.90E-03	4.15E-03	1.14E-02	2.29E-03	2.087E+00	4.237E+02
α_3	3.42E-04	3.28E-03	2.55E-03	8.74E-03	2.39E-04	1.398E+00	4.244E+02
α_4	1.49E-04	2.50E-03	1.77E-03	7.31E-03	1.50E-05	1.063E+00	4.247E+02
α_5	2.91E-05	1.65E-03	9.64E-04	5.60E-03	0.00E+00	7.026E-01	4.251E+02
α_6	3.22E-07	8.21E-04	2.52E-04	3.57E-03	0.00E+00	3.497E-01	4.254E+02
α_7	1.24E-15	2.53E-04	2.32E-06	1.46E-03	0.00E+00	1.078E-01	4.257E+02
α_8	2.59E-17	2.22E-04	9.42E-07	1.29E-03	0.00E+00	9.469E-02	4.257E+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	9.84E-01	9.82E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.55E-02	1.22E-02	1.19E-02	9.17E-03	6.92E-03	5.69E-03	4.90E-03
α_3		3.93E-03	3.74E-03	4.93E-03	4.81E-03	4.05E-03	3.28E-03
α_4			2.15E-03	1.79E-03	2.37E-03	2.68E-03	2.50E-03
α_5				3.60E-04	8.79E-04	1.40E-03	1.65E-03
α_6					4.36E-04	4.74E-04	8.21E-04
α_7						8.62E-05	2.53E-04
α_8							2.22E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.84E-01	9.82E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.55E-02	1.62E-02	1.78E-02	1.63E-02	1.54E-02	1.44E-02	1.36E-02
Gamma		2.43E-01	3.32E-01	4.36E-01	5.51E-01	6.04E-01	6.40E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.34E-01	6.24E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.41E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	7.40	11.10	14.80	18.50	22.20	25.90	29.60
N_1	0.1267	0.1800	0.2280	0.2708	0.3087	0.3421	0.3714
N_2	0.0033	0.0100	0.0185	0.0290	0.0411	0.0544	0.0688
N_3		0.0000	0.0005	0.0014	0.0028	0.0047	0.0072
N_4			0.0000	0.0000	0.0001	0.0002	0.0005
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

2.1.6 Auxiliary Feedwater Motor-Driven Pumps

2.1.6.1 AFW MOTOR-DRIVEN PUMPS FAIL TO START: AFW-MDP-FS

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 24.5

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9058862	0.9634829	0.9708773	0.9957424	0.9423077	3.875E+01	1.469E+00
α_2	4.26E-03	3.65E-02	2.91E-02	9.41E-02	5.77E-02	1.469E+00	3.875E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9421279	0.9748480	0.9784938	0.9951029	0.9607843	8.248E+01	2.128E+00
α_2	3.37E-04	1.01E-02	6.55E-03	3.18E-02	0.00E+00	8.512E-01	8.376E+01
α_3	1.34E-03	1.51E-02	1.15E-02	4.12E-02	3.92E-02	1.277E+00	8.333E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9518251	0.9770777	0.9795531	0.9938718	0.9702970	1.233E+02	2.894E+00
α_2	8.62E-04	9.98E-03	7.54E-03	2.74E-02	0.00E+00	1.260E+00	1.250E+02
α_3	2.82E-04	7.15E-03	4.77E-03	2.21E-02	1.49E-02	9.024E-01	1.253E+02
α_4	1.19E-04	5.79E-03	3.48E-03	1.94E-02	1.49E-02	7.315E-01	1.255E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9647959	0.9812280	0.9825683	0.9930773	0.9760956	2.317E+02	4.432E+00
α_2	1.39E-03	8.15E-03	6.81E-03	1.95E-02	0.00E+00	1.924E+00	2.342E+02
α_3	5.02E-04	5.50E-03	4.18E-03	1.50E-02	5.98E-03	1.299E+00	2.348E+02
α_4	1.38E-04	3.74E-03	2.46E-03	1.17E-02	1.20E-02	8.822E-01	2.352E+02
α_5	3.14E-07	1.38E-03	3.86E-04	6.16E-03	5.98E-03	3.267E-01	2.358E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9681904	0.9826739	0.9838120	0.9932571	0.9800000	2.742E+02	4.835E+00
α_2	8.73E-04	6.10E-03	4.96E-03	1.52E-02	0.00E+00	1.701E+00	2.774E+02
α_3	4.56E-04	4.77E-03	3.65E-03	1.29E-02	2.50E-03	1.332E+00	2.777E+02

α_4	1.66E-04	3.48E-03	2.39E-03	1.05E-02	7.50E-03	9.710E-01	2.781E+02
α_5	1.96E-05	2.14E-03	1.12E-03	7.70E-03	7.50E-03	5.961E-01	2.785E+02
α_6	6.90E-09	8.41E-04	1.29E-04	4.15E-03	2.50E-03	2.348E-01	2.788E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736985	0.9845142	0.9852473	0.9928144	0.9828080	4.290E+02	6.747E+00
α_2	1.05E-03	5.15E-03	4.41E-03	1.18E-02	0.00E+00	2.243E+00	4.335E+02
α_3	5.51E-04	3.88E-03	3.16E-03	9.70E-03	1.07E-03	1.692E+00	4.340E+02
α_4	2.92E-04	3.06E-03	2.34E-03	8.28E-03	4.30E-03	1.333E+00	4.344E+02
α_5	9.47E-05	2.16E-03	1.46E-03	6.60E-03	6.45E-03	9.404E-01	4.348E+02
α_6	1.98E-06	1.01E-03	4.10E-04	4.07E-03	4.30E-03	4.416E-01	4.353E+02
α_7	5.92E-17	2.23E-04	1.12E-06	1.30E-03	1.07E-03	9.730E-02	4.356E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752547	0.9854450	0.9861376	0.9932644	0.9849246	4.554E+02	6.726E+00
α_2	7.87E-04	4.37E-03	3.68E-03	1.03E-02	0.00E+00	2.018E+00	4.601E+02
α_3	3.30E-04	3.08E-03	2.40E-03	8.15E-03	4.71E-04	1.422E+00	4.607E+02
α_4	2.12E-04	2.64E-03	1.96E-03	7.36E-03	2.36E-03	1.218E+00	4.609E+02
α_5	1.17E-04	2.20E-03	1.53E-03	6.54E-03	4.71E-03	1.015E+00	4.611E+02
α_6	2.02E-05	1.43E-03	8.07E-04	4.97E-03	4.71E-03	6.622E-01	4.614E+02
α_7	1.75E-08	5.72E-04	1.11E-04	2.72E-03	2.36E-03	2.641E-01	4.618E+02
α_8	6.27E-14	2.73E-04	5.47E-06	1.55E-03	4.71E-04	1.259E-01	4.620E+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	9.75E-01	9.77E-01	9.81E-01	9.83E-01	9.85E-01	9.85E-01
α_2	3.65E-02	1.01E-02	9.98E-03	8.15E-03	6.10E-03	5.15E-03	4.37E-03
α_3		1.51E-02	7.15E-03	5.50E-03	4.77E-03	3.88E-03	3.08E-03
α_4			5.79E-03	3.74E-03	3.48E-03	3.06E-03	2.64E-03
α_5				1.38E-03	2.14E-03	2.16E-03	2.20E-03
α_6					8.41E-04	1.01E-03	1.43E-03
α_7						2.23E-04	5.72E-04
α_8							2.73E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.63E-01	9.75E-01	9.77E-01	9.81E-01	9.83E-01	9.85E-01	9.85E-01
Beta	3.65E-02	2.52E-02	2.29E-02	1.88E-02	1.73E-02	1.55E-02	1.46E-02
Gamma		6.00E-01	5.65E-01	5.66E-01	6.48E-01	6.68E-01	7.00E-01
Delta			4.48E-01	4.82E-01	5.75E-01	6.24E-01	6.98E-01
Epsilon				2.70E-01	4.61E-01	5.26E-01	6.29E-01
Mu					2.83E-01	3.64E-01	5.09E-01
Omega						1.81E-01	3.71E-01
Sigma							3.23E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	16.33	24.50	32.67	40.83	49.00	57.17	65.33
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		1.0000	0.5000	0.2500	0.1250	0.0625	0.0313
N_4			0.5000	0.5000	0.3750	0.2500	0.1563
N_5				0.2500	0.3750	0.3750	0.3125
N_6					0.1250	0.2500	0.3125
N_7						0.0625	0.1563
N_8							0.0313

2.1.6.2 AFW MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: AFW-MDP-FH

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

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	0.9293809	0.9818971	0.9920474	0.9999453	1.0000000	2.541E+01	4.685E-01
α_2	5.13E-05	1.81E-02	7.95E-03	7.06E-02	0.00E+00	4.685E-01	2.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483145	0.9818372	0.9866969	0.9987453	1.0000000	6.098E+01	1.128E+00
α_2	4.60E-04	1.37E-02	8.95E-03	4.32E-02	0.00E+00	8.512E-01	6.126E+01
α_3	2.23E-07	4.46E-03	9.56E-04	2.09E-02	0.00E+00	2.768E-01	6.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525994	0.9801860	0.9834318	0.9966772	1.0000000	9.368E+01	1.894E+00
α_2	1.14E-03	1.32E-02	9.97E-03	3.62E-02	0.00E+00	1.260E+00	9.431E+01
α_3	4.58E-06	4.21E-03	1.55E-03	1.74E-02	0.00E+00	4.024E-01	9.517E+01
α_4	1.68E-08	2.42E-03	3.61E-04	1.20E-02	0.00E+00	2.315E-01	9.534E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650736	0.9826018	0.9842043	0.9946508	1.0000000	1.938E+02	3.432E+00
α_2	1.66E-03	9.75E-03	8.15E-03	2.33E-02	0.00E+00	1.924E+00	1.953E+02
α_3	3.08E-04	5.32E-03	3.77E-03	1.56E-02	0.00E+00	1.049E+00	1.962E+02
α_4	1.47E-06	1.94E-03	6.68E-04	8.17E-03	0.00E+00	3.822E-01	1.969E+02
α_5	3.38E-20	3.89E-04	3.63E-07	2.26E-03	0.00E+00	7.674E-02	1.972E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677940	0.9834740	0.9848410	0.9944760	1.0000000	2.282E+02	3.835E+00
α_2	1.05E-03	7.33E-03	5.97E-03	1.83E-02	0.00E+00	1.701E+00	2.304E+02
α_3	4.10E-04	5.20E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.308E+02

α_4	2.35E-05	2.57E-03	1.35E-03	9.25E-03	0.00E+00	5.960E-01	2.315E+02
α_5	3.73E-09	9.53E-04	1.27E-04	4.78E-03	0.00E+00	2.211E-01	2.318E+02
α_6	3.72E-15	4.73E-04	4.79E-06	2.73E-03	0.00E+00	1.098E-01	2.319E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733872	0.9848971	0.9857364	0.9935299	1.0000000	3.748E+02	5.747E+00
α_2	1.21E-03	5.89E-03	5.05E-03	1.35E-02	0.00E+00	2.243E+00	3.783E+02
α_3	5.75E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.789E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.28E-03	0.00E+00	1.083E+00	3.795E+02
α_5	1.07E-05	1.49E-03	7.49E-04	5.46E-03	0.00E+00	5.654E-01	3.800E+02
α_6	2.76E-10	5.03E-04	4.65E-05	2.62E-03	0.00E+00	1.916E-01	3.804E+02
α_7	6.26E-41	9.14E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.805E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746696	0.9856411	0.9864433	0.9938665	1.0000000	3.930E+02	5.726E+00
α_2	9.13E-04	5.06E-03	4.26E-03	1.19E-02	0.00E+00	2.018E+00	3.967E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.30E-03	0.00E+00	1.391E+00	3.974E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.80E-03	0.00E+00	1.062E+00	3.977E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.98E-03	0.00E+00	7.026E-01	3.980E+02
α_6	3.44E-07	8.77E-04	2.69E-04	3.81E-03	0.00E+00	3.497E-01	3.984E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.986E+02
α_8	2.76E-17	2.37E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.987E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.81E-02	1.37E-02	1.32E-02	9.75E-03	7.33E-03	5.89E-03	5.06E-03
α_3		4.46E-03	4.21E-03	5.32E-03	5.20E-03	4.28E-03	3.49E-03
α_4			2.42E-03	1.94E-03	2.57E-03	2.85E-03	2.66E-03
α_5				3.89E-04	9.53E-04	1.49E-03	1.76E-03
α_6					4.73E-04	5.03E-04	8.77E-04
α_7						9.14E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.81E-02	1.82E-02	1.98E-02	1.74E-02	1.65E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	3.00	3.00	3.00	3.00	3.00	3.00	3.00
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

2.1.6.3 AFW MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: AFW-MDP-FHRH

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 6.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9377318	0.9840536	0.9930199	0.9999518	1.0000000	2.891E+01	4.685E-01
α_2	4.51E-05	1.59E-02	6.98E-03	6.23E-02	0.00E+00	4.685E-01	2.891E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9510473	0.9828061	0.9874090	0.9988142	1.0000000	6.448E+01	1.128E+00
α_2	4.35E-04	1.30E-02	8.47E-03	4.09E-02	0.00E+00	8.512E-01	6.476E+01
α_3	2.11E-07	4.22E-03	9.04E-04	1.98E-02	0.00E+00	2.768E-01	6.533E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9542594	0.9808860	0.9840211	0.9967962	1.0000000	9.718E+01	1.894E+00
α_2	1.10E-03	1.27E-02	9.62E-03	3.49E-02	0.00E+00	1.260E+00	9.781E+01
α_3	4.42E-06	4.06E-03	1.49E-03	1.68E-02	0.00E+00	4.024E-01	9.867E+01
α_4	1.62E-08	2.34E-03	3.48E-04	1.16E-02	0.00E+00	2.315E-01	9.884E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9656786	0.9829051	0.9844806	0.9947450	1.0000000	1.973E+02	3.432E+00
α_2	1.63E-03	9.58E-03	8.01E-03	2.29E-02	0.00E+00	1.924E+00	1.988E+02
α_3	3.03E-04	5.22E-03	3.70E-03	1.54E-02	0.00E+00	1.049E+00	1.997E+02
α_4	1.45E-06	1.90E-03	6.56E-04	8.03E-03	0.00E+00	3.822E-01	2.004E+02
α_5	3.32E-20	3.82E-04	3.56E-07	2.22E-03	0.00E+00	7.674E-02	2.007E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682699	0.9837196	0.9850668	0.9945583	1.0000000	2.317E+02	3.835E+00
α_2	1.04E-03	7.22E-03	5.88E-03	1.80E-02	0.00E+00	1.701E+00	2.339E+02

α_3	4.04E-04	5.12E-03	3.81E-03	1.43E-02	0.00E+00	1.207E+00	2.343E+02
α_4	2.32E-05	2.53E-03	1.33E-03	9.12E-03	0.00E+00	5.960E-01	2.350E+02
α_5	3.68E-09	9.39E-04	1.26E-04	4.71E-03	0.00E+00	2.211E-01	2.353E+02
α_6	3.67E-15	4.66E-04	4.72E-06	2.69E-03	0.00E+00	1.098E-01	2.354E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736327	0.9850348	0.9858667	0.9935893	1.0000000	3.783E+02	5.747E+00
α_2	1.19E-03	5.84E-03	5.01E-03	1.33E-02	0.00E+00	2.243E+00	3.818E+02
α_3	5.69E-04	4.24E-03	3.42E-03	1.07E-02	0.00E+00	1.630E+00	3.824E+02
α_4	1.75E-04	2.82E-03	2.02E-03	8.20E-03	0.00E+00	1.083E+00	3.830E+02
α_5	1.06E-05	1.47E-03	7.42E-04	5.41E-03	0.00E+00	5.654E-01	3.835E+02
α_6	2.74E-10	4.99E-04	4.61E-05	2.60E-03	0.00E+00	1.916E-01	3.839E+02
α_7	6.21E-41	9.06E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.840E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748888	0.9857660	0.9865615	0.9939151	1.0000000	3.965E+02	5.726E+00
α_2	9.05E-04	5.02E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.002E+02
α_3	3.57E-04	3.46E-03	2.68E-03	9.22E-03	0.00E+00	1.391E+00	4.009E+02
α_4	1.57E-04	2.64E-03	1.88E-03	7.73E-03	0.00E+00	1.062E+00	4.012E+02
α_5	3.08E-05	1.75E-03	1.02E-03	5.93E-03	0.00E+00	7.026E-01	4.015E+02
α_6	3.41E-07	8.69E-04	2.67E-04	3.78E-03	0.00E+00	3.497E-01	4.019E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.021E+02
α_8	2.74E-17	2.35E-04	9.97E-07	1.37E-03	0.00E+00	9.469E-02	4.022E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.59E-02	1.30E-02	1.27E-02	9.58E-03	7.22E-03	5.84E-03	5.02E-03
α_3		4.22E-03	4.06E-03	5.22E-03	5.12E-03	4.24E-03	3.46E-03
α_4			2.34E-03	1.90E-03	2.53E-03	2.82E-03	2.64E-03
α_5				3.82E-04	9.39E-04	1.47E-03	1.75E-03
α_6					4.66E-04	4.99E-04	8.69E-04
α_7						9.06E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.59E-02	1.72E-02	1.91E-02	1.71E-02	1.63E-02	1.50E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	6.50	6.50	6.50	6.50	6.50	6.50	6.50
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

2.1.6.4 AFW MOTOR-DRIVEN PUMPS FAIL TO RUN >1H: AFW-MDP-RH

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 3.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9307084	0.9822402	0.9922018	0.9999463	1.0000000	2.591E+01	4.685E-01
α_2	5.03E-05	1.78E-02	7.80E-03	6.93E-02	0.00E+00	4.685E-01	2.591E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9487234	0.9819822	0.9868043	0.9987556	1.0000000	6.148E+01	1.128E+00
α_2	4.57E-04	1.36E-02	8.88E-03	4.28E-02	0.00E+00	8.512E-01	6.176E+01
α_3	2.21E-07	4.42E-03	9.48E-04	2.07E-02	0.00E+00	2.768E-01	6.233E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9528439	0.9802891	0.9835187	0.9966947	1.0000000	9.418E+01	1.894E+00
α_2	1.14E-03	1.31E-02	9.92E-03	3.60E-02	0.00E+00	1.260E+00	9.481E+01
α_3	4.56E-06	4.19E-03	1.54E-03	1.73E-02	0.00E+00	4.024E-01	9.567E+01
α_4	1.67E-08	2.41E-03	3.59E-04	1.19E-02	0.00E+00	2.315E-01	9.584E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9651613	0.9826458	0.9842444	0.9946645	1.0000000	1.943E+02	3.432E+00
α_2	1.66E-03	9.73E-03	8.13E-03	2.33E-02	0.00E+00	1.924E+00	1.958E+02
α_3	3.07E-04	5.30E-03	3.76E-03	1.56E-02	0.00E+00	1.049E+00	1.967E+02
α_4	1.47E-06	1.93E-03	6.66E-04	8.15E-03	0.00E+00	3.822E-01	1.974E+02
α_5	3.37E-20	3.88E-04	3.62E-07	2.25E-03	0.00E+00	7.674E-02	1.977E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678629	0.9835096	0.9848737	0.9944879	1.0000000	2.287E+02	3.835E+00
α_2	1.05E-03	7.31E-03	5.96E-03	1.82E-02	0.00E+00	1.701E+00	2.309E+02
α_3	4.10E-04	5.19E-03	3.86E-03	1.45E-02	0.00E+00	1.207E+00	2.313E+02
α_4	2.35E-05	2.56E-03	1.35E-03	9.23E-03	0.00E+00	5.960E-01	2.320E+02
α_5	3.72E-09	9.51E-04	1.27E-04	4.77E-03	0.00E+00	2.211E-01	2.323E+02

α_6	3.71E-15	4.72E-04	4.78E-06	2.72E-03	0.00E+00	1.098E-01	2.324E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734220	0.9849169	0.9857552	0.9935384	1.0000000	3.753E+02	5.747E+00
α_2	1.20E-03	5.89E-03	5.05E-03	1.34E-02	0.00E+00	2.243E+00	3.788E+02
α_3	5.74E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.794E+02
α_4	1.77E-04	2.84E-03	2.03E-03	8.27E-03	0.00E+00	1.083E+00	3.800E+02
α_5	1.07E-05	1.48E-03	7.48E-04	5.45E-03	0.00E+00	5.654E-01	3.805E+02
α_6	2.76E-10	5.03E-04	4.64E-05	2.62E-03	0.00E+00	1.916E-01	3.809E+02
α_7	6.26E-41	9.13E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.810E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747012	0.9856591	0.9864603	0.9938741	1.0000000	3.935E+02	5.726E+00
α_2	9.11E-04	5.05E-03	4.26E-03	1.19E-02	0.00E+00	2.018E+00	3.972E+02
α_3	3.60E-04	3.48E-03	2.70E-03	9.29E-03	0.00E+00	1.391E+00	3.979E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.79E-03	0.00E+00	1.062E+00	3.982E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.98E-03	0.00E+00	7.026E-01	3.985E+02
α_6	3.44E-07	8.76E-04	2.69E-04	3.81E-03	0.00E+00	3.497E-01	3.989E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.991E+02
α_8	2.76E-17	2.37E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	3.992E+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	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.78E-02	1.36E-02	1.31E-02	9.73E-03	7.31E-03	5.89E-03	5.05E-03
α_3		4.42E-03	4.19E-03	5.30E-03	5.19E-03	4.28E-03	3.48E-03
α_4			2.41E-03	1.93E-03	2.56E-03	2.84E-03	2.66E-03
α_5				3.88E-04	9.51E-04	1.48E-03	1.76E-03
α_6					4.72E-04	5.03E-04	8.76E-04
α_7						9.13E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.78E-02	1.80E-02	1.97E-02	1.74E-02	1.65E-02	1.51E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	3.50	3.50	3.50	3.50	3.50	3.50	3.50
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

2.1.7 Auxiliary Feedwater Pump Volutes

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

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: 2006 through 2020

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	0.9425822	0.9853040	0.9935782	0.9999555	1.0000000	3.141E+01	4.685E-01
α_2	4.14E-05	1.47E-02	6.42E-03	5.74E-02	0.00E+00	4.685E-01	3.141E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9528289	0.9834372	0.9878757	0.9988590	1.0000000	6.698E+01	1.128E+00
α_2	4.19E-04	1.25E-02	8.15E-03	3.94E-02	0.00E+00	8.512E-01	6.726E+01
α_3	2.03E-07	4.06E-03	8.71E-04	1.91E-02	0.00E+00	2.768E-01	6.783E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553757	0.9813564	0.9844170	0.9968761	1.0000000	9.968E+01	1.894E+00
α_2	1.07E-03	1.24E-02	9.38E-03	3.41E-02	0.00E+00	1.260E+00	1.003E+02
α_3	4.31E-06	3.96E-03	1.46E-03	1.64E-02	0.00E+00	4.024E-01	1.012E+02
α_4	1.58E-08	2.28E-03	3.40E-04	1.13E-02	0.00E+00	2.315E-01	1.013E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9660981	0.9831153	0.9846721	0.9948103	1.0000000	1.998E+02	3.432E+00
α_2	1.61E-03	9.47E-03	7.91E-03	2.26E-02	0.00E+00	1.924E+00	2.013E+02
α_3	2.99E-04	5.16E-03	3.66E-03	1.52E-02	0.00E+00	1.049E+00	2.022E+02
α_4	1.43E-06	1.88E-03	6.48E-04	7.93E-03	0.00E+00	3.822E-01	2.029E+02
α_5	3.28E-20	3.78E-04	3.52E-07	2.19E-03	0.00E+00	7.674E-02	2.032E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9686013	0.9838906	0.9852241	0.9946207	1.0000000	2.342E+02	3.835E+00
α_2	1.02E-03	7.15E-03	5.82E-03	1.78E-02	0.00E+00	1.701E+00	2.364E+02
α_3	4.00E-04	5.07E-03	3.77E-03	1.42E-02	0.00E+00	1.207E+00	2.368E+02
α_4	2.29E-05	2.50E-03	1.31E-03	9.02E-03	0.00E+00	5.960E-01	2.375E+02
α_5	3.64E-09	9.29E-04	1.24E-04	4.66E-03	0.00E+00	2.211E-01	2.378E+02
α_6	3.63E-15	4.61E-04	4.67E-06	2.66E-03	0.00E+00	1.098E-01	2.379E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9737969	0.9851315	0.9859582	0.9936310	1.0000000	3.808E+02	5.747E+00
α_2	1.19E-03	5.80E-03	4.98E-03	1.32E-02	0.00E+00	2.243E+00	3.843E+02
α_3	5.66E-04	4.22E-03	3.40E-03	1.07E-02	0.00E+00	1.630E+00	3.849E+02
α_4	1.74E-04	2.80E-03	2.00E-03	8.15E-03	0.00E+00	1.083E+00	3.855E+02
α_5	1.06E-05	1.46E-03	7.38E-04	5.37E-03	0.00E+00	5.654E-01	3.860E+02
α_6	2.72E-10	4.96E-04	4.58E-05	2.58E-03	0.00E+00	1.916E-01	3.864E+02
α_7	6.17E-41	9.00E-05	3.35E-12	3.95E-04	0.00E+00	3.480E-02	3.865E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750431	0.9858539	0.9866446	0.9939535	1.0000000	3.990E+02	5.726E+00
α_2	8.99E-04	4.99E-03	4.20E-03	1.18E-02	0.00E+00	2.018E+00	4.027E+02
α_3	3.55E-04	3.44E-03	2.66E-03	9.17E-03	0.00E+00	1.391E+00	4.034E+02
α_4	1.56E-04	2.62E-03	1.86E-03	7.69E-03	0.00E+00	1.062E+00	4.037E+02
α_5	3.06E-05	1.74E-03	1.01E-03	5.90E-03	0.00E+00	7.026E-01	4.040E+02
α_6	3.39E-07	8.64E-04	2.65E-04	3.76E-03	0.00E+00	3.497E-01	4.044E+02
α_7	1.30E-15	2.66E-04	2.45E-06	1.54E-03	0.00E+00	1.078E-01	4.046E+02
α_8	2.72E-17	2.34E-04	9.91E-07	1.36E-03	0.00E+00	9.469E-02	4.047E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.85E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.47E-02	1.25E-02	1.24E-02	9.47E-03	7.15E-03	5.80E-03	4.99E-03
α_3		4.06E-03	3.96E-03	5.16E-03	5.07E-03	4.22E-03	3.44E-03
α_4			2.28E-03	1.88E-03	2.50E-03	2.80E-03	2.62E-03
α_5				3.78E-04	9.29E-04	1.46E-03	1.74E-03
α_6					4.61E-04	4.96E-04	8.64E-04
α_7						9.00E-05	2.66E-04
α_8							2.34E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.85E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.47E-02	1.66E-02	1.86E-02	1.69E-02	1.61E-02	1.49E-02	1.41E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	9.00	9.00	9.00	9.00	9.00	9.00	9.00
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

2.1.8 Service Water Motor-Driven Pumps

2.1.8.1 NORMALLY RUNNING SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO START: SWN-MDP-FS

Systems/Raw Water/Normally operating service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 26.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9625429	0.9904346	0.9958503	0.9999709	1.0000000	4.851E+01	4.685E-01
α_2	2.68E-05	9.57E-03	4.15E-03	3.75E-02	0.00E+00	4.685E-01	4.851E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9622357	0.9867612	0.9903283	0.9990859	1.0000000	8.408E+01	1.128E+00
α_2	3.34E-04	9.99E-03	6.51E-03	3.15E-02	0.00E+00	8.512E-01	8.436E+01
α_3	1.62E-07	3.25E-03	6.95E-04	1.52E-02	0.00E+00	2.768E-01	8.493E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9617640	0.9840429	0.9866750	0.9973311	1.0000000	1.168E+02	1.894E+00
α_2	9.17E-04	1.06E-02	8.02E-03	2.92E-02	0.00E+00	1.260E+00	1.174E+02
α_3	3.68E-06	3.39E-03	1.25E-03	1.40E-02	0.00E+00	4.024E-01	1.183E+02
α_4	1.35E-08	1.95E-03	2.91E-04	9.66E-03	0.00E+00	2.315E-01	1.184E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9687139	0.9844255	0.9858698	0.9952165	1.0000000	2.169E+02	3.432E+00
α_2	1.49E-03	8.73E-03	7.30E-03	2.09E-02	0.00E+00	1.924E+00	2.184E+02
α_3	2.76E-04	4.76E-03	3.37E-03	1.40E-02	0.00E+00	1.049E+00	2.193E+02
α_4	1.32E-06	1.73E-03	5.98E-04	7.32E-03	0.00E+00	3.822E-01	2.200E+02
α_5	3.02E-20	3.48E-04	3.24E-07	2.02E-03	0.00E+00	7.674E-02	2.203E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706943	0.9849702	0.9862170	0.9949842	1.0000000	2.513E+02	3.835E+00
α_2	9.56E-04	6.67E-03	5.43E-03	1.66E-02	0.00E+00	1.701E+00	2.535E+02

α_3	3.73E-04	4.73E-03	3.52E-03	1.32E-02	0.00E+00	1.207E+00	2.539E+02
α_4	2.14E-05	2.34E-03	1.23E-03	8.42E-03	0.00E+00	5.960E-01	2.546E+02
α_5	3.39E-09	8.66E-04	1.16E-04	4.35E-03	0.00E+00	2.211E-01	2.549E+02
α_6	3.38E-15	4.30E-04	4.36E-06	2.48E-03	0.00E+00	1.098E-01	2.550E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749032	0.9857614	0.9865541	0.9939056	1.0000000	3.979E+02	5.747E+00
α_2	1.14E-03	5.56E-03	4.76E-03	1.27E-02	0.00E+00	2.243E+00	4.014E+02
α_3	5.42E-04	4.04E-03	3.25E-03	1.02E-02	0.00E+00	1.630E+00	4.020E+02
α_4	1.67E-04	2.68E-03	1.92E-03	7.80E-03	0.00E+00	1.083E+00	4.026E+02
α_5	1.01E-05	1.40E-03	7.06E-04	5.15E-03	0.00E+00	5.654E-01	4.031E+02
α_6	2.61E-10	4.75E-04	4.38E-05	2.47E-03	0.00E+00	1.916E-01	4.035E+02
α_7	5.91E-41	8.62E-05	3.21E-12	3.78E-04	0.00E+00	3.480E-02	4.036E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9760551	0.9864274	0.9871869	0.9942044	1.0000000	4.161E+02	5.726E+00
α_2	8.62E-04	4.78E-03	4.03E-03	1.13E-02	0.00E+00	2.018E+00	4.198E+02
α_3	3.40E-04	3.30E-03	2.55E-03	8.79E-03	0.00E+00	1.391E+00	4.205E+02
α_4	1.50E-04	2.52E-03	1.79E-03	7.37E-03	0.00E+00	1.062E+00	4.208E+02
α_5	2.94E-05	1.67E-03	9.73E-04	5.66E-03	0.00E+00	7.026E-01	4.211E+02
α_6	3.25E-07	8.29E-04	2.54E-04	3.61E-03	0.00E+00	3.497E-01	4.215E+02
α_7	1.25E-15	2.56E-04	2.35E-06	1.48E-03	0.00E+00	1.078E-01	4.217E+02
α_8	2.61E-17	2.24E-04	9.51E-07	1.31E-03	0.00E+00	9.469E-02	4.218E+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	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.57E-03	9.99E-03	1.06E-02	8.73E-03	6.67E-03	5.56E-03	4.78E-03
α_3		3.25E-03	3.39E-03	4.76E-03	4.73E-03	4.04E-03	3.30E-03
α_4			1.95E-03	1.73E-03	2.34E-03	2.68E-03	2.52E-03
α_5				3.48E-04	8.66E-04	1.40E-03	1.67E-03
α_6					4.30E-04	4.75E-04	8.29E-04
α_7						8.62E-05	2.56E-04
α_8							2.24E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.57E-03	1.32E-02	1.60E-02	1.56E-02	1.50E-02	1.42E-02	1.36E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	26.10	26.10	26.10	26.10	26.10	26.10	26.10
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

2.1.8.2 NORMALLY RUNNING SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO RUN: SWN-MDP-FR

Systems/Raw Water/Normally operating service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 45.0

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9225386	0.9679469	0.9733310	0.9949219	0.9600000	5.441E+01	1.802E+00
α_2	5.08E-03	3.21E-02	2.67E-02	7.75E-02	4.00E-02	1.802E+00	5.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9406563	0.9710653	0.9739256	0.9917010	0.9591837	1.050E+02	3.128E+00
α_2	2.78E-03	1.71E-02	1.42E-02	4.13E-02	2.04E-02	1.851E+00	1.063E+02
α_3	1.05E-03	1.18E-02	8.96E-03	3.23E-02	2.04E-02	1.277E+00	1.068E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9475878	0.9720276	0.9740110	0.9896962	0.9612403	1.527E+02	4.394E+00
α_2	3.71E-03	1.60E-02	1.40E-02	3.51E-02	1.94E-02	2.510E+00	1.546E+02
α_3	5.26E-04	7.34E-03	5.38E-03	2.08E-02	1.16E-02	1.152E+00	1.559E+02
α_4	9.52E-05	4.66E-03	2.79E-03	1.56E-02	7.75E-03	7.315E-01	1.563E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9598133	0.9765375	0.9776904	0.9893300	0.9624413	2.677E+02	6.432E+00
α_2	3.70E-03	1.23E-02	1.11E-02	2.48E-02	1.80E-02	3.362E+00	2.708E+02
α_3	1.02E-03	6.56E-03	5.41E-03	1.61E-02	9.39E-03	1.799E+00	2.723E+02
α_4	1.53E-04	3.45E-03	2.34E-03	1.05E-02	7.04E-03	9.447E-01	2.732E+02
α_5	2.70E-07	1.19E-03	3.32E-04	5.30E-03	3.13E-03	3.267E-01	2.738E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9624754	0.9774725	0.9784508	0.9891390	0.9635468	3.169E+02	7.304E+00
α_2	2.94E-03	1.00E-02	9.03E-03	2.05E-02	1.63E-02	3.248E+00	3.210E+02
α_3	1.18E-03	6.37E-03	5.39E-03	1.49E-02	9.03E-03	2.066E+00	3.221E+02

α_4	2.48E-04	3.52E-03	2.57E-03	1.01E-02	5.75E-03	1.143E+00	3.231E+02
α_5	1.93E-05	1.89E-03	1.01E-03	6.74E-03	4.11E-03	6.117E-01	3.236E+02
α_6	5.93E-09	7.24E-04	1.11E-04	3.57E-03	1.31E-03	2.348E-01	3.240E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9688973	0.9802466	0.9808972	0.9893686	0.9647484	4.783E+02	9.638E+00
α_2	2.60E-03	7.84E-03	7.18E-03	1.53E-02	1.43E-02	3.825E+00	4.841E+02
α_3	1.30E-03	5.39E-03	4.73E-03	1.17E-02	9.06E-03	2.630E+00	4.853E+02
α_4	4.59E-04	3.37E-03	2.72E-03	8.51E-03	5.10E-03	1.645E+00	4.863E+02
α_5	1.04E-04	2.04E-03	1.41E-03	6.11E-03	3.89E-03	9.951E-01	4.869E+02
α_6	1.88E-06	9.13E-04	3.73E-04	3.65E-03	2.30E-03	4.455E-01	4.875E+02
α_7	5.29E-17	1.99E-04	1.00E-06	1.16E-03	5.66E-04	9.730E-02	4.878E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700396	0.9808443	0.9814538	0.9895601	0.9660645	5.113E+02	9.985E+00
α_2	2.16E-03	6.86E-03	6.24E-03	1.37E-02	1.24E-02	3.574E+00	5.177E+02
α_3	1.12E-03	4.84E-03	4.22E-03	1.07E-02	9.00E-03	2.520E+00	5.188E+02
α_4	4.57E-04	3.24E-03	2.63E-03	8.10E-03	4.98E-03	1.687E+00	5.196E+02
α_5	1.50E-04	2.18E-03	1.58E-03	6.23E-03	3.44E-03	1.134E+00	5.201E+02
α_6	2.02E-05	1.30E-03	7.45E-04	4.48E-03	2.62E-03	6.788E-01	5.206E+02
α_7	1.62E-08	5.09E-04	9.98E-05	2.42E-03	1.25E-03	2.651E-01	5.210E+02
α_8	5.55E-14	2.42E-04	4.85E-06	1.37E-03	2.49E-04	1.259E-01	5.211E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.68E-01	9.71E-01	9.72E-01	9.77E-01	9.77E-01	9.80E-01	9.81E-01
α_2	3.21E-02	1.71E-02	1.60E-02	1.23E-02	1.00E-02	7.84E-03	6.86E-03
α_3		1.18E-02	7.34E-03	6.56E-03	6.37E-03	5.39E-03	4.84E-03
α_4			4.66E-03	3.45E-03	3.52E-03	3.37E-03	3.24E-03
α_5				1.19E-03	1.89E-03	2.04E-03	2.18E-03
α_6					7.24E-04	9.13E-04	1.30E-03
α_7						1.99E-04	5.09E-04
α_8							2.42E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.68E-01	9.71E-01	9.72E-01	9.77E-01	9.77E-01	9.80E-01	9.81E-01
Beta	3.21E-02	2.89E-02	2.80E-02	2.35E-02	2.25E-02	1.98E-02	1.92E-02
Gamma		4.08E-01	4.29E-01	4.77E-01	5.55E-01	6.03E-01	6.42E-01
Delta			3.88E-01	4.14E-01	4.91E-01	5.48E-01	6.07E-01
Epsilon				2.57E-01	4.26E-01	4.83E-01	5.66E-01
Mu					2.77E-01	3.53E-01	4.85E-01
Omega						1.79E-01	3.65E-01
Sigma							3.22E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	30.00	45.00	60.00	75.00	90.00	105.00	120.00
N_1	2.0000	2.0000	2.0000	1.8750	1.6875	1.4766	1.2656
N_2	1.3333	1.0000	1.2500	1.4375	1.5469	1.5820	1.5557
N_3		1.0000	0.7500	0.7500	0.8594	1.0000	1.1299
N_4			0.5000	0.5625	0.5469	0.5625	0.6250
N_5				0.2500	0.3906	0.4297	0.4316
N_6					0.1250	0.2539	0.3291
N_7						0.0625	0.1572
N_8							0.0313

2.1.8.3 STANDBY SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO START: SSW-MDP-FS

Systems/Raw Water/Standby service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 108.0

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9655022	0.9905488	0.9951592	0.9999296	0.9972943	5.971E+01	5.697E-01
α_2	7.16E-05	9.45E-03	4.84E-03	3.45E-02	2.71E-03	5.697E-01	5.971E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9672730	0.9875570	0.9902469	0.9986405	0.9945739	1.136E+02	1.432E+00
α_2	7.25E-04	1.00E-02	7.38E-03	2.84E-02	5.43E-03	1.155E+00	1.139E+02
α_3	1.20E-07	2.41E-03	5.14E-04	1.13E-02	0.00E+00	2.768E-01	1.148E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670459	0.9850220	0.9869147	0.9965398	0.9918387	1.645E+02	2.501E+00
α_2	1.83E-03	1.12E-02	9.30E-03	2.70E-02	8.16E-03	1.867E+00	1.651E+02
α_3	2.61E-06	2.41E-03	8.84E-04	9.99E-03	0.00E+00	4.024E-01	1.666E+02
α_4	9.60E-09	1.39E-03	2.06E-04	6.87E-03	0.00E+00	2.315E-01	1.667E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9717583	0.9850988	0.9862089	0.9946395	0.9908898	2.828E+02	4.277E+00
α_2	2.32E-03	9.36E-03	8.24E-03	2.02E-02	8.21E-03	2.686E+00	2.844E+02
α_3	2.72E-04	3.94E-03	2.87E-03	1.13E-02	8.98E-04	1.132E+00	2.859E+02
α_4	1.01E-06	1.33E-03	4.59E-04	5.62E-03	0.00E+00	3.822E-01	2.867E+02
α_5	2.32E-20	2.67E-04	2.49E-07	1.55E-03	0.00E+00	7.674E-02	2.870E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734423	0.9854688	0.9864077	0.9942824	0.9900271	3.352E+02	4.943E+00
α_2	1.87E-03	7.73E-03	6.79E-03	1.68E-02	8.35E-03	2.629E+00	3.375E+02
α_3	4.08E-04	4.04E-03	3.12E-03	1.08E-02	1.50E-03	1.374E+00	3.388E+02

α_4	1.81E-05	1.79E-03	9.56E-04	6.41E-03	1.25E-04	6.098E-01	3.396E+02
α_5	2.54E-09	6.50E-04	8.69E-05	3.26E-03	0.00E+00	2.211E-01	3.399E+02
α_6	2.54E-15	3.23E-04	3.27E-06	1.86E-03	0.00E+00	1.098E-01	3.401E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763750	0.9859231	0.9865552	0.9933062	0.9892668	4.998E+02	7.136E+00
α_2	1.97E-03	6.59E-03	5.95E-03	1.34E-02	8.49E-03	3.342E+00	5.036E+02
α_3	6.09E-04	3.71E-03	3.08E-03	8.95E-03	1.92E-03	1.878E+00	5.051E+02
α_4	1.49E-04	2.21E-03	1.60E-03	6.36E-03	3.04E-04	1.122E+00	5.058E+02
α_5	8.24E-06	1.12E-03	5.66E-04	4.11E-03	1.79E-05	5.677E-01	5.064E+02
α_6	2.07E-10	3.78E-04	3.49E-05	1.97E-03	0.00E+00	1.916E-01	5.068E+02
α_7	4.70E-41	6.86E-05	2.55E-12	3.01E-04	0.00E+00	3.480E-02	5.069E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9773068	0.9863667	0.9869571	0.9934094	0.9886034	5.360E+02	7.408E+00
α_2	1.79E-03	6.05E-03	5.46E-03	1.23E-02	8.61E-03	3.290E+00	5.401E+02
α_3	4.59E-04	3.16E-03	2.58E-03	7.86E-03	2.22E-03	1.718E+00	5.417E+02
α_4	1.45E-04	2.09E-03	1.52E-03	5.98E-03	5.03E-04	1.136E+00	5.423E+02
α_5	2.41E-05	1.31E-03	7.70E-04	4.43E-03	5.75E-05	7.111E-01	5.427E+02
α_6	2.55E-07	6.44E-04	1.98E-04	2.80E-03	2.61E-06	3.501E-01	5.430E+02
α_7	9.70E-16	1.98E-04	1.82E-06	1.15E-03	0.00E+00	1.078E-01	5.433E+02
α_8	2.03E-17	1.74E-04	7.38E-07	1.01E-03	0.00E+00	9.469E-02	5.433E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.45E-03	1.00E-02	1.12E-02	9.36E-03	7.73E-03	6.59E-03	6.05E-03
α_3		2.41E-03	2.41E-03	3.94E-03	4.04E-03	3.71E-03	3.16E-03
α_4			1.39E-03	1.33E-03	1.79E-03	2.21E-03	2.09E-03
α_5				2.67E-04	6.50E-04	1.12E-03	1.31E-03
α_6					3.23E-04	3.78E-04	6.44E-04
α_7						6.86E-05	1.98E-04
α_8							1.74E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.45E-03	1.24E-02	1.50E-02	1.49E-02	1.45E-02	1.41E-02	1.36E-02
Gamma		1.93E-01	2.53E-01	3.72E-01	4.68E-01	5.32E-01	5.56E-01
Delta			3.65E-01	2.88E-01	4.06E-01	5.05E-01	5.83E-01
Epsilon				1.67E-01	3.52E-01	4.14E-01	5.27E-01
Mu					3.32E-01	2.85E-01	4.37E-01
Omega						1.54E-01	3.66E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	36.00	54.00	72.00	90.00	108.00	126.00	144.00
N_1	1.2976	1.6429	1.7857	1.9345	2.0060	2.0127	1.9645
N_2	0.1012	0.3036	0.6071	0.7619	0.9276	1.0984	1.2716
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

2.1.8.4 STANDBY SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO RUN: SSW-MDP-FR

Systems/Raw Water/Standby service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 78.9

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9427937	0.9795860	0.9848267	0.9984523	0.9796271	5.639E+01	1.175E+00
α_2	1.54E-03	2.04E-02	1.52E-02	5.72E-02	2.04E-02	1.175E+00	5.639E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9469087	0.9750919	0.9779095	0.9936437	0.9683717	1.076E+02	2.748E+00
α_2	4.11E-03	2.01E-02	1.73E-02	4.58E-02	2.67E-02	2.221E+00	1.081E+02
α_3	2.47E-05	4.78E-03	2.29E-03	1.80E-02	4.88E-03	5.268E-01	1.098E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9508292	0.9741836	0.9761367	0.9908728	0.9668377	1.560E+02	4.134E+00
α_2	3.61E-03	1.56E-02	1.36E-02	3.43E-02	1.84E-02	2.500E+00	1.576E+02
α_3	9.22E-04	8.76E-03	6.82E-03	2.32E-02	1.48E-02	1.402E+00	1.587E+02
α_4	1.00E-08	1.45E-03	2.15E-04	7.16E-03	0.00E+00	2.315E-01	1.599E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9632435	0.9790289	0.9801652	0.9909325	0.9713718	2.723E+02	5.832E+00
α_2	2.94E-03	1.08E-02	9.61E-03	2.25E-02	1.27E-02	2.991E+00	2.751E+02
α_3	8.95E-04	6.17E-03	5.03E-03	1.53E-02	7.95E-03	1.716E+00	2.764E+02
α_4	2.18E-04	3.77E-03	2.67E-03	1.11E-02	7.95E-03	1.049E+00	2.771E+02
α_5	2.40E-20	2.76E-04	2.57E-07	1.60E-03	0.00E+00	7.674E-02	2.780E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9664787	0.9804490	0.9814122	0.9911177	0.9740208	3.227E+02	6.435E+00
α_2	2.11E-03	8.34E-03	7.37E-03	1.79E-02	1.04E-02	2.746E+00	3.264E+02

α_3	8.07E-04	5.36E-03	4.39E-03	1.32E-02	5.55E-03	1.763E+00	3.274E+02
α_4	2.50E-04	3.50E-03	2.56E-03	9.96E-03	5.55E-03	1.152E+00	3.280E+02
α_5	2.91E-05	2.02E-03	1.14E-03	7.00E-03	4.44E-03	6.655E-01	3.285E+02
α_6	2.62E-15	3.34E-04	3.37E-06	1.92E-03	0.00E+00	1.098E-01	3.290E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9722323	0.9828220	0.9834672	0.9912006	0.9764754	4.854E+02	8.483E+00
α_2	1.90E-03	6.53E-03	5.87E-03	1.34E-02	8.43E-03	3.223E+00	4.906E+02
α_3	8.58E-04	4.38E-03	3.73E-03	1.01E-02	4.59E-03	2.163E+00	4.917E+02
α_4	3.75E-04	3.09E-03	2.45E-03	8.00E-03	3.82E-03	1.527E+00	4.923E+02
α_5	1.22E-04	2.12E-03	1.50E-03	6.24E-03	4.14E-03	1.047E+00	4.928E+02
α_6	3.41E-06	9.88E-04	4.40E-04	3.83E-03	2.55E-03	4.879E-01	4.934E+02
α_7	4.83E-41	7.05E-05	2.62E-12	3.09E-04	0.00E+00	3.480E-02	4.938E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9737320	0.9837053	0.9843094	0.9916069	0.9782490	5.196E+02	8.608E+00
α_2	1.54E-03	5.66E-03	5.05E-03	1.19E-02	7.32E-03	2.988E+00	5.253E+02
α_3	6.02E-04	3.60E-03	3.00E-03	8.67E-03	3.86E-03	1.903E+00	5.264E+02
α_4	3.12E-04	2.77E-03	2.17E-03	7.26E-03	3.02E-03	1.462E+00	5.268E+02
α_5	1.33E-04	2.08E-03	1.49E-03	6.02E-03	2.98E-03	1.098E+00	5.272E+02
α_6	3.28E-05	1.43E-03	8.74E-04	4.74E-03	3.07E-03	7.571E-01	5.275E+02
α_7	7.28E-08	5.78E-04	1.45E-04	2.63E-03	1.49E-03	3.054E-01	5.279E+02
α_8	2.09E-17	1.79E-04	7.59E-07	1.04E-03	0.00E+00	9.469E-02	5.282E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.75E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
α_2	2.04E-02	2.01E-02	1.56E-02	1.08E-02	8.34E-03	6.53E-03	5.66E-03
α_3		4.78E-03	8.76E-03	6.17E-03	5.36E-03	4.38E-03	3.60E-03
α_4			1.45E-03	3.77E-03	3.50E-03	3.09E-03	2.77E-03
α_5				2.76E-04	2.02E-03	2.12E-03	2.08E-03
α_6					3.34E-04	9.88E-04	1.43E-03
α_7						7.05E-05	5.78E-04
α_8							1.79E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.75E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
Beta	2.04E-02	2.49E-02	2.58E-02	2.10E-02	1.96E-02	1.72E-02	1.63E-02
Gamma		1.92E-01	3.95E-01	4.87E-01	5.73E-01	6.20E-01	6.53E-01
Delta			1.42E-01	3.96E-01	5.22E-01	5.89E-01	6.61E-01
Epsilon				6.82E-02	4.02E-01	5.07E-01	6.07E-01
Mu					1.42E-01	3.33E-01	5.13E-01
Omega						6.66E-02	3.46E-01

Sigma							2.37E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	31.56	47.34	63.12	78.90	94.68	110.46	126.24
N_1	2.4200	2.2600	2.1867	2.5333	2.8000	3.1080	3.3850
N_2	0.7067	1.3700	1.2400	1.0667	1.0444	0.9803	0.9700
N_3		0.2500	1.0000	0.6667	0.5556	0.5335	0.5120
N_4			0.0000	0.6667	0.5556	0.4444	0.4001
N_5				0.0000	0.4444	0.4815	0.3951
N_6					0.0000	0.2963	0.4074
N_7						0.0000	0.1975
N_8							0.0000

2.1.8.5 SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO START: SWS-MDP-FS

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 134.1

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9698407	0.9917408	0.9957802	0.9999394	0.9978049	6.841E+01	5.697E-01
α_2	6.24E-05	8.26E-03	4.22E-03	3.02E-02	2.20E-03	5.697E-01	6.841E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9705892	0.9888246	0.9912489	0.9987756	0.9956002	1.267E+02	1.432E+00
α_2	6.51E-04	9.01E-03	6.62E-03	2.56E-02	4.40E-03	1.155E+00	1.269E+02
α_3	1.08E-07	2.16E-03	4.61E-04	1.01E-02	0.00E+00	2.768E-01	1.278E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9701347	0.9864356	0.9881538	0.9968689	0.9933857	1.819E+02	2.501E+00
α_2	1.66E-03	1.01E-02	8.42E-03	2.44E-02	6.61E-03	1.867E+00	1.825E+02
α_3	2.37E-06	2.18E-03	8.00E-04	9.04E-03	0.00E+00	4.024E-01	1.840E+02
α_4	8.69E-09	1.26E-03	1.87E-04	6.22E-03	0.00E+00	2.315E-01	1.841E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9737436	0.9861483	0.9871870	0.9950147	0.9926199	3.045E+02	4.277E+00
α_2	2.15E-03	8.70E-03	7.66E-03	1.88E-02	6.65E-03	2.686E+00	3.061E+02
α_3	2.52E-04	3.67E-03	2.67E-03	1.05E-02	7.28E-04	1.132E+00	3.077E+02
α_4	9.40E-07	1.24E-03	4.26E-04	5.22E-03	0.00E+00	3.822E-01	3.084E+02
α_5	2.16E-20	2.49E-04	2.31E-07	1.44E-03	0.00E+00	7.674E-02	3.087E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753271	0.9865043	0.9873828	0.9946862	0.9919240	3.613E+02	4.943E+00
α_2	1.74E-03	7.18E-03	6.30E-03	1.56E-02	6.76E-03	2.629E+00	3.636E+02

α_3	3.79E-04	3.75E-03	2.89E-03	1.00E-02	1.21E-03	1.374E+00	3.649E+02
α_4	1.68E-05	1.67E-03	8.88E-04	5.95E-03	1.01E-04	6.098E-01	3.657E+02
α_5	2.36E-09	6.04E-04	8.07E-05	3.03E-03	0.00E+00	2.211E-01	3.660E+02
α_6	2.36E-15	3.00E-04	3.03E-06	1.73E-03	0.00E+00	1.098E-01	3.662E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9777087	0.9867208	0.9873182	0.9936875	0.9913114	5.303E+02	7.136E+00
α_2	1.86E-03	6.22E-03	5.62E-03	1.26E-02	6.87E-03	3.342E+00	5.341E+02
α_3	5.74E-04	3.50E-03	2.90E-03	8.44E-03	1.56E-03	1.878E+00	5.355E+02
α_4	1.41E-04	2.09E-03	1.51E-03	6.00E-03	2.46E-04	1.122E+00	5.363E+02
α_5	7.78E-06	1.06E-03	5.34E-04	3.88E-03	1.45E-05	5.677E-01	5.368E+02
α_6	1.96E-10	3.57E-04	3.29E-05	1.86E-03	0.00E+00	1.916E-01	5.372E+02
α_7	4.43E-41	6.48E-05	2.41E-12	2.84E-04	0.00E+00	3.480E-02	5.374E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9786675	0.9871873	0.9877479	0.9938075	0.9907772	5.708E+02	7.408E+00
α_2	1.68E-03	5.69E-03	5.13E-03	1.16E-02	6.97E-03	3.290E+00	5.749E+02
α_3	4.31E-04	2.97E-03	2.42E-03	7.39E-03	1.80E-03	1.718E+00	5.765E+02
α_4	1.36E-04	1.97E-03	1.43E-03	5.62E-03	4.07E-04	1.136E+00	5.771E+02
α_5	2.27E-05	1.23E-03	7.23E-04	4.16E-03	4.65E-05	7.111E-01	5.775E+02
α_6	2.40E-07	6.06E-04	1.86E-04	2.63E-03	2.11E-06	3.501E-01	5.778E+02
α_7	9.12E-16	1.87E-04	1.71E-06	1.08E-03	0.00E+00	1.078E-01	5.781E+02
α_8	1.91E-17	1.64E-04	6.93E-07	9.53E-04	0.00E+00	9.469E-02	5.781E+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	9.89E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
α_2	8.26E-03	9.01E-03	1.01E-02	8.70E-03	7.18E-03	6.22E-03	5.69E-03
α_3		2.16E-03	2.18E-03	3.67E-03	3.75E-03	3.50E-03	2.97E-03
α_4			1.26E-03	1.24E-03	1.67E-03	2.09E-03	1.97E-03
α_5				2.49E-04	6.04E-04	1.06E-03	1.23E-03
α_6					3.00E-04	3.57E-04	6.06E-04
α_7						6.48E-05	1.87E-04
α_8							1.64E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.89E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
Beta	8.26E-03	1.12E-02	1.36E-02	1.39E-02	1.35E-02	1.33E-02	1.28E-02
Gamma		1.93E-01	2.53E-01	3.72E-01	4.68E-01	5.32E-01	5.56E-01
Delta			3.65E-01	2.88E-01	4.06E-01	5.05E-01	5.83E-01
Epsilon				1.67E-01	3.52E-01	4.14E-01	5.27E-01
Mu					3.32E-01	2.85E-01	4.37E-01
Omega						1.54E-01	3.66E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	44.70	67.05	89.40	111.75	134.10	156.45	178.80
N_1	1.2976	1.6429	1.7857	1.9345	2.0060	2.0127	1.9645
N_2	0.1012	0.3036	0.6071	0.7619	0.9276	1.0984	1.2716
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

2.1.8.6 SERVICE WATER MOTOR-DRIVEN PUMPS FAIL TO RUN: SWS-MDP-FR

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run >1H
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 130.4

Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9405513	0.9728200	0.9761654	0.9936529	0.9706102	8.978E+01	2.509E+00
α_2	6.35E-03	2.72E-02	2.38E-02	5.94E-02	2.94E-02	2.509E+00	8.978E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9459684	0.9705848	0.9725107	0.9886218	0.9646165	1.567E+02	4.748E+00
α_2	5.84E-03	2.00E-02	1.80E-02	4.07E-02	2.32E-02	3.221E+00	1.582E+02
α_3	1.15E-03	9.46E-03	7.52E-03	2.44E-02	1.22E-02	1.527E+00	1.599E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9504647	0.9708284	0.9721962	0.9865141	0.9648446	2.208E+02	6.634E+00
α_2	5.42E-03	1.65E-02	1.51E-02	3.23E-02	1.85E-02	3.750E+00	2.237E+02
α_3	1.85E-03	9.47E-03	8.07E-03	2.19E-02	1.30E-02	2.152E+00	2.252E+02
α_4	6.56E-05	3.22E-03	1.93E-03	1.08E-02	3.71E-03	7.315E-01	2.267E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9609014	0.9755652	0.9764398	0.9872544	0.9677010	3.526E+02	8.832E+00
α_2	4.50E-03	1.23E-02	1.14E-02	2.30E-02	1.50E-02	4.428E+00	3.570E+02
α_3	1.55E-03	6.82E-03	5.94E-03	1.51E-02	8.47E-03	2.466E+00	3.590E+02
α_4	5.88E-04	4.46E-03	3.58E-03	1.13E-02	7.35E-03	1.611E+00	3.598E+02
α_5	2.05E-07	9.04E-04	2.52E-04	4.02E-03	1.50E-03	3.267E-01	3.611E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9638310	0.9768857	0.9776267	0.9874188	0.9695667	4.186E+02	9.904E+00

α_2	3.61E-03	1.00E-02	9.27E-03	1.90E-02	1.30E-02	4.292E+00	4.242E+02
α_3	1.48E-03	6.12E-03	5.37E-03	1.33E-02	7.10E-03	2.622E+00	4.258E+02
α_4	5.66E-04	3.96E-03	3.22E-03	9.89E-03	5.53E-03	1.698E+00	4.268E+02
α_5	1.45E-04	2.46E-03	1.75E-03	7.23E-03	4.19E-03	1.056E+00	4.274E+02
α_6	4.49E-09	5.48E-04	8.39E-05	2.70E-03	6.27E-04	2.348E-01	4.282E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694786	0.9796845	0.9802054	0.9881056	0.9713805	5.967E+02	1.237E+01
α_2	3.05E-03	7.89E-03	7.36E-03	1.46E-02	1.11E-02	4.806E+00	6.043E+02
α_3	1.49E-03	5.19E-03	4.66E-03	1.07E-02	6.62E-03	3.163E+00	6.059E+02
α_4	6.45E-04	3.43E-03	2.91E-03	8.01E-03	4.35E-03	2.090E+00	6.070E+02
α_5	2.77E-04	2.42E-03	1.91E-03	6.34E-03	3.94E-03	1.477E+00	6.076E+02
α_6	2.60E-05	1.22E-03	7.34E-04	4.06E-03	2.38E-03	7.418E-01	6.083E+02
α_7	4.24E-17	1.60E-04	8.03E-07	9.29E-04	2.70E-04	9.730E-02	6.090E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9708828	0.9804844	0.9809661	0.9884403	0.9729061	6.465E+02	1.287E+01
α_2	2.57E-03	6.89E-03	6.40E-03	1.29E-02	9.58E-03	4.544E+00	6.548E+02
α_3	1.27E-03	4.60E-03	4.11E-03	9.61E-03	6.23E-03	3.032E+00	6.563E+02
α_4	5.94E-04	3.17E-03	2.68E-03	7.40E-03	3.89E-03	2.087E+00	6.573E+02
α_5	2.81E-04	2.32E-03	1.84E-03	6.00E-03	3.14E-03	1.529E+00	6.578E+02
α_6	1.03E-04	1.65E-03	1.18E-03	4.79E-03	2.79E-03	1.086E+00	6.583E+02
α_7	1.80E-06	7.02E-04	2.97E-04	2.77E-03	1.35E-03	4.626E-01	6.589E+02
α_8	4.39E-14	1.91E-04	3.83E-06	1.08E-03	1.19E-04	1.259E-01	6.592E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.73E-01	9.71E-01	9.71E-01	9.76E-01	9.77E-01	9.80E-01	9.80E-01
α_2	2.72E-02	2.00E-02	1.65E-02	1.23E-02	1.00E-02	7.89E-03	6.89E-03
α_3		9.46E-03	9.47E-03	6.82E-03	6.12E-03	5.19E-03	4.60E-03
α_4			3.22E-03	4.46E-03	3.96E-03	3.43E-03	3.17E-03
α_5				9.04E-04	2.46E-03	2.42E-03	2.32E-03
α_6					5.48E-04	1.22E-03	1.65E-03
α_7						1.60E-04	7.02E-04
α_8							1.91E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.73E-01	9.71E-01	9.71E-01	9.76E-01	9.77E-01	9.80E-01	9.80E-01
Beta	2.72E-02	2.94E-02	2.92E-02	2.44E-02	2.31E-02	2.03E-02	1.95E-02
Gamma		3.22E-01	4.35E-01	4.99E-01	5.67E-01	6.12E-01	6.47E-01
Delta			2.54E-01	4.40E-01	5.33E-01	5.82E-01	6.36E-01
Epsilon				1.69E-01	4.32E-01	5.26E-01	6.06E-01
Mu					1.82E-01	3.62E-01	5.23E-01

Omega						1.16E-01	3.51E-01
Sigma							2.14E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	62.95	94.43	125.90	157.38	188.86	220.33	251.81
N_1	4.4200	4.2600	4.1867	4.4083	4.4875	4.5846	4.6506
N_2	2.0400	2.3700	2.4900	2.5042	2.5913	2.5623	2.5257
N_3		1.2500	1.7500	1.4167	1.4149	1.5335	1.6419
N_4			0.5000	1.2292	1.1024	1.0069	1.0251
N_5				0.2500	0.8351	0.9112	0.8267
N_6					0.1250	0.5502	0.7365
N_7						0.0625	0.3548
N_8							0.0313

2.1.9 High Pressure Safety Injection Pumps

2.1.9.1 HPSI MOTOR-DRIVEN PUMPS FAIL TO START: HPI-MDP-FS

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 42.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9717411	0.9927898	0.9968831	0.9999780	1.0000000	6.451E+01	4.685E-01
α_2	2.01E-05	7.21E-03	3.12E-03	2.83E-02	0.00E+00	4.685E-01	6.451E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9681735	0.9888541	0.9918709	0.9992312	1.0000000	1.001E+02	1.128E+00
α_2	2.81E-04	8.41E-03	5.47E-03	2.66E-02	0.00E+00	8.512E-01	1.004E+02
α_3	1.36E-07	2.74E-03	5.84E-04	1.28E-02	0.00E+00	2.768E-01	1.009E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9662771	0.9859388	0.9882609	0.9976511	1.0000000	1.328E+02	1.894E+00
α_2	8.07E-04	9.35E-03	7.06E-03	2.57E-02	0.00E+00	1.260E+00	1.334E+02
α_3	3.24E-06	2.99E-03	1.10E-03	1.24E-02	0.00E+00	4.024E-01	1.343E+02
α_4	1.19E-08	1.72E-03	2.56E-04	8.51E-03	0.00E+00	2.315E-01	1.344E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9708151	0.9854798	0.9868289	0.9955425	1.0000000	2.329E+02	3.432E+00
α_2	1.38E-03	8.14E-03	6.80E-03	1.95E-02	0.00E+00	1.924E+00	2.344E+02
α_3	2.57E-04	4.44E-03	3.14E-03	1.30E-02	0.00E+00	1.049E+00	2.353E+02
α_4	1.23E-06	1.62E-03	5.57E-04	6.82E-03	0.00E+00	3.822E-01	2.360E+02
α_5	2.82E-20	3.25E-04	3.02E-07	1.89E-03	0.00E+00	7.674E-02	2.363E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724157	0.9858571	0.9870367	0.9952820	1.0000000	2.673E+02	3.835E+00
α_2	8.99E-04	6.27E-03	5.11E-03	1.56E-02	0.00E+00	1.701E+00	2.695E+02

α_3	3.51E-04	4.45E-03	3.31E-03	1.25E-02	0.00E+00	1.207E+00	2.699E+02
α_4	2.01E-05	2.20E-03	1.15E-03	7.92E-03	0.00E+00	5.960E-01	2.706E+02
α_5	3.19E-09	8.15E-04	1.09E-04	4.09E-03	0.00E+00	2.211E-01	2.709E+02
α_6	3.18E-15	4.05E-04	4.10E-06	2.34E-03	0.00E+00	1.098E-01	2.710E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9758612	0.9863043	0.9870677	0.9941355	1.0000000	4.139E+02	5.747E+00
α_2	1.09E-03	5.35E-03	4.58E-03	1.22E-02	0.00E+00	2.243E+00	4.174E+02
α_3	5.21E-04	3.88E-03	3.13E-03	9.82E-03	0.00E+00	1.630E+00	4.180E+02
α_4	1.61E-04	2.58E-03	1.85E-03	7.51E-03	0.00E+00	1.083E+00	4.186E+02
α_5	9.74E-06	1.35E-03	6.79E-04	4.95E-03	0.00E+00	5.654E-01	4.191E+02
α_6	2.51E-10	4.57E-04	4.22E-05	2.38E-03	0.00E+00	1.916E-01	4.195E+02
α_7	5.68E-41	8.29E-05	3.08E-12	3.64E-04	0.00E+00	3.480E-02	4.196E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9769221	0.9869233	0.9876605	0.9944129	1.0000000	4.321E+02	5.726E+00
α_2	8.31E-04	4.61E-03	3.88E-03	1.09E-02	0.00E+00	2.018E+00	4.358E+02
α_3	3.28E-04	3.18E-03	2.46E-03	8.47E-03	0.00E+00	1.391E+00	4.365E+02
α_4	1.44E-04	2.43E-03	1.72E-03	7.11E-03	0.00E+00	1.062E+00	4.368E+02
α_5	2.83E-05	1.60E-03	9.37E-04	5.45E-03	0.00E+00	7.026E-01	4.371E+02
α_6	3.14E-07	7.99E-04	2.45E-04	3.47E-03	0.00E+00	3.497E-01	4.375E+02
α_7	1.20E-15	2.46E-04	2.26E-06	1.42E-03	0.00E+00	1.078E-01	4.377E+02
α_8	2.52E-17	2.16E-04	9.16E-07	1.26E-03	0.00E+00	9.469E-02	4.378E+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	9.89E-01	9.86E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
α_2	7.21E-03	8.41E-03	9.35E-03	8.14E-03	6.27E-03	5.35E-03	4.61E-03
α_3		2.74E-03	2.99E-03	4.44E-03	4.45E-03	3.88E-03	3.18E-03
α_4			1.72E-03	1.62E-03	2.20E-03	2.58E-03	2.43E-03
α_5				3.25E-04	8.15E-04	1.35E-03	1.60E-03
α_6					4.05E-04	4.57E-04	7.99E-04
α_7						8.29E-05	2.46E-04
α_8							2.16E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.93E-01	9.89E-01	9.86E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
Beta	7.21E-03	1.11E-02	1.41E-02	1.45E-02	1.41E-02	1.37E-02	1.31E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	42.10	42.10	42.10	42.10	42.10	42.10	42.10
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

2.1.9.2 HPSI MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1 HOUR: HPI-MDP-FH

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run (Normally running equipment)
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

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	0.9265716	0.9811696	0.9917194	0.9999431	1.0000000	2.441E+01	4.685E-01
α_2	5.35E-05	1.88E-02	8.28E-03	7.34E-02	0.00E+00	4.685E-01	2.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474768	0.9815399	0.9864769	0.9987198	1.0000000	5.998E+01	1.128E+00
α_2	4.68E-04	1.39E-02	9.10E-03	4.39E-02	0.00E+00	8.512E-01	6.026E+01
α_3	2.27E-07	4.53E-03	9.72E-04	2.13E-02	0.00E+00	2.768E-01	6.083E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521027	0.9799764	0.9832554	0.9966416	1.0000000	9.268E+01	1.894E+00
α_2	1.15E-03	1.33E-02	1.01E-02	3.66E-02	0.00E+00	1.260E+00	9.331E+01
α_3	4.63E-06	4.26E-03	1.56E-03	1.76E-02	0.00E+00	4.024E-01	9.417E+01
α_4	1.70E-08	2.45E-03	3.65E-04	1.21E-02	0.00E+00	2.315E-01	9.434E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648968	0.9825131	0.9841236	0.9946232	1.0000000	1.928E+02	3.432E+00
α_2	1.67E-03	9.80E-03	8.20E-03	2.34E-02	0.00E+00	1.924E+00	1.943E+02
α_3	3.10E-04	5.34E-03	3.79E-03	1.57E-02	0.00E+00	1.049E+00	1.952E+02
α_4	1.48E-06	1.95E-03	6.71E-04	8.21E-03	0.00E+00	3.822E-01	1.959E+02
α_5	3.40E-20	3.91E-04	3.64E-07	2.27E-03	0.00E+00	7.674E-02	1.962E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676555	0.9834025	0.9847752	0.9944521	1.0000000	2.272E+02	3.835E+00

α_2	1.06E-03	7.36E-03	6.00E-03	1.83E-02	0.00E+00	1.701E+00	2.294E+02
α_3	4.12E-04	5.22E-03	3.88E-03	1.46E-02	0.00E+00	1.207E+00	2.298E+02
α_4	2.36E-05	2.58E-03	1.35E-03	9.29E-03	0.00E+00	5.960E-01	2.305E+02
α_5	3.75E-09	9.57E-04	1.28E-04	4.80E-03	0.00E+00	2.211E-01	2.308E+02
α_6	3.74E-15	4.75E-04	4.81E-06	2.74E-03	0.00E+00	1.098E-01	2.309E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733172	0.9848573	0.9856988	0.9935127	1.0000000	3.738E+02	5.747E+00
α_2	1.21E-03	5.91E-03	5.07E-03	1.35E-02	0.00E+00	2.243E+00	3.773E+02
α_3	5.76E-04	4.29E-03	3.46E-03	1.09E-02	0.00E+00	1.630E+00	3.779E+02
α_4	1.78E-04	2.85E-03	2.04E-03	8.30E-03	0.00E+00	1.083E+00	3.785E+02
α_5	1.08E-05	1.49E-03	7.51E-04	5.47E-03	0.00E+00	5.654E-01	3.790E+02
α_6	2.77E-10	5.05E-04	4.66E-05	2.63E-03	0.00E+00	1.916E-01	3.794E+02
α_7	6.28E-41	9.17E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.795E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746063	0.9856050	0.9864091	0.9938511	1.0000000	3.920E+02	5.726E+00
α_2	9.15E-04	5.07E-03	4.27E-03	1.20E-02	0.00E+00	2.018E+00	3.957E+02
α_3	3.61E-04	3.50E-03	2.71E-03	9.33E-03	0.00E+00	1.391E+00	3.964E+02
α_4	1.59E-04	2.67E-03	1.90E-03	7.82E-03	0.00E+00	1.062E+00	3.967E+02
α_5	3.12E-05	1.77E-03	1.03E-03	6.00E-03	0.00E+00	7.026E-01	3.970E+02
α_6	3.45E-07	8.79E-04	2.70E-04	3.82E-03	0.00E+00	3.497E-01	3.974E+02
α_7	1.33E-15	2.71E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.976E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.977E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.88E-02	1.39E-02	1.33E-02	9.80E-03	7.36E-03	5.91E-03	5.07E-03
α_3		4.53E-03	4.26E-03	5.34E-03	5.22E-03	4.29E-03	3.50E-03
α_4			2.45E-03	1.95E-03	2.58E-03	2.85E-03	2.67E-03
α_5				3.91E-04	9.57E-04	1.49E-03	1.77E-03
α_6					4.75E-04	5.05E-04	8.79E-04
α_7						9.17E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.88E-02	1.85E-02	2.00E-02	1.75E-02	1.66E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	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

2.1.9.3 HPSI MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: HPI-MDP-FHRH

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run (Normally running equipment)
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 18.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9424464	0.9827821	0.9896609	0.9996625	0.9867374	4.101E+01	7.185E-01
α_2	3.36E-04	1.72E-02	1.03E-02	5.76E-02	1.33E-02	7.185E-01	4.101E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9530440	0.9813153	0.9848585	0.9974714	0.9821588	8.550E+01	1.628E+00
α_2	1.16E-03	1.41E-02	1.06E-02	3.90E-02	1.34E-02	1.226E+00	8.591E+01
α_3	4.97E-06	4.61E-03	1.69E-03	1.91E-02	4.46E-03	4.018E-01	8.673E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9567102	0.9801004	0.9825167	0.9952391	0.9814877	1.271E+02	2.581E+00
α_2	1.71E-03	1.26E-02	1.02E-02	3.17E-02	1.01E-02	1.635E+00	1.281E+02
α_3	6.73E-05	5.03E-03	2.82E-03	1.75E-02	6.73E-03	6.524E-01	1.291E+02
α_4	2.02E-07	2.27E-03	5.37E-04	1.04E-02	1.68E-03	2.940E-01	1.294E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9665141	0.9823499	0.9836679	0.9936713	0.9824206	2.362E+02	4.245E+00
α_2	1.90E-03	9.30E-03	7.98E-03	2.12E-02	6.76E-03	2.237E+00	2.383E+02
α_3	5.64E-04	5.66E-03	4.36E-03	1.52E-02	6.76E-03	1.362E+00	2.391E+02
α_4	1.29E-05	2.24E-03	1.09E-03	8.37E-03	3.38E-03	5.385E-01	2.400E+02
α_5	2.28E-15	4.49E-04	4.16E-06	2.59E-03	6.76E-04	1.080E-01	2.404E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9693058	0.9833806	0.9844988	0.9936235	0.9838901	2.796E+02	4.726E+00
α_2	1.17E-03	6.81E-03	5.69E-03	1.63E-02	4.24E-03	1.935E+00	2.824E+02
α_3	6.43E-04	5.34E-03	4.24E-03	1.38E-02	5.65E-03	1.520E+00	2.828E+02
α_4	9.00E-05	2.92E-03	1.87E-03	9.33E-03	4.24E-03	8.303E-01	2.835E+02
α_5	1.83E-07	1.11E-03	2.92E-04	4.99E-03	1.70E-03	3.148E-01	2.840E+02
α_6	9.20E-14	4.41E-04	8.69E-06	2.50E-03	2.83E-04	1.254E-01	2.842E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742501	0.9848721	0.9855954	0.9930170	0.9854295	4.352E+02	6.685E+00
α_2	1.20E-03	5.45E-03	4.72E-03	1.22E-02	2.55E-03	2.407E+00	4.395E+02
α_3	7.20E-04	4.31E-03	3.59E-03	1.04E-02	4.25E-03	1.903E+00	4.400E+02
α_4	3.03E-04	3.07E-03	2.36E-03	8.26E-03	4.25E-03	1.356E+00	4.405E+02
α_5	3.33E-05	1.65E-03	9.86E-04	5.53E-03	2.55E-03	7.294E-01	4.412E+02
α_6	7.96E-09	5.57E-04	9.45E-05	2.71E-03	8.50E-04	2.463E-01	4.416E+02
α_7	3.88E-34	9.64E-05	1.14E-10	4.79E-04	1.21E-04	4.261E-02	4.418E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757244	0.9857391	0.9864216	0.9934125	0.9868543	4.625E+02	6.690E+00
α_2	8.72E-04	4.53E-03	3.85E-03	1.05E-02	1.49E-03	2.127E+00	4.670E+02
α_3	4.51E-04	3.43E-03	2.76E-03	8.72E-03	2.98E-03	1.609E+00	4.675E+02
α_4	2.73E-04	2.85E-03	2.18E-03	7.70E-03	3.73E-03	1.336E+00	4.678E+02
α_5	8.15E-05	1.96E-03	1.32E-03	6.05E-03	2.98E-03	9.213E-01	4.682E+02
α_6	2.40E-06	9.79E-04	4.12E-04	3.87E-03	1.49E-03	4.591E-01	4.687E+02
α_7	5.91E-13	2.96E-04	9.17E-06	1.66E-03	4.26E-04	1.391E-01	4.690E+02
α_8	8.25E-17	2.10E-04	1.15E-06	1.22E-03	5.32E-05	9.860E-02	4.690E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.72E-02	1.41E-02	1.26E-02	9.30E-03	6.81E-03	5.45E-03	4.53E-03
α_3		4.61E-03	5.03E-03	5.66E-03	5.34E-03	4.31E-03	3.43E-03
α_4			2.27E-03	2.24E-03	2.92E-03	3.07E-03	2.85E-03
α_5				4.49E-04	1.11E-03	1.65E-03	1.96E-03
α_6					4.41E-04	5.57E-04	9.79E-04
α_7						9.64E-05	2.96E-04
α_8							2.10E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.72E-02	1.87E-02	1.99E-02	1.77E-02	1.66E-02	1.51E-02	1.43E-02
Gamma		2.47E-01	3.67E-01	4.73E-01	5.90E-01	6.40E-01	6.82E-01
Delta			3.11E-01	3.22E-01	4.55E-01	5.55E-01	6.47E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01

Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01
Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	18.10	27.15	36.20	45.25	54.30	63.35	72.40
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	0.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		0.1250	0.2500	0.3125	0.3125	0.2734	0.2188
N_4			0.0625	0.1563	0.2344	0.2734	0.2734
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.1.9.4 HPSI MOTOR-DRIVEN PUMPS FAIL TO RUN > 1 HOUR: HPI-MDP-RH

Systems/Clean Water/Chemical and volume control
Systems/Clean Water/High pressure injection
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run (Normally running equipment)
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 16.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9395767	0.9819154	0.9891318	0.9996452	0.9851632	3.901E+01	7.185E-01
α_2	3.53E-04	1.81E-02	1.09E-02	6.04E-02	1.48E-02	7.185E-01	3.901E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9513850	0.9806490	0.9843143	0.9973799	0.9800200	8.250E+01	1.628E+00
α_2	1.20E-03	1.46E-02	1.09E-02	4.04E-02	1.50E-02	1.226E+00	8.291E+01
α_3	5.15E-06	4.78E-03	1.75E-03	1.98E-02	5.00E-03	4.018E-01	8.373E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9553443	0.9794672	0.9819574	0.9950855	0.9792531	1.231E+02	2.581E+00
α_2	1.76E-03	1.30E-02	1.05E-02	3.27E-02	1.13E-02	1.635E+00	1.241E+02
α_3	6.95E-05	5.19E-03	2.91E-03	1.81E-02	7.54E-03	6.524E-01	1.251E+02
α_4	2.08E-07	2.34E-03	5.54E-04	1.08E-02	1.89E-03	2.940E-01	1.254E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9658074	0.9819752	0.9833202	0.9935354	0.9802881	2.312E+02	4.245E+00
α_2	1.94E-03	9.50E-03	8.15E-03	2.17E-02	7.58E-03	2.237E+00	2.333E+02
α_3	5.76E-04	5.78E-03	4.46E-03	1.55E-02	7.58E-03	1.362E+00	2.341E+02
α_4	1.31E-05	2.29E-03	1.11E-03	8.55E-03	3.79E-03	5.385E-01	2.350E+02
α_5	2.33E-15	4.59E-04	4.25E-06	2.65E-03	7.58E-04	1.080E-01	2.354E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686482	0.9830223	0.9841639	0.9934847	0.9819289	2.736E+02	4.726E+00
α_2	1.19E-03	6.95E-03	5.81E-03	1.66E-02	4.76E-03	1.935E+00	2.764E+02

α_3	6.57E-04	5.46E-03	4.33E-03	1.41E-02	6.34E-03	1.520E+00	2.768E+02
α_4	9.19E-05	2.98E-03	1.91E-03	9.53E-03	4.76E-03	8.303E-01	2.775E+02
α_5	1.87E-07	1.13E-03	2.98E-04	5.09E-03	1.90E-03	3.148E-01	2.780E+02
α_6	9.40E-14	4.51E-04	8.88E-06	2.56E-03	3.17E-04	1.254E-01	2.782E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738424	0.9846286	0.9853632	0.9929035	0.9836508	4.282E+02	6.685E+00
α_2	1.22E-03	5.54E-03	4.80E-03	1.24E-02	2.86E-03	2.407E+00	4.325E+02
α_3	7.31E-04	4.38E-03	3.64E-03	1.05E-02	4.77E-03	1.903E+00	4.330E+02
α_4	3.08E-04	3.12E-03	2.40E-03	8.39E-03	4.77E-03	1.356E+00	4.335E+02
α_5	3.38E-05	1.68E-03	1.00E-03	5.62E-03	2.86E-03	7.294E-01	4.342E+02
α_6	8.08E-09	5.66E-04	9.61E-05	2.75E-03	9.54E-04	2.463E-01	4.346E+02
α_7	3.94E-34	9.80E-05	1.15E-10	4.87E-04	1.36E-04	4.261E-02	4.348E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753048	0.9854917	0.9861857	0.9933028	0.9852462	4.545E+02	6.690E+00
α_2	8.87E-04	4.61E-03	3.92E-03	1.07E-02	1.67E-03	2.127E+00	4.590E+02
α_3	4.59E-04	3.49E-03	2.80E-03	8.87E-03	3.35E-03	1.609E+00	4.595E+02
α_4	2.78E-04	2.90E-03	2.22E-03	7.84E-03	4.18E-03	1.336E+00	4.598E+02
α_5	8.30E-05	2.00E-03	1.34E-03	6.16E-03	3.35E-03	9.213E-01	4.602E+02
α_6	2.45E-06	9.96E-04	4.19E-04	3.94E-03	1.67E-03	4.591E-01	4.607E+02
α_7	6.01E-13	3.02E-04	9.33E-06	1.68E-03	4.78E-04	1.391E-01	4.610E+02
α_8	8.39E-17	2.14E-04	1.17E-06	1.24E-03	5.97E-05	9.860E-02	4.610E+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	9.81E-01	9.79E-01	9.82E-01	9.83E-01	9.85E-01	9.85E-01
α_2	1.81E-02	1.46E-02	1.30E-02	9.50E-03	6.95E-03	5.54E-03	4.61E-03
α_3		4.78E-03	5.19E-03	5.78E-03	5.46E-03	4.38E-03	3.49E-03
α_4			2.34E-03	2.29E-03	2.98E-03	3.12E-03	2.90E-03
α_5				4.59E-04	1.13E-03	1.68E-03	2.00E-03
α_6					4.51E-04	5.66E-04	9.96E-04
α_7						9.80E-05	3.02E-04
α_8							2.14E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.81E-01	9.79E-01	9.82E-01	9.83E-01	9.85E-01	9.85E-01
Beta	1.81E-02	1.94E-02	2.05E-02	1.80E-02	1.70E-02	1.54E-02	1.45E-02
Gamma		2.47E-01	3.67E-01	4.73E-01	5.90E-01	6.40E-01	6.82E-01
Delta			3.11E-01	3.22E-01	4.55E-01	5.55E-01	6.47E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01

Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	16.10	24.15	32.20	40.25	48.30	56.35	64.40
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	0.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		0.1250	0.2500	0.3125	0.3125	0.2734	0.2188
N_4			0.0625	0.1563	0.2344	0.2734	0.2734
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.1.10 PWR Residual Heat Removal Pumps

2.1.10.1 PWR RHR MOTOR-DRIVEN PUMPS FAIL TO START: PWR-RHR-MDP-FS

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 16.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9528639	0.9879498	0.9947483	0.9999634	1.0000000	3.841E+01	4.685E-01
α_2	3.38E-05	1.21E-02	5.25E-03	4.71E-02	0.00E+00	4.685E-01	3.841E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9571920	0.9849809	0.9890158	0.9989621	1.0000000	7.398E+01	1.128E+00
α_2	3.80E-04	1.13E-02	7.39E-03	3.57E-02	0.00E+00	8.512E-01	7.426E+01
α_3	1.84E-07	3.69E-03	7.89E-04	1.73E-02	0.00E+00	2.768E-01	7.483E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582301	0.9825585	0.9854279	0.9970799	1.0000000	1.067E+02	1.894E+00
α_2	1.00E-03	1.16E-02	8.77E-03	3.19E-02	0.00E+00	1.260E+00	1.073E+02
α_3	4.03E-06	3.71E-03	1.36E-03	1.53E-02	0.00E+00	4.024E-01	1.082E+02
α_4	1.48E-08	2.13E-03	3.18E-04	1.06E-02	0.00E+00	2.315E-01	1.083E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9672200	0.9836774	0.9851839	0.9949847	1.0000000	2.068E+02	3.432E+00
α_2	1.56E-03	9.15E-03	7.65E-03	2.19E-02	0.00E+00	1.924E+00	2.083E+02
α_3	2.89E-04	4.99E-03	3.53E-03	1.47E-02	0.00E+00	1.049E+00	2.092E+02
α_4	1.38E-06	1.82E-03	6.27E-04	7.67E-03	0.00E+00	3.822E-01	2.099E+02
α_5	3.17E-20	3.65E-04	3.40E-07	2.12E-03	0.00E+00	7.674E-02	2.102E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694933	0.9843507	0.9856473	0.9947758	1.0000000	2.412E+02	3.835E+00
α_2	9.95E-04	6.94E-03	5.65E-03	1.73E-02	0.00E+00	1.701E+00	2.434E+02

α_3	3.89E-04	4.93E-03	3.66E-03	1.38E-02	0.00E+00	1.207E+00	2.438E+02
α_4	2.23E-05	2.43E-03	1.28E-03	8.76E-03	0.00E+00	5.960E-01	2.445E+02
α_5	3.53E-09	9.02E-04	1.21E-04	4.53E-03	0.00E+00	2.211E-01	2.448E+02
α_6	3.52E-15	4.48E-04	4.54E-06	2.58E-03	0.00E+00	1.098E-01	2.449E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742614	0.9853960	0.9862084	0.9937495	1.0000000	3.878E+02	5.747E+00
α_2	1.17E-03	5.70E-03	4.89E-03	1.30E-02	0.00E+00	2.243E+00	3.913E+02
α_3	5.56E-04	4.14E-03	3.34E-03	1.05E-02	0.00E+00	1.630E+00	3.919E+02
α_4	1.71E-04	2.75E-03	1.97E-03	8.00E-03	0.00E+00	1.083E+00	3.925E+02
α_5	1.04E-05	1.44E-03	7.25E-04	5.28E-03	0.00E+00	5.654E-01	3.930E+02
α_6	2.67E-10	4.87E-04	4.50E-05	2.54E-03	0.00E+00	1.916E-01	3.934E+02
α_7	6.06E-41	8.84E-05	3.29E-12	3.88E-04	0.00E+00	3.480E-02	3.935E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754657	0.9860944	0.9868721	0.9940574	1.0000000	4.060E+02	5.726E+00
α_2	8.84E-04	4.90E-03	4.13E-03	1.16E-02	0.00E+00	2.018E+00	4.097E+02
α_3	3.49E-04	3.38E-03	2.62E-03	9.01E-03	0.00E+00	1.391E+00	4.104E+02
α_4	1.53E-04	2.58E-03	1.83E-03	7.56E-03	0.00E+00	1.062E+00	4.107E+02
α_5	3.01E-05	1.71E-03	9.97E-04	5.80E-03	0.00E+00	7.026E-01	4.110E+02
α_6	3.33E-07	8.49E-04	2.61E-04	3.69E-03	0.00E+00	3.497E-01	4.114E+02
α_7	1.28E-15	2.62E-04	2.40E-06	1.51E-03	0.00E+00	1.078E-01	4.116E+02
α_8	2.68E-17	2.30E-04	9.74E-07	1.34E-03	0.00E+00	9.469E-02	4.117E+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	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.21E-02	1.13E-02	1.16E-02	9.15E-03	6.94E-03	5.70E-03	4.90E-03
α_3		3.69E-03	3.71E-03	4.99E-03	4.93E-03	4.14E-03	3.38E-03
α_4			2.13E-03	1.82E-03	2.43E-03	2.75E-03	2.58E-03
α_5				3.65E-04	9.02E-04	1.44E-03	1.71E-03
α_6					4.48E-04	4.87E-04	8.49E-04
α_7						8.84E-05	2.62E-04
α_8							2.30E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.21E-02	1.50E-02	1.74E-02	1.63E-02	1.56E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	16.00	16.00	16.00	16.00	16.00	16.00	16.00
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

2.1.10.2 PWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: PWR-RHR-MDP-FH

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

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	0.9293809	0.9818971	0.9920474	0.9999453	1.0000000	2.541E+01	4.685E-01
α_2	5.13E-05	1.81E-02	7.95E-03	7.06E-02	0.00E+00	4.685E-01	2.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483145	0.9818372	0.9866969	0.9987453	1.0000000	6.098E+01	1.128E+00
α_2	4.60E-04	1.37E-02	8.95E-03	4.32E-02	0.00E+00	8.512E-01	6.126E+01
α_3	2.23E-07	4.46E-03	9.56E-04	2.09E-02	0.00E+00	2.768E-01	6.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525994	0.9801860	0.9834318	0.9966772	1.0000000	9.368E+01	1.894E+00
α_2	1.14E-03	1.32E-02	9.97E-03	3.62E-02	0.00E+00	1.260E+00	9.431E+01
α_3	4.58E-06	4.21E-03	1.55E-03	1.74E-02	0.00E+00	4.024E-01	9.517E+01
α_4	1.68E-08	2.42E-03	3.61E-04	1.20E-02	0.00E+00	2.315E-01	9.534E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650736	0.9826018	0.9842043	0.9946508	1.0000000	1.938E+02	3.432E+00
α_2	1.66E-03	9.75E-03	8.15E-03	2.33E-02	0.00E+00	1.924E+00	1.953E+02
α_3	3.08E-04	5.32E-03	3.77E-03	1.56E-02	0.00E+00	1.049E+00	1.962E+02
α_4	1.47E-06	1.94E-03	6.68E-04	8.17E-03	0.00E+00	3.822E-01	1.969E+02
α_5	3.38E-20	3.89E-04	3.63E-07	2.26E-03	0.00E+00	7.674E-02	1.972E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677940	0.9834740	0.9848410	0.9944760	1.0000000	2.282E+02	3.835E+00
α_2	1.05E-03	7.33E-03	5.97E-03	1.83E-02	0.00E+00	1.701E+00	2.304E+02

α_3	4.10E-04	5.20E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.308E+02
α_4	2.35E-05	2.57E-03	1.35E-03	9.25E-03	0.00E+00	5.960E-01	2.315E+02
α_5	3.73E-09	9.53E-04	1.27E-04	4.78E-03	0.00E+00	2.211E-01	2.318E+02
α_6	3.72E-15	4.73E-04	4.79E-06	2.73E-03	0.00E+00	1.098E-01	2.319E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733872	0.9848971	0.9857364	0.9935299	1.0000000	3.748E+02	5.747E+00
α_2	1.21E-03	5.89E-03	5.05E-03	1.35E-02	0.00E+00	2.243E+00	3.783E+02
α_3	5.75E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.789E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.28E-03	0.00E+00	1.083E+00	3.795E+02
α_5	1.07E-05	1.49E-03	7.49E-04	5.46E-03	0.00E+00	5.654E-01	3.800E+02
α_6	2.76E-10	5.03E-04	4.65E-05	2.62E-03	0.00E+00	1.916E-01	3.804E+02
α_7	6.26E-41	9.14E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.805E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746696	0.9856411	0.9864433	0.9938665	1.0000000	3.930E+02	5.726E+00
α_2	9.13E-04	5.06E-03	4.26E-03	1.19E-02	0.00E+00	2.018E+00	3.967E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.30E-03	0.00E+00	1.391E+00	3.974E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.80E-03	0.00E+00	1.062E+00	3.977E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.98E-03	0.00E+00	7.026E-01	3.980E+02
α_6	3.44E-07	8.77E-04	2.69E-04	3.81E-03	0.00E+00	3.497E-01	3.984E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.986E+02
α_8	2.76E-17	2.37E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.987E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.81E-02	1.37E-02	1.32E-02	9.75E-03	7.33E-03	5.89E-03	5.06E-03
α_3		4.46E-03	4.21E-03	5.32E-03	5.20E-03	4.28E-03	3.49E-03
α_4			2.42E-03	1.94E-03	2.57E-03	2.85E-03	2.66E-03
α_5				3.89E-04	9.53E-04	1.49E-03	1.76E-03
α_6					4.73E-04	5.03E-04	8.77E-04
α_7						9.14E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.81E-02	1.82E-02	1.98E-02	1.74E-02	1.65E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	3.00	3.00	3.00	3.00	3.00	3.00	3.00
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

2.1.10.3 PWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: PWR-RHR-MDP-FHRH

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 7.7

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9401582	0.9846793	0.9932995	0.9999536	1.0000000	3.011E+01	4.685E-01
α_2	4.33E-05	1.53E-02	6.70E-03	5.98E-02	0.00E+00	4.685E-01	3.011E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9519189	0.9831150	0.9876374	0.9988361	1.0000000	6.568E+01	1.128E+00
α_2	4.28E-04	1.27E-02	8.31E-03	4.02E-02	0.00E+00	8.512E-01	6.596E+01
α_3	2.07E-07	4.14E-03	8.88E-04	1.94E-02	0.00E+00	2.768E-01	6.653E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9548021	0.9811147	0.9842136	0.9968350	1.0000000	9.838E+01	1.894E+00
α_2	1.09E-03	1.26E-02	9.50E-03	3.45E-02	0.00E+00	1.260E+00	9.901E+01
α_3	4.36E-06	4.01E-03	1.48E-03	1.66E-02	0.00E+00	4.024E-01	9.987E+01
α_4	1.60E-08	2.31E-03	3.44E-04	1.14E-02	0.00E+00	2.315E-01	1.000E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9658813	0.9830067	0.9845731	0.9947766	1.0000000	1.985E+02	3.432E+00
α_2	1.62E-03	9.53E-03	7.96E-03	2.28E-02	0.00E+00	1.924E+00	2.000E+02
α_3	3.01E-04	5.19E-03	3.68E-03	1.53E-02	0.00E+00	1.049E+00	2.009E+02
α_4	1.44E-06	1.89E-03	6.52E-04	7.98E-03	0.00E+00	3.822E-01	2.016E+02
α_5	3.30E-20	3.80E-04	3.54E-07	2.21E-03	0.00E+00	7.674E-02	2.019E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9684298	0.9838021	0.9851427	0.9945909	1.0000000	2.329E+02	3.835E+00

α_2	1.03E-03	7.19E-03	5.85E-03	1.79E-02	0.00E+00	1.701E+00	2.351E+02
α_3	4.02E-04	5.10E-03	3.79E-03	1.43E-02	0.00E+00	1.207E+00	2.355E+02
α_4	2.31E-05	2.52E-03	1.32E-03	9.07E-03	0.00E+00	5.960E-01	2.362E+02
α_5	3.66E-09	9.34E-04	1.25E-04	4.68E-03	0.00E+00	2.211E-01	2.365E+02
α_6	3.65E-15	4.64E-04	4.69E-06	2.67E-03	0.00E+00	1.098E-01	2.366E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9737141	0.9850814	0.9859108	0.9936094	1.0000000	3.795E+02	5.747E+00
α_2	1.19E-03	5.82E-03	4.99E-03	1.33E-02	0.00E+00	2.243E+00	3.830E+02
α_3	5.68E-04	4.23E-03	3.41E-03	1.07E-02	0.00E+00	1.630E+00	3.836E+02
α_4	1.75E-04	2.81E-03	2.01E-03	8.18E-03	0.00E+00	1.083E+00	3.842E+02
α_5	1.06E-05	1.47E-03	7.40E-04	5.39E-03	0.00E+00	5.654E-01	3.847E+02
α_6	2.73E-10	4.97E-04	4.59E-05	2.59E-03	0.00E+00	1.916E-01	3.851E+02
α_7	6.19E-41	9.03E-05	3.36E-12	3.96E-04	0.00E+00	3.480E-02	3.852E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749631	0.9858083	0.9866015	0.9939336	1.0000000	3.977E+02	5.726E+00
α_2	9.02E-04	5.00E-03	4.21E-03	1.18E-02	0.00E+00	2.018E+00	4.014E+02
α_3	3.56E-04	3.45E-03	2.67E-03	9.19E-03	0.00E+00	1.391E+00	4.021E+02
α_4	1.57E-04	2.63E-03	1.87E-03	7.71E-03	0.00E+00	1.062E+00	4.024E+02
α_5	3.07E-05	1.74E-03	1.02E-03	5.91E-03	0.00E+00	7.026E-01	4.027E+02
α_6	3.40E-07	8.67E-04	2.66E-04	3.77E-03	0.00E+00	3.497E-01	4.031E+02
α_7	1.31E-15	2.67E-04	2.45E-06	1.54E-03	0.00E+00	1.078E-01	4.033E+02
α_8	2.73E-17	2.35E-04	9.94E-07	1.37E-03	0.00E+00	9.469E-02	4.034E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.85E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.53E-02	1.27E-02	1.26E-02	9.53E-03	7.19E-03	5.82E-03	5.00E-03
α_3		4.14E-03	4.01E-03	5.19E-03	5.10E-03	4.23E-03	3.45E-03
α_4			2.31E-03	1.89E-03	2.52E-03	2.81E-03	2.63E-03
α_5				3.80E-04	9.34E-04	1.47E-03	1.74E-03
α_6					4.64E-04	4.97E-04	8.67E-04
α_7						9.03E-05	2.67E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.85E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.53E-02	1.69E-02	1.89E-02	1.70E-02	1.62E-02	1.49E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	7.70	7.70	7.70	7.70	7.70	7.70	7.70
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

2.1.10.4 PWR RHR MOTOR-DRIVEN PUMPS FAIL TO RUN >1H: PWR-RHR-MDP-RH

Plants/PWR
Systems/Clean Water/Residual Heat Removal (LCI in BWRs; LPI in PWRs)
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 4.7

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9336996	0.9830129	0.9925539	0.9999486	1.0000000	2.711E+01	4.685E-01
α_2	4.81E-05	1.70E-02	7.45E-03	6.63E-02	0.00E+00	4.685E-01	2.711E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496789	0.9823211	0.9870501	0.9987797	1.0000000	6.268E+01	1.128E+00
α_2	4.48E-04	1.33E-02	8.71E-03	4.20E-02	0.00E+00	8.512E-01	6.296E+01
α_3	2.17E-07	4.34E-03	9.30E-04	2.04E-02	0.00E+00	2.768E-01	6.353E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9534205	0.9805323	0.9837234	0.9967361	1.0000000	9.538E+01	1.894E+00
α_2	1.12E-03	1.30E-02	9.80E-03	3.56E-02	0.00E+00	1.260E+00	9.601E+01
α_3	4.50E-06	4.14E-03	1.52E-03	1.71E-02	0.00E+00	4.024E-01	9.687E+01
α_4	1.65E-08	2.38E-03	3.55E-04	1.18E-02	0.00E+00	2.315E-01	9.704E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9653701	0.9827504	0.9843397	0.9946970	1.0000000	1.955E+02	3.432E+00
α_2	1.65E-03	9.67E-03	8.08E-03	2.31E-02	0.00E+00	1.924E+00	1.970E+02
α_3	3.05E-04	5.27E-03	3.73E-03	1.55E-02	0.00E+00	1.049E+00	1.979E+02
α_4	1.46E-06	1.92E-03	6.62E-04	8.10E-03	0.00E+00	3.822E-01	1.986E+02
α_5	3.35E-20	3.86E-04	3.59E-07	2.24E-03	0.00E+00	7.674E-02	1.989E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680270	0.9835942	0.9849515	0.9945163	1.0000000	2.299E+02	3.835E+00
α_2	1.04E-03	7.28E-03	5.93E-03	1.81E-02	0.00E+00	1.701E+00	2.321E+02

α_3	4.07E-04	5.16E-03	3.84E-03	1.44E-02	0.00E+00	1.207E+00	2.325E+02
α_4	2.34E-05	2.55E-03	1.34E-03	9.19E-03	0.00E+00	5.960E-01	2.332E+02
α_5	3.70E-09	9.46E-04	1.26E-04	4.74E-03	0.00E+00	2.211E-01	2.335E+02
α_6	3.69E-15	4.70E-04	4.76E-06	2.71E-03	0.00E+00	1.098E-01	2.336E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735096	0.9849643	0.9858000	0.9935588	1.0000000	3.765E+02	5.747E+00
α_2	1.20E-03	5.87E-03	5.03E-03	1.34E-02	0.00E+00	2.243E+00	3.800E+02
α_3	5.72E-04	4.26E-03	3.44E-03	1.08E-02	0.00E+00	1.630E+00	3.806E+02
α_4	1.76E-04	2.83E-03	2.03E-03	8.24E-03	0.00E+00	1.083E+00	3.812E+02
α_5	1.07E-05	1.48E-03	7.46E-04	5.43E-03	0.00E+00	5.654E-01	3.817E+02
α_6	2.75E-10	5.01E-04	4.63E-05	2.61E-03	0.00E+00	1.916E-01	3.821E+02
α_7	6.24E-41	9.10E-05	3.39E-12	3.99E-04	0.00E+00	3.480E-02	3.822E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747765	0.9857020	0.9865009	0.9938924	1.0000000	3.947E+02	5.726E+00
α_2	9.09E-04	5.04E-03	4.24E-03	1.19E-02	0.00E+00	2.018E+00	3.984E+02
α_3	3.59E-04	3.47E-03	2.69E-03	9.26E-03	0.00E+00	1.391E+00	3.991E+02
α_4	1.58E-04	2.65E-03	1.88E-03	7.77E-03	0.00E+00	1.062E+00	3.994E+02
α_5	3.10E-05	1.75E-03	1.03E-03	5.96E-03	0.00E+00	7.026E-01	3.997E+02
α_6	3.43E-07	8.73E-04	2.68E-04	3.80E-03	0.00E+00	3.497E-01	4.001E+02
α_7	1.32E-15	2.69E-04	2.47E-06	1.56E-03	0.00E+00	1.078E-01	4.003E+02
α_8	2.75E-17	2.36E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	4.004E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.70E-02	1.33E-02	1.30E-02	9.67E-03	7.28E-03	5.87E-03	5.04E-03
α_3		4.34E-03	4.14E-03	5.27E-03	5.16E-03	4.26E-03	3.47E-03
α_4			2.38E-03	1.92E-03	2.55E-03	2.83E-03	2.65E-03
α_5				3.86E-04	9.46E-04	1.48E-03	1.75E-03
α_6					4.70E-04	5.01E-04	8.73E-04
α_7						9.10E-05	2.69E-04
α_8							2.36E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.70E-02	1.77E-02	1.95E-02	1.72E-02	1.64E-02	1.50E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	4.70	4.70	4.70	4.70	4.70	4.70	4.70
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

2.1.11 Component Cooling Water Pumps

2.1.11.1 CCW MOTOR-DRIVEN PUMPS FAIL TO START: CCW-MDP-FS

Systems/Clean Water/Component cooling water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Start
Date Range: 2006 through 2020

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	0.9698449	0.9923042	0.9966704	0.9999765	1.0000000	6.041E+01	4.685E-01
α_2	2.15E-05	7.70E-03	3.33E-03	3.02E-02	0.00E+00	4.685E-01	6.041E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668371	0.9883835	0.9915256	0.9991985	1.0000000	9.598E+01	1.128E+00
α_2	2.93E-04	8.77E-03	5.70E-03	2.77E-02	0.00E+00	8.512E-01	9.626E+01
α_3	1.42E-07	2.85E-03	6.09E-04	1.34E-02	0.00E+00	2.768E-01	9.683E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9652254	0.9854972	0.9878954	0.9975767	1.0000000	1.287E+02	1.894E+00
α_2	8.33E-04	9.65E-03	7.29E-03	2.65E-02	0.00E+00	1.260E+00	1.293E+02
α_3	3.35E-06	3.08E-03	1.13E-03	1.28E-02	0.00E+00	4.024E-01	1.302E+02
α_4	1.23E-08	1.77E-03	2.64E-04	8.78E-03	0.00E+00	2.315E-01	1.303E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9703077	0.9852234	0.9865958	0.9954633	1.0000000	2.288E+02	3.432E+00
α_2	1.41E-03	8.28E-03	6.92E-03	1.98E-02	0.00E+00	1.924E+00	2.303E+02
α_3	2.61E-04	4.52E-03	3.20E-03	1.33E-02	0.00E+00	1.049E+00	2.312E+02
α_4	1.25E-06	1.65E-03	5.67E-04	6.94E-03	0.00E+00	3.822E-01	2.319E+02
α_5	2.87E-20	3.30E-04	3.08E-07	1.92E-03	0.00E+00	7.674E-02	2.322E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9719897	0.9856399	0.9868372	0.9952091	1.0000000	2.632E+02	3.835E+00
α_2	9.13E-04	6.37E-03	5.19E-03	1.59E-02	0.00E+00	1.701E+00	2.654E+02
α_3	3.56E-04	4.52E-03	3.36E-03	1.26E-02	0.00E+00	1.207E+00	2.658E+02

α_4	2.04E-05	2.23E-03	1.17E-03	8.04E-03	0.00E+00	5.960E-01	2.665E+02
α_5	3.24E-09	8.28E-04	1.11E-04	4.15E-03	0.00E+00	2.211E-01	2.668E+02
α_6	3.23E-15	4.11E-04	4.16E-06	2.37E-03	0.00E+00	1.098E-01	2.669E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9756190	0.9861692	0.9869399	0.9940714	1.0000000	4.098E+02	5.747E+00
α_2	1.10E-03	5.40E-03	4.63E-03	1.23E-02	0.00E+00	2.243E+00	4.133E+02
α_3	5.26E-04	3.92E-03	3.16E-03	9.92E-03	0.00E+00	1.630E+00	4.139E+02
α_4	1.62E-04	2.61E-03	1.86E-03	7.58E-03	0.00E+00	1.083E+00	4.145E+02
α_5	9.83E-06	1.36E-03	6.86E-04	5.00E-03	0.00E+00	5.654E-01	4.150E+02
α_6	2.53E-10	4.61E-04	4.26E-05	2.40E-03	0.00E+00	1.916E-01	4.154E+02
α_7	5.74E-41	8.37E-05	3.11E-12	3.67E-04	0.00E+00	3.480E-02	4.155E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9767059	0.9867997	0.9875438	0.9943600	1.0000000	4.280E+02	5.726E+00
α_2	8.39E-04	4.65E-03	3.92E-03	1.10E-02	0.00E+00	2.018E+00	4.317E+02
α_3	3.31E-04	3.21E-03	2.48E-03	8.55E-03	0.00E+00	1.391E+00	4.324E+02
α_4	1.46E-04	2.45E-03	1.74E-03	7.17E-03	0.00E+00	1.062E+00	4.327E+02
α_5	2.86E-05	1.62E-03	9.46E-04	5.50E-03	0.00E+00	7.026E-01	4.330E+02
α_6	3.17E-07	8.06E-04	2.47E-04	3.51E-03	0.00E+00	3.497E-01	4.334E+02
α_7	1.22E-15	2.49E-04	2.28E-06	1.44E-03	0.00E+00	1.078E-01	4.336E+02
α_8	2.54E-17	2.18E-04	9.25E-07	1.27E-03	0.00E+00	9.469E-02	4.337E+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	9.88E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
α_2	7.70E-03	8.77E-03	9.65E-03	8.28E-03	6.37E-03	5.40E-03	4.65E-03
α_3		2.85E-03	3.08E-03	4.52E-03	4.52E-03	3.92E-03	3.21E-03
α_4			1.77E-03	1.65E-03	2.23E-03	2.61E-03	2.45E-03
α_5				3.30E-04	8.28E-04	1.36E-03	1.62E-03
α_6					4.11E-04	4.61E-04	8.06E-04
α_7						8.37E-05	2.49E-04
α_8							2.18E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
Beta	7.70E-03	1.16E-02	1.45E-02	1.48E-02	1.44E-02	1.38E-02	1.32E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	38.00	38.00	38.00	38.00	38.00	38.00	38.00
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

2.1.11.2 CCW MOTOR-DRIVEN PUMPS FAIL TO RUN: CCW-MDP-FR

Systems/Clean Water/Component cooling water
Components/Pump/Motor-Driven Pump/Centrifugal
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 43.3

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9722517	0.9929205	0.9969402	0.9999783	1.0000000	6.571E+01	4.685E-01
α_2	1.97E-05	7.08E-03	3.06E-03	2.78E-02	0.00E+00	4.685E-01	6.571E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9685444	0.9889847	0.9919667	0.9992402	1.0000000	1.013E+02	1.128E+00
α_2	2.78E-04	8.31E-03	5.41E-03	2.63E-02	0.00E+00	8.512E-01	1.016E+02
α_3	1.35E-07	2.70E-03	5.77E-04	1.27E-02	0.00E+00	2.768E-01	1.021E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9665729	0.9860630	0.9883651	0.9976721	1.0000000	1.340E+02	1.894E+00
α_2	8.00E-04	9.27E-03	7.00E-03	2.55E-02	0.00E+00	1.260E+00	1.346E+02
α_3	3.21E-06	2.96E-03	1.09E-03	1.23E-02	0.00E+00	4.024E-01	1.355E+02
α_4	1.18E-08	1.70E-03	2.54E-04	8.44E-03	0.00E+00	2.315E-01	1.356E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9709619	0.9855531	0.9868956	0.9955652	1.0000000	2.341E+02	3.432E+00
α_2	1.38E-03	8.10E-03	6.77E-03	1.94E-02	0.00E+00	1.924E+00	2.356E+02
α_3	2.56E-04	4.42E-03	3.13E-03	1.30E-02	0.00E+00	1.049E+00	2.365E+02
α_4	1.22E-06	1.61E-03	5.54E-04	6.79E-03	0.00E+00	3.822E-01	2.372E+02
α_5	2.80E-20	3.23E-04	3.01E-07	1.88E-03	0.00E+00	7.674E-02	2.375E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9725361	0.9859194	0.9870939	0.9953029	1.0000000	2.685E+02	3.835E+00
α_2	8.95E-04	6.25E-03	5.09E-03	1.56E-02	0.00E+00	1.701E+00	2.707E+02
α_3	3.49E-04	4.43E-03	3.29E-03	1.24E-02	0.00E+00	1.207E+00	2.711E+02
α_4	2.01E-05	2.19E-03	1.15E-03	7.88E-03	0.00E+00	5.960E-01	2.718E+02

α_5	3.18E-09	8.12E-04	1.09E-04	4.07E-03	0.00E+00	2.211E-01	2.721E+02
α_6	3.17E-15	4.03E-04	4.08E-06	2.32E-03	0.00E+00	1.098E-01	2.722E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9759295	0.9863434	0.9871046	0.9941518	1.0000000	4.151E+02	5.747E+00
α_2	1.09E-03	5.33E-03	4.57E-03	1.22E-02	0.00E+00	2.243E+00	4.186E+02
α_3	5.19E-04	3.87E-03	3.12E-03	9.79E-03	0.00E+00	1.630E+00	4.192E+02
α_4	1.60E-04	2.57E-03	1.84E-03	7.49E-03	0.00E+00	1.083E+00	4.198E+02
α_5	9.71E-06	1.34E-03	6.77E-04	4.94E-03	0.00E+00	5.654E-01	4.203E+02
α_6	2.50E-10	4.55E-04	4.21E-05	2.37E-03	0.00E+00	1.916E-01	4.207E+02
α_7	5.66E-41	8.27E-05	3.08E-12	3.63E-04	0.00E+00	3.480E-02	4.208E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9769841	0.9869591	0.9876943	0.9944282	1.0000000	4.333E+02	5.726E+00
α_2	8.28E-04	4.60E-03	3.87E-03	1.08E-02	0.00E+00	2.018E+00	4.370E+02
α_3	3.27E-04	3.17E-03	2.45E-03	8.45E-03	0.00E+00	1.391E+00	4.377E+02
α_4	1.44E-04	2.42E-03	1.72E-03	7.09E-03	0.00E+00	1.062E+00	4.380E+02
α_5	2.82E-05	1.60E-03	9.35E-04	5.44E-03	0.00E+00	7.026E-01	4.383E+02
α_6	3.13E-07	7.97E-04	2.44E-04	3.46E-03	0.00E+00	3.497E-01	4.387E+02
α_7	1.20E-15	2.46E-04	2.25E-06	1.42E-03	0.00E+00	1.078E-01	4.389E+02
α_8	2.51E-17	2.16E-04	9.14E-07	1.26E-03	0.00E+00	9.469E-02	4.390E+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	9.89E-01	9.86E-01	9.86E-01	9.86E-01	9.86E-01	9.87E-01
α_2	7.08E-03	8.31E-03	9.27E-03	8.10E-03	6.25E-03	5.33E-03	4.60E-03
α_3		2.70E-03	2.96E-03	4.42E-03	4.43E-03	3.87E-03	3.17E-03
α_4			1.70E-03	1.61E-03	2.19E-03	2.57E-03	2.42E-03
α_5				3.23E-04	8.12E-04	1.34E-03	1.60E-03
α_6					4.03E-04	4.55E-04	7.97E-04
α_7						8.27E-05	2.46E-04
α_8							2.16E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.93E-01	9.89E-01	9.86E-01	9.86E-01	9.86E-01	9.86E-01	9.87E-01
Beta	7.08E-03	1.10E-02	1.39E-02	1.44E-02	1.41E-02	1.37E-02	1.30E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	43.30	43.30	43.30	43.30	43.30	43.30	43.30
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

2.1.12 Positive Displacement Pumps

2.1.12.1 POSITIVE DISPLACEMENT PUMPS FAIL TO START: ALL-PDP-FS

Components/Pump/Motor-Driven Pump/Positive Displacement
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 76.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9814107	0.9952617	0.9979596	0.9999854	1.0000000	9.841E+01	4.685E-01
α_2	1.32E-05	4.74E-03	2.04E-03	1.86E-02	0.00E+00	4.685E-01	9.841E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9761218	0.9916508	0.9939173	0.9994248	1.0000000	1.340E+02	1.128E+00
α_2	2.10E-04	6.30E-03	4.09E-03	1.99E-02	0.00E+00	8.512E-01	1.343E+02
α_3	1.02E-07	2.05E-03	4.37E-04	9.61E-03	0.00E+00	2.768E-01	1.348E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9730251	0.9887665	0.9906352	0.9981231	1.0000000	1.667E+02	1.894E+00
α_2	6.44E-04	7.47E-03	5.64E-03	2.06E-02	0.00E+00	1.260E+00	1.673E+02
α_3	2.59E-06	2.39E-03	8.75E-04	9.89E-03	0.00E+00	4.024E-01	1.682E+02
α_4	9.51E-09	1.37E-03	2.04E-04	6.80E-03	0.00E+00	2.315E-01	1.683E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744584	0.9873010	0.9884843	0.9961014	1.0000000	2.668E+02	3.432E+00
α_2	1.21E-03	7.12E-03	5.95E-03	1.70E-02	0.00E+00	1.924E+00	2.683E+02
α_3	2.24E-04	3.88E-03	2.75E-03	1.14E-02	0.00E+00	1.049E+00	2.692E+02
α_4	1.07E-06	1.41E-03	4.87E-04	5.97E-03	0.00E+00	3.822E-01	2.699E+02
α_5	2.46E-20	2.84E-04	2.64E-07	1.65E-03	0.00E+00	7.674E-02	2.702E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754631	0.9874287	0.9884797	0.9958100	1.0000000	3.012E+02	3.835E+00
α_2	7.99E-04	5.58E-03	4.54E-03	1.39E-02	0.00E+00	1.701E+00	3.034E+02
α_3	3.12E-04	3.96E-03	2.94E-03	1.11E-02	0.00E+00	1.207E+00	3.038E+02
α_4	1.79E-05	1.95E-03	1.03E-03	7.04E-03	0.00E+00	5.960E-01	3.045E+02

α_5	2.84E-09	7.25E-04	9.69E-05	3.64E-03	0.00E+00	2.211E-01	3.048E+02
α_6	2.83E-15	3.60E-04	3.64E-06	2.08E-03	0.00E+00	1.098E-01	3.049E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9776574	0.9873280	0.9880400	0.9945756	1.0000000	4.478E+02	5.747E+00
α_2	1.01E-03	4.95E-03	4.24E-03	1.13E-02	0.00E+00	2.243E+00	4.513E+02
α_3	4.82E-04	3.59E-03	2.89E-03	9.09E-03	0.00E+00	1.630E+00	4.519E+02
α_4	1.49E-04	2.39E-03	1.71E-03	6.95E-03	0.00E+00	1.083E+00	4.525E+02
α_5	9.01E-06	1.25E-03	6.29E-04	4.58E-03	0.00E+00	5.654E-01	4.530E+02
α_6	2.32E-10	4.22E-04	3.90E-05	2.20E-03	0.00E+00	1.916E-01	4.534E+02
α_7	5.25E-41	7.67E-05	2.85E-12	3.36E-04	0.00E+00	3.480E-02	4.535E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9785747	0.9878630	0.9885478	0.9948206	1.0000000	4.660E+02	5.726E+00
α_2	7.71E-04	4.28E-03	3.60E-03	1.01E-02	0.00E+00	2.018E+00	4.697E+02
α_3	3.04E-04	2.95E-03	2.28E-03	7.87E-03	0.00E+00	1.391E+00	4.704E+02
α_4	1.34E-04	2.25E-03	1.60E-03	6.60E-03	0.00E+00	1.062E+00	4.707E+02
α_5	2.63E-05	1.49E-03	8.70E-04	5.06E-03	0.00E+00	7.026E-01	4.710E+02
α_6	2.91E-07	7.41E-04	2.28E-04	3.22E-03	0.00E+00	3.497E-01	4.714E+02
α_7	1.12E-15	2.29E-04	2.10E-06	1.32E-03	0.00E+00	1.078E-01	4.716E+02
α_8	2.34E-17	2.01E-04	8.50E-07	1.17E-03	0.00E+00	9.469E-02	4.717E+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	9.89E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
α_2	4.74E-03	6.30E-03	7.47E-03	7.12E-03	5.58E-03	4.95E-03	4.28E-03
α_3		2.05E-03	2.39E-03	3.88E-03	3.96E-03	3.59E-03	2.95E-03
α_4			1.37E-03	1.41E-03	1.95E-03	2.39E-03	2.25E-03
α_5				2.84E-04	7.25E-04	1.25E-03	1.49E-03
α_6					3.60E-04	4.22E-04	7.41E-04
α_7						7.67E-05	2.29E-04
α_8							2.01E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.92E-01	9.89E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
Beta	4.74E-03	8.35E-03	1.12E-02	1.27E-02	1.26E-02	1.27E-02	1.21E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	76.00	76.00	76.00	76.00	76.00	76.00	76.00
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

2.1.12.2 POSITIVE DISPLACEMENT PUMPS FAIL TO RUN: ALL-PDP-FR

Components/Pump/Motor-Driven Pump/Positive Displacement
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 75.2

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9610479	0.9870601	0.9910663	0.9993771	0.9903784	7.388E+01	9.685E-01
α_2	6.20E-04	1.29E-02	8.93E-03	3.89E-02	9.62E-03	9.685E-01	7.388E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582691	0.9807197	0.9830229	0.9953062	0.9805699	1.337E+02	2.628E+00
α_2	3.74E-03	1.72E-02	1.49E-02	3.86E-02	1.94E-02	2.351E+00	1.340E+02
α_3	1.01E-07	2.03E-03	4.33E-04	9.53E-03	0.00E+00	2.768E-01	1.360E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9637142	0.9817372	0.9833572	0.9942218	0.9837204	1.914E+02	3.560E+00
α_2	2.40E-03	1.16E-02	9.97E-03	2.63E-02	9.77E-03	2.260E+00	1.927E+02
α_3	3.32E-04	5.48E-03	3.91E-03	1.60E-02	6.51E-03	1.069E+00	1.939E+02
α_4	8.22E-09	1.19E-03	1.77E-04	5.88E-03	0.00E+00	2.315E-01	1.947E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706517	0.9836944	0.9846840	0.9933489	0.9857682	3.165E+02	5.247E+00
α_2	2.02E-03	8.25E-03	7.26E-03	1.79E-02	5.74E-03	2.656E+00	3.191E+02
α_3	8.99E-04	5.68E-03	4.69E-03	1.38E-02	6.10E-03	1.827E+00	3.200E+02
α_4	3.49E-05	2.14E-03	1.23E-03	7.31E-03	2.40E-03	6.878E-01	3.211E+02
α_5	2.07E-20	2.38E-04	2.22E-07	1.38E-03	0.00E+00	7.674E-02	3.217E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733757	0.9848746	0.9857114	0.9935048	0.9873012	3.759E+02	5.773E+00
α_2	1.23E-03	5.95E-03	5.11E-03	1.35E-02	3.73E-03	2.271E+00	3.794E+02
α_3	8.59E-04	5.05E-03	4.22E-03	1.21E-02	4.72E-03	1.928E+00	3.798E+02
α_4	1.86E-04	2.88E-03	2.08E-03	8.34E-03	3.31E-03	1.101E+00	3.806E+02
α_5	5.15E-07	9.55E-04	3.10E-04	4.10E-03	9.40E-04	3.646E-01	3.813E+02

α_6	2.26E-15	2.88E-04	2.91E-06	1.66E-03	0.00E+00	1.098E-01	3.816E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9769093	0.9859812	0.9865585	0.9930750	0.9885389	5.475E+02	7.784E+00
α_2	1.21E-03	4.86E-03	4.28E-03	1.05E-02	2.57E-03	2.701E+00	5.526E+02
α_3	8.37E-04	4.07E-03	3.49E-03	9.27E-03	3.54E-03	2.258E+00	5.530E+02
α_4	4.12E-04	2.99E-03	2.42E-03	7.52E-03	3.24E-03	1.660E+00	5.536E+02
α_5	5.56E-05	1.57E-03	1.03E-03	4.93E-03	1.72E-03	8.709E-01	5.544E+02
α_6	1.23E-08	4.69E-04	8.88E-05	2.24E-03	3.86E-04	2.603E-01	5.550E+02
α_7	4.29E-41	6.27E-05	2.33E-12	2.75E-04	0.00E+00	3.480E-02	5.552E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9784600	0.9869031	0.9874398	0.9935137	0.9895778	5.907E+02	7.839E+00
α_2	8.74E-04	3.99E-03	3.45E-03	8.95E-03	1.83E-03	2.390E+00	5.962E+02
α_3	5.49E-04	3.23E-03	2.69E-03	7.73E-03	2.66E-03	1.931E+00	5.966E+02
α_4	3.68E-04	2.73E-03	2.20E-03	6.91E-03	2.83E-03	1.635E+00	5.969E+02
α_5	1.25E-04	1.87E-03	1.35E-03	5.38E-03	2.05E-03	1.119E+00	5.974E+02
α_6	4.62E-06	8.83E-04	4.22E-04	3.32E-03	8.82E-04	5.286E-01	5.980E+02
α_7	6.34E-13	2.36E-04	7.74E-06	1.31E-03	1.64E-04	1.411E-01	5.984E+02
α_8	1.84E-17	1.58E-04	6.70E-07	9.21E-04	0.00E+00	9.469E-02	5.985E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.76E-01	9.78E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01
α_2	1.67E-02	2.11E-02	1.40E-02	9.49E-03	6.85E-03	5.44E-03	4.49E-03
α_3		2.49E-03	6.62E-03	6.53E-03	5.82E-03	4.55E-03	3.63E-03
α_4			1.43E-03	2.46E-03	3.32E-03	3.34E-03	3.08E-03
α_5				2.74E-04	1.10E-03	1.75E-03	2.11E-03
α_6					3.31E-04	5.24E-04	9.94E-04
α_7						7.01E-05	2.65E-04
α_8							1.78E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.76E-01	9.78E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01
Beta	1.67E-02	2.36E-02	2.20E-02	1.87E-02	1.74E-02	1.57E-02	1.47E-02
Gamma		1.05E-01	3.65E-01	4.94E-01	6.07E-01	6.53E-01	6.95E-01
Delta			1.78E-01	2.95E-01	4.50E-01	5.56E-01	6.46E-01
Epsilon				1.00E-01	3.01E-01	4.13E-01	5.35E-01
Mu					2.31E-01	2.53E-01	4.06E-01
Omega						1.18E-01	3.09E-01
Sigma							4.02E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	33.40	50.10	66.80	83.50	100.20	116.90	133.60
N_1	1.3333	0.5000	0.4444	0.3704	0.2963	0.2305	0.1756
N_2	0.5000	1.5000	1.0000	0.7315	0.5694	0.4576	0.3714
N_3		0.0000	0.6667	0.7778	0.7207	0.6286	0.5403
N_4			0.0000	0.3056	0.5046	0.5766	0.5731
N_5				0.0000	0.1435	0.3056	0.4168
N_6					0.0000	0.0687	0.1789
N_7						0.0000	0.0333
N_8							0.0000

2.2 Turbine-Driven Pumps

2.2.1 Pooled Turbine-Driven Pumps

2.2.1.1 TURBINE-DRIVEN PUMPS FAIL TO START: ALL-TDP-FS

Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 145.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9890496	0.9972108	0.9987981	0.9999931	1.0000000	1.675E+02	4.685E-01
α_2	7.72E-06	2.79E-03	1.20E-03	1.10E-02	0.00E+00	4.685E-01	1.675E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9841832	0.9944760	0.9959859	0.9996199	1.0000000	2.031E+02	1.128E+00
α_2	1.39E-04	4.17E-03	2.70E-03	1.32E-02	0.00E+00	8.512E-01	2.034E+02
α_3	6.73E-08	1.36E-03	2.89E-04	6.36E-03	0.00E+00	2.768E-01	2.039E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9808361	0.9920326	0.9933615	0.9986752	1.0000000	2.358E+02	1.894E+00
α_2	4.56E-04	5.30E-03	3.99E-03	1.46E-02	0.00E+00	1.260E+00	2.364E+02
α_3	1.83E-06	1.69E-03	6.20E-04	7.02E-03	0.00E+00	4.024E-01	2.373E+02
α_4	6.74E-09	9.74E-04	1.45E-04	4.82E-03	0.00E+00	2.315E-01	2.374E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9796448	0.9898867	0.9908297	0.9969038	1.0000000	3.359E+02	3.432E+00
α_2	9.62E-04	5.67E-03	4.73E-03	1.36E-02	0.00E+00	1.924E+00	3.374E+02
α_3	1.79E-04	3.09E-03	2.19E-03	9.09E-03	0.00E+00	1.049E+00	3.383E+02
α_4	8.55E-07	1.13E-03	3.88E-04	4.75E-03	0.00E+00	3.822E-01	3.390E+02
α_5	1.96E-20	2.26E-04	2.10E-07	1.31E-03	0.00E+00	7.674E-02	3.393E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9799780	0.9897504	0.9906073	0.9965885	1.0000000	3.703E+02	3.835E+00
α_2	6.51E-04	4.55E-03	3.70E-03	1.13E-02	0.00E+00	1.701E+00	3.725E+02

α_3	2.54E-04	3.23E-03	2.40E-03	9.03E-03	0.00E+00	1.207E+00	3.729E+02
α_4	1.46E-05	1.59E-03	8.35E-04	5.74E-03	0.00E+00	5.960E-01	3.736E+02
α_5	2.31E-09	5.91E-04	7.90E-05	2.96E-03	0.00E+00	2.211E-01	3.739E+02
α_6	2.31E-15	2.93E-04	2.97E-06	1.69E-03	0.00E+00	1.098E-01	3.740E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9805976	0.9890034	0.9896229	0.9952957	1.0000000	5.169E+02	5.747E+00
α_2	8.77E-04	4.29E-03	3.68E-03	9.80E-03	0.00E+00	2.243E+00	5.204E+02
α_3	4.18E-04	3.12E-03	2.51E-03	7.89E-03	0.00E+00	1.630E+00	5.210E+02
α_4	1.29E-04	2.07E-03	1.48E-03	6.03E-03	0.00E+00	1.083E+00	5.216E+02
α_5	7.81E-06	1.08E-03	5.45E-04	3.97E-03	0.00E+00	5.654E-01	5.221E+02
α_6	2.01E-10	3.67E-04	3.39E-05	1.91E-03	0.00E+00	1.916E-01	5.225E+02
α_7	4.56E-41	6.66E-05	2.48E-12	2.92E-04	0.00E+00	3.480E-02	5.226E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9813067	0.9894137	0.9900126	0.9954801	1.0000000	5.351E+02	5.726E+00
α_2	6.72E-04	3.73E-03	3.14E-03	8.81E-03	0.00E+00	2.018E+00	5.388E+02
α_3	2.65E-04	2.57E-03	1.99E-03	6.86E-03	0.00E+00	1.391E+00	5.395E+02
α_4	1.17E-04	1.96E-03	1.39E-03	5.75E-03	0.00E+00	1.062E+00	5.398E+02
α_5	2.29E-05	1.30E-03	7.59E-04	4.41E-03	0.00E+00	7.026E-01	5.401E+02
α_6	2.54E-07	6.47E-04	1.98E-04	2.81E-03	0.00E+00	3.497E-01	5.405E+02
α_7	9.75E-16	1.99E-04	1.83E-06	1.15E-03	0.00E+00	1.078E-01	5.407E+02
α_8	2.04E-17	1.75E-04	7.41E-07	1.02E-03	0.00E+00	9.469E-02	5.408E+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	9.92E-01	9.90E-01	9.90E-01	9.89E-01	9.89E-01
α_2	2.79E-03	4.17E-03	5.30E-03	5.67E-03	4.55E-03	4.29E-03	3.73E-03
α_3		1.36E-03	1.69E-03	3.09E-03	3.23E-03	3.12E-03	2.57E-03
α_4			9.74E-04	1.13E-03	1.59E-03	2.07E-03	1.96E-03
α_5				2.26E-04	5.91E-04	1.08E-03	1.30E-03
α_6					2.93E-04	3.67E-04	6.47E-04
α_7						6.66E-05	1.99E-04
α_8							1.75E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.97E-01	9.94E-01	9.92E-01	9.90E-01	9.90E-01	9.89E-01	9.89E-01
Beta	2.79E-03	5.52E-03	7.97E-03	1.01E-02	1.02E-02	1.10E-02	1.06E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	145.10	145.10	145.10	145.10	145.10	145.10	145.10
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

2.2.1.2 TURBINE-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: ALL-TDP-FH

Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 41.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712562	0.9926656	0.9968287	0.9999776	1.0000000	6.341E+01	4.685E-01
α_2	2.04E-05	7.33E-03	3.17E-03	2.87E-02	0.00E+00	4.685E-01	6.341E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678256	0.9887317	0.9917811	0.9992227	1.0000000	9.898E+01	1.128E+00
α_2	2.84E-04	8.50E-03	5.53E-03	2.69E-02	0.00E+00	8.512E-01	9.926E+01
α_3	1.38E-07	2.77E-03	5.91E-04	1.30E-02	0.00E+00	2.768E-01	9.983E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9660012	0.9858230	0.9881637	0.9976316	1.0000000	1.317E+02	1.894E+00
α_2	8.14E-04	9.43E-03	7.12E-03	2.59E-02	0.00E+00	1.260E+00	1.323E+02
α_3	3.27E-06	3.01E-03	1.11E-03	1.25E-02	0.00E+00	4.024E-01	1.332E+02
α_4	1.20E-08	1.73E-03	2.58E-04	8.58E-03	0.00E+00	2.315E-01	1.333E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706792	0.9854119	0.9867671	0.9955215	1.0000000	2.318E+02	3.432E+00
α_2	1.39E-03	8.18E-03	6.83E-03	1.96E-02	0.00E+00	1.924E+00	2.333E+02
α_3	2.58E-04	4.46E-03	3.16E-03	1.31E-02	0.00E+00	1.049E+00	2.342E+02
α_4	1.23E-06	1.62E-03	5.60E-04	6.85E-03	0.00E+00	3.822E-01	2.349E+02
α_5	2.83E-20	3.26E-04	3.04E-07	1.89E-03	0.00E+00	7.674E-02	2.352E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9723043	0.9857994	0.9869838	0.9952626	1.0000000	2.662E+02	3.835E+00
α_2	9.03E-04	6.30E-03	5.13E-03	1.57E-02	0.00E+00	1.701E+00	2.684E+02
α_3	3.52E-04	4.47E-03	3.32E-03	1.25E-02	0.00E+00	1.207E+00	2.688E+02
α_4	2.02E-05	2.21E-03	1.16E-03	7.95E-03	0.00E+00	5.960E-01	2.695E+02
α_5	3.20E-09	8.19E-04	1.09E-04	4.11E-03	0.00E+00	2.211E-01	2.698E+02

α_6	3.20E-15	4.07E-04	4.11E-06	2.34E-03	0.00E+00	1.098E-01	2.699E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757932	0.9862683	0.9870336	0.9941254	1.0000000	4.128E+02	5.747E+00
α_2	1.10E-03	5.36E-03	4.59E-03	1.22E-02	0.00E+00	2.243E+00	4.163E+02
α_3	5.22E-04	3.89E-03	3.14E-03	9.85E-03	0.00E+00	1.630E+00	4.169E+02
α_4	1.61E-04	2.59E-03	1.85E-03	7.53E-03	0.00E+00	1.083E+00	4.175E+02
α_5	9.76E-06	1.35E-03	6.81E-04	4.96E-03	0.00E+00	5.654E-01	4.180E+02
α_6	2.51E-10	4.58E-04	4.23E-05	2.39E-03	0.00E+00	1.916E-01	4.184E+02
α_7	5.69E-41	8.31E-05	3.09E-12	3.65E-04	0.00E+00	3.480E-02	4.185E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9768659	0.9868904	0.9876294	0.9943988	1.0000000	4.310E+02	5.726E+00
α_2	8.33E-04	4.62E-03	3.89E-03	1.09E-02	0.00E+00	2.018E+00	4.347E+02
α_3	3.29E-04	3.18E-03	2.47E-03	8.49E-03	0.00E+00	1.391E+00	4.354E+02
α_4	1.45E-04	2.43E-03	1.73E-03	7.12E-03	0.00E+00	1.062E+00	4.357E+02
α_5	2.84E-05	1.61E-03	9.40E-04	5.46E-03	0.00E+00	7.026E-01	4.360E+02
α_6	3.14E-07	8.01E-04	2.46E-04	3.48E-03	0.00E+00	3.497E-01	4.364E+02
α_7	1.21E-15	2.47E-04	2.27E-06	1.43E-03	0.00E+00	1.078E-01	4.366E+02
α_8	2.52E-17	2.17E-04	9.18E-07	1.26E-03	0.00E+00	9.469E-02	4.367E+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	9.89E-01	9.86E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
α_2	7.33E-03	8.50E-03	9.43E-03	8.18E-03	6.30E-03	5.36E-03	4.62E-03
α_3		2.77E-03	3.01E-03	4.46E-03	4.47E-03	3.89E-03	3.18E-03
α_4			1.73E-03	1.62E-03	2.21E-03	2.59E-03	2.43E-03
α_5				3.26E-04	8.19E-04	1.35E-03	1.61E-03
α_6					4.07E-04	4.58E-04	8.01E-04
α_7						8.31E-05	2.47E-04
α_8							2.17E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.93E-01	9.89E-01	9.86E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
Beta	7.33E-03	1.13E-02	1.42E-02	1.46E-02	1.42E-02	1.37E-02	1.31E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	41.00	41.00	41.00	41.00	41.00	41.00	41.00
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

2.2.1.3 TURBINE-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR ALL SYSTEMS: ALL-TDP-FHRH

Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run <1H
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 58.9

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9775332	0.9942710	0.9975293	0.9999824	1.0000000	8.131E+01	4.685E-01
α_2	1.59E-05	5.73E-03	2.47E-03	2.25E-02	0.00E+00	4.685E-01	8.131E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9726827	0.9904409	0.9930304	0.9993411	1.0000000	1.169E+02	1.128E+00
α_2	2.41E-04	7.21E-03	4.69E-03	2.28E-02	0.00E+00	8.512E-01	1.172E+02
α_3	1.17E-07	2.35E-03	5.01E-04	1.10E-02	0.00E+00	2.768E-01	1.177E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9699975	0.9874984	0.9895694	0.9979090	1.0000000	1.496E+02	1.894E+00
α_2	7.17E-04	8.32E-03	6.28E-03	2.29E-02	0.00E+00	1.260E+00	1.502E+02
α_3	2.88E-06	2.66E-03	9.74E-04	1.10E-02	0.00E+00	4.024E-01	1.511E+02
α_4	1.06E-08	1.53E-03	2.27E-04	7.57E-03	0.00E+00	2.315E-01	1.512E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9727431	0.9864433	0.9877049	0.9958355	1.0000000	2.497E+02	3.432E+00
α_2	1.29E-03	7.60E-03	6.35E-03	1.82E-02	0.00E+00	1.924E+00	2.512E+02
α_3	2.40E-04	4.14E-03	2.93E-03	1.22E-02	0.00E+00	1.049E+00	2.521E+02
α_4	1.15E-06	1.51E-03	5.20E-04	6.37E-03	0.00E+00	3.822E-01	2.528E+02
α_5	2.63E-20	3.03E-04	2.82E-07	1.76E-03	0.00E+00	7.674E-02	2.531E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740125	0.9866822	0.9877945	0.9955550	1.0000000	2.841E+02	3.835E+00
α_2	8.46E-04	5.91E-03	4.81E-03	1.47E-02	0.00E+00	1.701E+00	2.863E+02
α_3	3.30E-04	4.19E-03	3.11E-03	1.17E-02	0.00E+00	1.207E+00	2.867E+02

α_4	1.90E-05	2.07E-03	1.09E-03	7.46E-03	0.00E+00	5.960E-01	2.874E+02
α_5	3.01E-09	7.68E-04	1.03E-04	3.85E-03	0.00E+00	2.211E-01	2.877E+02
α_6	3.00E-15	3.81E-04	3.86E-06	2.20E-03	0.00E+00	1.098E-01	2.878E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9767863	0.9868315	0.9875710	0.9943623	1.0000000	4.307E+02	5.747E+00
α_2	1.05E-03	5.14E-03	4.41E-03	1.17E-02	0.00E+00	2.243E+00	4.342E+02
α_3	5.01E-04	3.73E-03	3.01E-03	9.45E-03	0.00E+00	1.630E+00	4.348E+02
α_4	1.54E-04	2.48E-03	1.78E-03	7.22E-03	0.00E+00	1.083E+00	4.354E+02
α_5	9.36E-06	1.30E-03	6.53E-04	4.76E-03	0.00E+00	5.654E-01	4.359E+02
α_6	2.41E-10	4.39E-04	4.05E-05	2.29E-03	0.00E+00	1.916E-01	4.363E+02
α_7	5.46E-41	7.97E-05	2.97E-12	3.50E-04	0.00E+00	3.480E-02	4.364E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9777761	0.9874065	0.9881168	0.9946203	1.0000000	4.489E+02	5.726E+00
α_2	8.00E-04	4.44E-03	3.74E-03	1.05E-02	0.00E+00	2.018E+00	4.526E+02
α_3	3.16E-04	3.06E-03	2.37E-03	8.16E-03	0.00E+00	1.391E+00	4.533E+02
α_4	1.39E-04	2.34E-03	1.66E-03	6.84E-03	0.00E+00	1.062E+00	4.536E+02
α_5	2.73E-05	1.55E-03	9.03E-04	5.25E-03	0.00E+00	7.026E-01	4.539E+02
α_6	3.02E-07	7.69E-04	2.36E-04	3.35E-03	0.00E+00	3.497E-01	4.543E+02
α_7	1.16E-15	2.37E-04	2.18E-06	1.37E-03	0.00E+00	1.078E-01	4.545E+02
α_8	2.42E-17	2.08E-04	8.82E-07	1.21E-03	0.00E+00	9.469E-02	4.546E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
α_2	5.73E-03	7.21E-03	8.32E-03	7.60E-03	5.91E-03	5.14E-03	4.44E-03
α_3		2.35E-03	2.66E-03	4.14E-03	4.19E-03	3.73E-03	3.06E-03
α_4			1.53E-03	1.51E-03	2.07E-03	2.48E-03	2.34E-03
α_5				3.03E-04	7.68E-04	1.30E-03	1.55E-03
α_6					3.81E-04	4.39E-04	7.69E-04
α_7						7.97E-05	2.37E-04
α_8							2.08E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
Beta	5.73E-03	9.56E-03	1.25E-02	1.36E-02	1.33E-02	1.32E-02	1.26E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	58.90	58.90	58.90	58.90	58.90	58.90	58.90
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

2.2.1.4 TURBINE-DRIVEN PUMPS FAIL TO RUN >1H: ALL-TDP-RH

Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 17.9

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9550489	0.9885112	0.9949973	0.9999651	1.0000000	4.031E+01	4.685E-01
α_2	3.22E-05	1.15E-02	5.00E-03	4.49E-02	0.00E+00	4.685E-01	4.031E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582406	0.9853515	0.9892892	0.9989879	1.0000000	7.588E+01	1.128E+00
α_2	3.70E-04	1.11E-02	7.20E-03	3.49E-02	0.00E+00	8.512E-01	7.616E+01
α_3	1.80E-07	3.59E-03	7.69E-04	1.69E-02	0.00E+00	2.768E-01	7.673E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9589429	0.9828585	0.9856800	0.9971307	1.0000000	1.086E+02	1.894E+00
α_2	9.86E-04	1.14E-02	8.62E-03	3.13E-02	0.00E+00	1.260E+00	1.092E+02
α_3	3.96E-06	3.64E-03	1.34E-03	1.51E-02	0.00E+00	4.024E-01	1.101E+02
α_4	1.45E-08	2.10E-03	3.12E-04	1.04E-02	0.00E+00	2.315E-01	1.102E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9675119	0.9838236	0.9853170	0.9950300	1.0000000	2.087E+02	3.432E+00
α_2	1.54E-03	9.07E-03	7.58E-03	2.17E-02	0.00E+00	1.924E+00	2.102E+02
α_3	2.86E-04	4.94E-03	3.50E-03	1.45E-02	0.00E+00	1.049E+00	2.111E+02
α_4	1.37E-06	1.80E-03	6.21E-04	7.60E-03	0.00E+00	3.822E-01	2.118E+02
α_5	3.14E-20	3.62E-04	3.37E-07	2.10E-03	0.00E+00	7.674E-02	2.121E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9697267	0.9844711	0.9857581	0.9948163	1.0000000	2.431E+02	3.835E+00
α_2	9.87E-04	6.89E-03	5.61E-03	1.72E-02	0.00E+00	1.701E+00	2.453E+02
α_3	3.86E-04	4.89E-03	3.63E-03	1.37E-02	0.00E+00	1.207E+00	2.457E+02
α_4	2.21E-05	2.41E-03	1.27E-03	8.70E-03	0.00E+00	5.960E-01	2.464E+02
α_5	3.51E-09	8.95E-04	1.20E-04	4.49E-03	0.00E+00	2.211E-01	2.467E+02

α_6	3.50E-15	4.45E-04	4.50E-06	2.56E-03	0.00E+00	1.098E-01	2.468E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743893	0.9854662	0.9862748	0.9937795	1.0000000	3.897E+02	5.747E+00
α_2	1.16E-03	5.67E-03	4.86E-03	1.29E-02	0.00E+00	2.243E+00	3.932E+02
α_3	5.53E-04	4.12E-03	3.32E-03	1.04E-02	0.00E+00	1.630E+00	3.938E+02
α_4	1.70E-04	2.74E-03	1.96E-03	7.97E-03	0.00E+00	1.083E+00	3.944E+02
α_5	1.03E-05	1.43E-03	7.21E-04	5.25E-03	0.00E+00	5.654E-01	3.949E+02
α_6	2.66E-10	4.84E-04	4.48E-05	2.52E-03	0.00E+00	1.916E-01	3.953E+02
α_7	6.03E-41	8.80E-05	3.27E-12	3.86E-04	0.00E+00	3.480E-02	3.954E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9755780	0.9861583	0.9869325	0.9940887	1.0000000	4.079E+02	5.726E+00
α_2	8.80E-04	4.88E-03	4.11E-03	1.15E-02	0.00E+00	2.018E+00	4.116E+02
α_3	3.47E-04	3.36E-03	2.60E-03	8.97E-03	0.00E+00	1.391E+00	4.123E+02
α_4	1.53E-04	2.57E-03	1.82E-03	7.52E-03	0.00E+00	1.062E+00	4.126E+02
α_5	3.00E-05	1.70E-03	9.92E-04	5.77E-03	0.00E+00	7.026E-01	4.129E+02
α_6	3.32E-07	8.46E-04	2.60E-04	3.68E-03	0.00E+00	3.497E-01	4.133E+02
α_7	1.27E-15	2.61E-04	2.39E-06	1.51E-03	0.00E+00	1.078E-01	4.135E+02
α_8	2.66E-17	2.29E-04	9.70E-07	1.33E-03	0.00E+00	9.469E-02	4.136E+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	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.15E-02	1.11E-02	1.14E-02	9.07E-03	6.89E-03	5.67E-03	4.88E-03
α_3		3.59E-03	3.64E-03	4.94E-03	4.89E-03	4.12E-03	3.36E-03
α_4			2.10E-03	1.80E-03	2.41E-03	2.74E-03	2.57E-03
α_5				3.62E-04	8.95E-04	1.43E-03	1.70E-03
α_6					4.45E-04	4.84E-04	8.46E-04
α_7						8.80E-05	2.61E-04
α_8							2.29E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.15E-02	1.46E-02	1.71E-02	1.62E-02	1.55E-02	1.45E-02	1.38E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	17.90	17.90	17.90	17.90	17.90	17.90	17.90
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

2.2.1.5 TURBINE-DRIVEN PUMPS FAIL TO RUN NORMAL RUNNING ALL SYSTEMS: ALL-TDP-FR-NR

Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 76.9

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9815781	0.9953044	0.9979781	0.9999855	1.0000000	9.931E+01	4.685E-01
α_2	1.30E-05	4.70E-03	2.02E-03	1.84E-02	0.00E+00	4.685E-01	9.931E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9762792	0.9917060	0.9939577	0.9994286	1.0000000	1.349E+02	1.128E+00
α_2	2.09E-04	6.26E-03	4.06E-03	1.98E-02	0.00E+00	8.512E-01	1.352E+02
α_3	1.01E-07	2.04E-03	4.34E-04	9.55E-03	0.00E+00	2.768E-01	1.357E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9731676	0.9888262	0.9906801	0.9981332	1.0000000	1.676E+02	1.894E+00
α_2	6.40E-04	7.43E-03	5.61E-03	2.05E-02	0.00E+00	1.260E+00	1.682E+02
α_3	2.57E-06	2.37E-03	8.71E-04	9.84E-03	0.00E+00	4.024E-01	1.691E+02
α_4	9.46E-09	1.37E-03	2.03E-04	6.76E-03	0.00E+00	2.315E-01	1.692E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9745427	0.9873432	0.9885226	0.9961145	1.0000000	2.677E+02	3.432E+00
α_2	1.21E-03	7.10E-03	5.93E-03	1.70E-02	0.00E+00	1.924E+00	2.692E+02
α_3	2.24E-04	3.87E-03	2.74E-03	1.14E-02	0.00E+00	1.049E+00	2.701E+02
α_4	1.07E-06	1.41E-03	4.86E-04	5.95E-03	0.00E+00	3.822E-01	2.708E+02
α_5	2.46E-20	2.83E-04	2.64E-07	1.64E-03	0.00E+00	7.674E-02	2.711E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9755351	0.9874657	0.9885137	0.9958222	1.0000000	3.021E+02	3.835E+00
α_2	7.96E-04	5.56E-03	4.53E-03	1.39E-02	0.00E+00	1.701E+00	3.043E+02
α_3	3.11E-04	3.95E-03	2.93E-03	1.10E-02	0.00E+00	1.207E+00	3.047E+02
α_4	1.78E-05	1.95E-03	1.02E-03	7.02E-03	0.00E+00	5.960E-01	3.054E+02

α_5	2.83E-09	7.23E-04	9.66E-05	3.62E-03	0.00E+00	2.211E-01	3.057E+02
α_6	2.82E-15	3.59E-04	3.63E-06	2.07E-03	0.00E+00	1.098E-01	3.058E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9776969	0.9873531	0.9880637	0.9945864	1.0000000	4.487E+02	5.747E+00
α_2	1.01E-03	4.94E-03	4.23E-03	1.13E-02	0.00E+00	2.243E+00	4.522E+02
α_3	4.81E-04	3.59E-03	2.89E-03	9.07E-03	0.00E+00	1.630E+00	4.528E+02
α_4	1.48E-04	2.38E-03	1.70E-03	6.93E-03	0.00E+00	1.083E+00	4.534E+02
α_5	8.99E-06	1.24E-03	6.27E-04	4.57E-03	0.00E+00	5.654E-01	4.539E+02
α_6	2.31E-10	4.22E-04	3.89E-05	2.20E-03	0.00E+00	1.916E-01	4.543E+02
α_7	5.24E-41	7.66E-05	2.85E-12	3.36E-04	0.00E+00	3.480E-02	4.544E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9786153	0.9878861	0.9885696	0.9948303	1.0000000	4.669E+02	5.726E+00
α_2	7.69E-04	4.27E-03	3.59E-03	1.01E-02	0.00E+00	2.018E+00	4.706E+02
α_3	3.04E-04	2.94E-03	2.28E-03	7.85E-03	0.00E+00	1.391E+00	4.713E+02
α_4	1.34E-04	2.25E-03	1.60E-03	6.58E-03	0.00E+00	1.062E+00	4.716E+02
α_5	2.62E-05	1.49E-03	8.68E-04	5.05E-03	0.00E+00	7.026E-01	4.719E+02
α_6	2.90E-07	7.40E-04	2.27E-04	3.22E-03	0.00E+00	3.497E-01	4.723E+02
α_7	1.12E-15	2.28E-04	2.09E-06	1.32E-03	0.00E+00	1.078E-01	4.725E+02
α_8	2.33E-17	2.00E-04	8.49E-07	1.17E-03	0.00E+00	9.469E-02	4.726E+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	9.89E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
α_2	4.70E-03	6.26E-03	7.43E-03	7.10E-03	5.56E-03	4.94E-03	4.27E-03
α_3		2.04E-03	2.37E-03	3.87E-03	3.95E-03	3.59E-03	2.94E-03
α_4			1.37E-03	1.41E-03	1.95E-03	2.38E-03	2.25E-03
α_5				2.83E-04	7.23E-04	1.24E-03	1.49E-03
α_6					3.59E-04	4.22E-04	7.40E-04
α_7						7.66E-05	2.28E-04
α_8							2.00E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.92E-01	9.89E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
Beta	4.70E-03	8.29E-03	1.12E-02	1.27E-02	1.25E-02	1.26E-02	1.21E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	76.90	76.90	76.90	76.90	76.90	76.90	76.90
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

2.2.2 Auxiliary Feedwater Turbine-Driven Pumps

2.2.2.1 AFW TURBINE-DRIVEN PUMPS FAIL TO START: AFW-TDP-FS

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 60.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9778572	0.9943538	0.9975654	0.9999827	1.0000000	8.251E+01	4.685E-01
α_2	1.57E-05	5.65E-03	2.44E-03	2.21E-02	0.00E+00	4.685E-01	8.251E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9729563	0.9905371	0.9931011	0.9993478	1.0000000	1.181E+02	1.128E+00
α_2	2.38E-04	7.14E-03	4.64E-03	2.26E-02	0.00E+00	8.512E-01	1.184E+02
α_3	1.16E-07	2.32E-03	4.96E-04	1.09E-02	0.00E+00	2.768E-01	1.189E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9702273	0.9875966	0.9896518	0.9979256	1.0000000	1.508E+02	1.894E+00
α_2	7.11E-04	8.25E-03	6.23E-03	2.27E-02	0.00E+00	1.260E+00	1.514E+02
α_3	2.86E-06	2.64E-03	9.67E-04	1.09E-02	0.00E+00	4.024E-01	1.523E+02
α_4	1.05E-08	1.52E-03	2.26E-04	7.51E-03	0.00E+00	2.315E-01	1.524E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728747	0.9865072	0.9877630	0.9958553	1.0000000	2.509E+02	3.432E+00
α_2	1.29E-03	7.56E-03	6.32E-03	1.81E-02	0.00E+00	1.924E+00	2.524E+02
α_3	2.39E-04	4.12E-03	2.92E-03	1.21E-02	0.00E+00	1.049E+00	2.533E+02
α_4	1.14E-06	1.50E-03	5.18E-04	6.34E-03	0.00E+00	3.822E-01	2.540E+02
α_5	2.62E-20	3.02E-04	2.81E-07	1.75E-03	0.00E+00	7.674E-02	2.543E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741198	0.9867375	0.9878452	0.9955736	1.0000000	2.853E+02	3.835E+00
α_2	8.43E-04	5.88E-03	4.79E-03	1.47E-02	0.00E+00	1.701E+00	2.875E+02
α_3	3.29E-04	4.17E-03	3.10E-03	1.17E-02	0.00E+00	1.207E+00	2.879E+02

α_4	1.89E-05	2.06E-03	1.08E-03	7.43E-03	0.00E+00	5.960E-01	2.886E+02
α_5	2.99E-09	7.65E-04	1.02E-04	3.84E-03	0.00E+00	2.211E-01	2.889E+02
α_6	2.99E-15	3.80E-04	3.84E-06	2.19E-03	0.00E+00	1.098E-01	2.890E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9768451	0.9868676	0.9876051	0.9943778	1.0000000	4.319E+02	5.747E+00
α_2	1.05E-03	5.13E-03	4.39E-03	1.17E-02	0.00E+00	2.243E+00	4.354E+02
α_3	4.99E-04	3.72E-03	3.00E-03	9.42E-03	0.00E+00	1.630E+00	4.360E+02
α_4	1.54E-04	2.47E-03	1.77E-03	7.20E-03	0.00E+00	1.083E+00	4.366E+02
α_5	9.34E-06	1.29E-03	6.51E-04	4.75E-03	0.00E+00	5.654E-01	4.371E+02
α_6	2.40E-10	4.38E-04	4.04E-05	2.28E-03	0.00E+00	1.916E-01	4.375E+02
α_7	5.45E-41	7.95E-05	2.96E-12	3.49E-04	0.00E+00	3.480E-02	4.376E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9778316	0.9874397	0.9881481	0.9946345	1.0000000	4.501E+02	5.726E+00
α_2	7.98E-04	4.43E-03	3.73E-03	1.05E-02	0.00E+00	2.018E+00	4.538E+02
α_3	3.15E-04	3.05E-03	2.36E-03	8.14E-03	0.00E+00	1.391E+00	4.545E+02
α_4	1.39E-04	2.33E-03	1.66E-03	6.83E-03	0.00E+00	1.062E+00	4.548E+02
α_5	2.72E-05	1.54E-03	9.00E-04	5.24E-03	0.00E+00	7.026E-01	4.551E+02
α_6	3.01E-07	7.67E-04	2.35E-04	3.34E-03	0.00E+00	3.497E-01	4.555E+02
α_7	1.16E-15	2.37E-04	2.17E-06	1.37E-03	0.00E+00	1.078E-01	4.557E+02
α_8	2.42E-17	2.08E-04	8.80E-07	1.21E-03	0.00E+00	9.469E-02	4.558E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.91E-01	9.88E-01	9.87E-01	9.87E-01	9.87E-01	9.87E-01
α_2	5.65E-03	7.14E-03	8.25E-03	7.56E-03	5.88E-03	5.13E-03	4.43E-03
α_3		2.32E-03	2.64E-03	4.12E-03	4.17E-03	3.72E-03	3.05E-03
α_4			1.52E-03	1.50E-03	2.06E-03	2.47E-03	2.33E-03
α_5				3.02E-04	7.65E-04	1.29E-03	1.54E-03
α_6					3.80E-04	4.38E-04	7.67E-04
α_7						7.95E-05	2.37E-04
α_8							2.08E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.91E-01	9.88E-01	9.87E-01	9.87E-01	9.87E-01	9.87E-01
Beta	5.65E-03	9.46E-03	1.24E-02	1.35E-02	1.33E-02	1.31E-02	1.26E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	60.10	60.10	60.10	60.10	60.10	60.10	60.10
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

2.2.2.2 AFW TURBINE-DRIVEN PUMPS FAIL TO RUN LESS THAN 1H: AFW-TDP-FH

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run <1H
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 22.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9595847	0.9896758	0.9955157	0.9999686	1.0000000	4.491E+01	4.685E-01
α_2	2.89E-05	1.03E-02	4.49E-03	4.04E-02	0.00E+00	4.685E-01	4.491E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9605819	0.9861772	0.9898980	0.9990453	1.0000000	8.048E+01	1.128E+00
α_2	3.49E-04	1.04E-02	6.79E-03	3.29E-02	0.00E+00	8.512E-01	8.076E+01
α_3	1.69E-07	3.39E-03	7.26E-04	1.59E-02	0.00E+00	2.768E-01	8.133E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9605720	0.9835437	0.9862557	0.9972467	1.0000000	1.132E+02	1.894E+00
α_2	9.46E-04	1.09E-02	8.27E-03	3.01E-02	0.00E+00	1.260E+00	1.138E+02
α_3	3.80E-06	3.50E-03	1.28E-03	1.45E-02	0.00E+00	4.024E-01	1.147E+02
α_4	1.40E-08	2.01E-03	3.00E-04	9.96E-03	0.00E+00	2.315E-01	1.148E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9681973	0.9841669	0.9856345	0.9951364	1.0000000	2.133E+02	3.432E+00
α_2	1.51E-03	8.88E-03	7.42E-03	2.12E-02	0.00E+00	1.924E+00	2.148E+02
α_3	2.80E-04	4.84E-03	3.43E-03	1.42E-02	0.00E+00	1.049E+00	2.157E+02
α_4	1.34E-06	1.76E-03	6.08E-04	7.44E-03	0.00E+00	3.822E-01	2.164E+02
α_5	3.07E-20	3.54E-04	3.30E-07	2.06E-03	0.00E+00	7.674E-02	2.167E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9702773	0.9847551	0.9860192	0.9949118	1.0000000	2.477E+02	3.835E+00
α_2	9.69E-04	6.76E-03	5.51E-03	1.68E-02	0.00E+00	1.701E+00	2.499E+02
α_3	3.79E-04	4.80E-03	3.57E-03	1.34E-02	0.00E+00	1.207E+00	2.503E+02

α_4	2.17E-05	2.37E-03	1.24E-03	8.54E-03	0.00E+00	5.960E-01	2.510E+02
α_5	3.44E-09	8.79E-04	1.18E-04	4.41E-03	0.00E+00	2.211E-01	2.513E+02
α_6	3.43E-15	4.36E-04	4.42E-06	2.52E-03	0.00E+00	1.098E-01	2.514E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746786	0.9856333	0.9864329	0.9938509	1.0000000	3.943E+02	5.747E+00
α_2	1.15E-03	5.61E-03	4.81E-03	1.28E-02	0.00E+00	2.243E+00	3.978E+02
α_3	5.46E-04	4.07E-03	3.28E-03	1.03E-02	0.00E+00	1.630E+00	3.984E+02
α_4	1.68E-04	2.71E-03	1.94E-03	7.87E-03	0.00E+00	1.083E+00	3.990E+02
α_5	1.02E-05	1.41E-03	7.13E-04	5.19E-03	0.00E+00	5.654E-01	3.995E+02
α_6	2.63E-10	4.79E-04	4.42E-05	2.50E-03	0.00E+00	1.916E-01	3.999E+02
α_7	5.96E-41	8.70E-05	3.24E-12	3.82E-04	0.00E+00	3.480E-02	4.000E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9758506	0.9863105	0.9870765	0.9941494	1.0000000	4.125E+02	5.726E+00
α_2	8.70E-04	4.83E-03	4.06E-03	1.14E-02	0.00E+00	2.018E+00	4.162E+02
α_3	3.43E-04	3.32E-03	2.57E-03	8.87E-03	0.00E+00	1.391E+00	4.169E+02
α_4	1.51E-04	2.54E-03	1.80E-03	7.44E-03	0.00E+00	1.062E+00	4.172E+02
α_5	2.96E-05	1.68E-03	9.81E-04	5.71E-03	0.00E+00	7.026E-01	4.175E+02
α_6	3.28E-07	8.36E-04	2.57E-04	3.64E-03	0.00E+00	3.497E-01	4.179E+02
α_7	1.26E-15	2.58E-04	2.37E-06	1.49E-03	0.00E+00	1.078E-01	4.181E+02
α_8	2.63E-17	2.26E-04	9.59E-07	1.32E-03	0.00E+00	9.469E-02	4.182E+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	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.03E-02	1.04E-02	1.09E-02	8.88E-03	6.76E-03	5.61E-03	4.83E-03
α_3		3.39E-03	3.50E-03	4.84E-03	4.80E-03	4.07E-03	3.32E-03
α_4			2.01E-03	1.76E-03	2.37E-03	2.71E-03	2.54E-03
α_5				3.54E-04	8.79E-04	1.41E-03	1.68E-03
α_6					4.36E-04	4.79E-04	8.36E-04
α_7						8.70E-05	2.58E-04
α_8							2.26E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.03E-02	1.38E-02	1.65E-02	1.58E-02	1.52E-02	1.44E-02	1.37E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	22.50	22.50	22.50	22.50	22.50	22.50	22.50
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

2.2.2.3 AFW TURBINE-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: AFW-TDP-FHRH

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: 2006 through 2020

Total Number of Independent Failure Events: 33.3

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9673263	0.9916604	0.9963878	0.9999746	1.0000000	5.571E+01	4.685E-01
α_2	2.33E-05	8.34E-03	3.61E-03	3.27E-02	0.00E+00	4.685E-01	5.571E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9651555	0.9877927	0.9910918	0.9991575	1.0000000	9.128E+01	1.128E+00
α_2	3.08E-04	9.21E-03	5.99E-03	2.91E-02	0.00E+00	8.512E-01	9.156E+01
α_3	1.49E-07	3.00E-03	6.40E-04	1.41E-02	0.00E+00	2.768E-01	9.213E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9639360	0.9849557	0.9874411	0.9974853	1.0000000	1.240E+02	1.894E+00
α_2	8.64E-04	1.00E-02	7.56E-03	2.75E-02	0.00E+00	1.260E+00	1.246E+02
α_3	3.47E-06	3.20E-03	1.17E-03	1.32E-02	0.00E+00	4.024E-01	1.255E+02
α_4	1.28E-08	1.84E-03	2.74E-04	9.11E-03	0.00E+00	2.315E-01	1.256E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696981	0.9849183	0.9863182	0.9953690	1.0000000	2.241E+02	3.432E+00
α_2	1.44E-03	8.46E-03	7.06E-03	2.02E-02	0.00E+00	1.924E+00	2.256E+02
α_3	2.67E-04	4.61E-03	3.26E-03	1.35E-02	0.00E+00	1.049E+00	2.265E+02
α_4	1.28E-06	1.68E-03	5.79E-04	7.09E-03	0.00E+00	3.822E-01	2.272E+02
α_5	2.93E-20	3.37E-04	3.14E-07	1.96E-03	0.00E+00	7.674E-02	2.275E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9714898	0.9853827	0.9866009	0.9951228	1.0000000	2.585E+02	3.835E+00
α_2	9.29E-04	6.48E-03	5.28E-03	1.62E-02	0.00E+00	1.701E+00	2.607E+02

α_3	3.63E-04	4.60E-03	3.42E-03	1.29E-02	0.00E+00	1.207E+00	2.611E+02
α_4	2.08E-05	2.27E-03	1.19E-03	8.19E-03	0.00E+00	5.960E-01	2.618E+02
α_5	3.30E-09	8.43E-04	1.13E-04	4.23E-03	0.00E+00	2.211E-01	2.621E+02
α_6	3.29E-15	4.18E-04	4.24E-06	2.41E-03	0.00E+00	1.098E-01	2.622E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753410	0.9860110	0.9867902	0.9940140	1.0000000	4.051E+02	5.747E+00
α_2	1.12E-03	5.46E-03	4.68E-03	1.25E-02	0.00E+00	2.243E+00	4.086E+02
α_3	5.32E-04	3.97E-03	3.20E-03	1.00E-02	0.00E+00	1.630E+00	4.092E+02
α_4	1.64E-04	2.64E-03	1.89E-03	7.67E-03	0.00E+00	1.083E+00	4.098E+02
α_5	9.95E-06	1.38E-03	6.94E-04	5.06E-03	0.00E+00	5.654E-01	4.103E+02
α_6	2.56E-10	4.66E-04	4.31E-05	2.43E-03	0.00E+00	1.916E-01	4.107E+02
α_7	5.80E-41	8.47E-05	3.15E-12	3.72E-04	0.00E+00	3.480E-02	4.108E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9764513	0.9866551	0.9874072	0.9942982	1.0000000	4.233E+02	5.726E+00
α_2	8.48E-04	4.70E-03	3.96E-03	1.11E-02	0.00E+00	2.018E+00	4.270E+02
α_3	3.35E-04	3.24E-03	2.51E-03	8.65E-03	0.00E+00	1.391E+00	4.277E+02
α_4	1.47E-04	2.48E-03	1.76E-03	7.25E-03	0.00E+00	1.062E+00	4.280E+02
α_5	2.89E-05	1.64E-03	9.57E-04	5.56E-03	0.00E+00	7.026E-01	4.283E+02
α_6	3.20E-07	8.15E-04	2.50E-04	3.54E-03	0.00E+00	3.497E-01	4.287E+02
α_7	1.23E-15	2.51E-04	2.31E-06	1.45E-03	0.00E+00	1.078E-01	4.289E+02
α_8	2.57E-17	2.21E-04	9.35E-07	1.29E-03	0.00E+00	9.469E-02	4.290E+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	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	8.34E-03	9.21E-03	1.00E-02	8.46E-03	6.48E-03	5.46E-03	4.70E-03
α_3		3.00E-03	3.20E-03	4.61E-03	4.60E-03	3.97E-03	3.24E-03
α_4			1.84E-03	1.68E-03	2.27E-03	2.64E-03	2.48E-03
α_5				3.37E-04	8.43E-04	1.38E-03	1.64E-03
α_6					4.18E-04	4.66E-04	8.15E-04
α_7						8.47E-05	2.51E-04
α_8							2.21E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	8.34E-03	1.22E-02	1.50E-02	1.51E-02	1.46E-02	1.40E-02	1.33E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	33.30	33.30	33.30	33.30	33.30	33.30	33.30
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

2.2.2.4 AFW TURBINE-DRIVEN PUMPS FAIL TO RUN >1H: AFW-TDP-RH

Systems/Clean Water/Auxiliary feedwater
Components/Pump/Turbine-Driven Pump
Failure Modes/Fail to Run > 1H (Standby equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 10.8

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9456316	0.9860894	0.9939278	0.9999579	1.0000000	3.321E+01	4.685E-01
α_2	3.92E-05	1.39E-02	6.07E-03	5.44E-02	0.00E+00	4.685E-01	3.321E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9540335	0.9838637	0.9881909	0.9988892	1.0000000	6.878E+01	1.128E+00
α_2	4.08E-04	1.22E-02	7.94E-03	3.84E-02	0.00E+00	8.512E-01	6.906E+01
α_3	1.98E-07	3.96E-03	8.48E-04	1.86E-02	0.00E+00	2.768E-01	6.963E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9561463	0.9816811	0.9846901	0.9969311	1.0000000	1.015E+02	1.894E+00
α_2	1.05E-03	1.22E-02	9.21E-03	3.35E-02	0.00E+00	1.260E+00	1.021E+02
α_3	4.23E-06	3.89E-03	1.43E-03	1.61E-02	0.00E+00	4.024E-01	1.030E+02
α_4	1.55E-08	2.24E-03	3.34E-04	1.11E-02	0.00E+00	2.315E-01	1.031E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9663939	0.9832635	0.9848070	0.9948563	1.0000000	2.016E+02	3.432E+00
α_2	1.60E-03	9.38E-03	7.84E-03	2.24E-02	0.00E+00	1.924E+00	2.031E+02
α_3	2.96E-04	5.12E-03	3.62E-03	1.50E-02	0.00E+00	1.049E+00	2.040E+02
α_4	1.42E-06	1.86E-03	6.42E-04	7.86E-03	0.00E+00	3.822E-01	2.047E+02
α_5	3.25E-20	3.74E-04	3.49E-07	2.17E-03	0.00E+00	7.674E-02	2.050E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9688356	0.9840115	0.9853353	0.9946615	1.0000000	2.360E+02	3.835E+00
α_2	1.02E-03	7.09E-03	5.78E-03	1.77E-02	0.00E+00	1.701E+00	2.382E+02
α_3	3.97E-04	5.03E-03	3.74E-03	1.41E-02	0.00E+00	1.207E+00	2.386E+02
α_4	2.28E-05	2.48E-03	1.30E-03	8.95E-03	0.00E+00	5.960E-01	2.393E+02

α_5	3.61E-09	9.22E-04	1.23E-04	4.62E-03	0.00E+00	2.211E-01	2.396E+02
α_6	3.60E-15	4.58E-04	4.63E-06	2.64E-03	0.00E+00	1.098E-01	2.397E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9739190	0.9852005	0.9860234	0.9936608	1.0000000	3.826E+02	5.747E+00
α_2	1.18E-03	5.78E-03	4.95E-03	1.32E-02	0.00E+00	2.243E+00	3.861E+02
α_3	5.63E-04	4.20E-03	3.38E-03	1.06E-02	0.00E+00	1.630E+00	3.867E+02
α_4	1.74E-04	2.79E-03	2.00E-03	8.11E-03	0.00E+00	1.083E+00	3.873E+02
α_5	1.05E-05	1.46E-03	7.34E-04	5.35E-03	0.00E+00	5.654E-01	3.878E+02
α_6	2.71E-10	4.93E-04	4.56E-05	2.57E-03	0.00E+00	1.916E-01	3.882E+02
α_7	6.14E-41	8.96E-05	3.33E-12	3.93E-04	0.00E+00	3.480E-02	3.883E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751531	0.9859166	0.9867039	0.9939809	1.0000000	4.008E+02	5.726E+00
α_2	8.95E-04	4.96E-03	4.18E-03	1.17E-02	0.00E+00	2.018E+00	4.045E+02
α_3	3.53E-04	3.42E-03	2.65E-03	9.12E-03	0.00E+00	1.391E+00	4.052E+02
α_4	1.55E-04	2.61E-03	1.86E-03	7.65E-03	0.00E+00	1.062E+00	4.055E+02
α_5	3.05E-05	1.73E-03	1.01E-03	5.87E-03	0.00E+00	7.026E-01	4.058E+02
α_6	3.38E-07	8.60E-04	2.64E-04	3.74E-03	0.00E+00	3.497E-01	4.062E+02
α_7	1.30E-15	2.65E-04	2.43E-06	1.53E-03	0.00E+00	1.078E-01	4.064E+02
α_8	2.71E-17	2.33E-04	9.87E-07	1.36E-03	0.00E+00	9.469E-02	4.065E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.39E-02	1.22E-02	1.22E-02	9.38E-03	7.09E-03	5.78E-03	4.96E-03
α_3		3.96E-03	3.89E-03	5.12E-03	5.03E-03	4.20E-03	3.42E-03
α_4			2.24E-03	1.86E-03	2.48E-03	2.79E-03	2.61E-03
α_5				3.74E-04	9.22E-04	1.46E-03	1.73E-03
α_6					4.58E-04	4.93E-04	8.60E-04
α_7						8.96E-05	2.65E-04
α_8							2.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.39E-02	1.61E-02	1.83E-02	1.67E-02	1.60E-02	1.48E-02	1.41E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	10.80	10.80	10.80	10.80	10.80	10.80	10.80
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

2.2.3 High Pressure Coolant Injection and Reactor Core Isolation Cooling Turbine-Driven Pumps

2.2.3.1 COMBINED HPCI AND RCIC TURBINE-DRIVEN PUMPS FAIL TO START: HCI-RCI-TDP-FS

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: 2006 through 2020

Total Number of Independent Failure Events: 81.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9823039	0.9954898	0.9980584	0.9999861	1.0000000	1.034E+02	4.685E-01
α_2	1.25E-05	4.51E-03	1.94E-03	1.77E-02	0.00E+00	4.685E-01	1.034E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9769745	0.9919487	0.9941401	0.9994454	1.0000000	1.390E+02	1.128E+00
α_2	2.02E-04	6.08E-03	3.94E-03	1.92E-02	0.00E+00	8.512E-01	1.393E+02
α_3	9.83E-08	1.98E-03	4.21E-04	9.27E-03	0.00E+00	2.768E-01	1.398E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9737982	0.9890901	0.9909020	0.9981777	1.0000000	1.717E+02	1.894E+00
α_2	6.25E-04	7.26E-03	5.47E-03	2.00E-02	0.00E+00	1.260E+00	1.723E+02
α_3	2.51E-06	2.32E-03	8.50E-04	9.61E-03	0.00E+00	4.024E-01	1.732E+02
α_4	9.24E-09	1.33E-03	1.98E-04	6.60E-03	0.00E+00	2.315E-01	1.733E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749203	0.9875317	0.9886939	0.9961729	1.0000000	2.718E+02	3.432E+00
α_2	1.19E-03	6.99E-03	5.84E-03	1.67E-02	0.00E+00	1.924E+00	2.733E+02
α_3	2.20E-04	3.81E-03	2.70E-03	1.12E-02	0.00E+00	1.049E+00	2.742E+02
α_4	1.05E-06	1.39E-03	4.78E-04	5.86E-03	0.00E+00	3.822E-01	2.749E+02
α_5	2.42E-20	2.79E-04	2.60E-07	1.62E-03	0.00E+00	7.674E-02	2.752E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9758618	0.9876314	0.9886658	0.9958733	1.0000000	3.062E+02	3.835E+00
α_2	7.86E-04	5.49E-03	4.47E-03	1.37E-02	0.00E+00	1.701E+00	3.084E+02
α_3	3.07E-04	3.89E-03	2.89E-03	1.09E-02	0.00E+00	1.207E+00	3.088E+02
α_4	1.76E-05	1.92E-03	1.01E-03	6.93E-03	0.00E+00	5.960E-01	3.095E+02
α_5	2.79E-09	7.13E-04	9.53E-05	3.58E-03	0.00E+00	2.211E-01	3.098E+02
α_6	2.78E-15	3.54E-04	3.58E-06	2.04E-03	0.00E+00	1.098E-01	3.099E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9778961	0.9874662	0.9881705	0.9946352	1.0000000	4.528E+02	5.747E+00
α_2	1.00E-03	4.89E-03	4.19E-03	1.12E-02	0.00E+00	2.243E+00	4.563E+02
α_3	4.77E-04	3.55E-03	2.86E-03	8.99E-03	0.00E+00	1.630E+00	4.569E+02
α_4	1.47E-04	2.36E-03	1.69E-03	6.87E-03	0.00E+00	1.083E+00	4.575E+02
α_5	8.91E-06	1.23E-03	6.22E-04	4.53E-03	0.00E+00	5.654E-01	4.580E+02
α_6	2.29E-10	4.18E-04	3.86E-05	2.18E-03	0.00E+00	1.916E-01	4.584E+02
α_7	5.20E-41	7.59E-05	2.82E-12	3.33E-04	0.00E+00	3.480E-02	4.585E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9787981	0.9879903	0.9886679	0.9948704	1.0000000	4.710E+02	5.726E+00
α_2	7.63E-04	4.23E-03	3.56E-03	9.99E-03	0.00E+00	2.018E+00	4.747E+02
α_3	3.01E-04	2.92E-03	2.26E-03	7.78E-03	0.00E+00	1.391E+00	4.754E+02
α_4	1.32E-04	2.23E-03	1.58E-03	6.53E-03	0.00E+00	1.062E+00	4.757E+02
α_5	2.60E-05	1.47E-03	8.61E-04	5.01E-03	0.00E+00	7.026E-01	4.760E+02
α_6	2.88E-07	7.34E-04	2.25E-04	3.19E-03	0.00E+00	3.497E-01	4.764E+02
α_7	1.11E-15	2.26E-04	2.08E-06	1.31E-03	0.00E+00	1.078E-01	4.766E+02
α_8	2.31E-17	1.99E-04	8.41E-07	1.16E-03	0.00E+00	9.469E-02	4.767E+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	9.89E-01	9.88E-01	9.88E-01	9.87E-01	9.88E-01
α_2	4.51E-03	6.08E-03	7.26E-03	6.99E-03	5.49E-03	4.89E-03	4.23E-03
α_3		1.98E-03	2.32E-03	3.81E-03	3.89E-03	3.55E-03	2.92E-03
α_4			1.33E-03	1.39E-03	1.92E-03	2.36E-03	2.23E-03
α_5				2.79E-04	7.13E-04	1.23E-03	1.47E-03
α_6					3.54E-04	4.18E-04	7.34E-04
α_7						7.59E-05	2.26E-04
α_8							1.99E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.92E-01	9.89E-01	9.88E-01	9.88E-01	9.87E-01	9.88E-01
Beta	4.51E-03	8.05E-03	1.09E-02	1.25E-02	1.24E-02	1.25E-02	1.20E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	81.00	81.00	81.00	81.00	81.00	81.00	81.00
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

2.2.3.2 COMBINED HPCI AND RCIC TURBINE-DRIVEN PUMPS FTR LESS THAN 1H: HCI-RCI-TDP-FH

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: 2006 through 2020

Total Number of Independent Failure Events: 18.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9556974	0.9886778	0.9950711	0.9999656	1.0000000	4.091E+01	4.685E-01
α_2	3.18E-05	1.13E-02	4.93E-03	4.43E-02	0.00E+00	4.685E-01	4.091E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9585611	0.9854647	0.9893728	0.9989957	1.0000000	7.648E+01	1.128E+00
α_2	3.67E-04	1.10E-02	7.15E-03	3.46E-02	0.00E+00	8.512E-01	7.676E+01
α_3	1.78E-07	3.57E-03	7.63E-04	1.67E-02	0.00E+00	2.768E-01	7.733E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9591630	0.9829511	0.9857578	0.9971464	1.0000000	1.092E+02	1.894E+00
α_2	9.80E-04	1.13E-02	8.57E-03	3.12E-02	0.00E+00	1.260E+00	1.098E+02
α_3	3.94E-06	3.62E-03	1.33E-03	1.50E-02	0.00E+00	4.024E-01	1.107E+02
α_4	1.45E-08	2.08E-03	3.11E-04	1.03E-02	0.00E+00	2.315E-01	1.108E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676029	0.9838692	0.9853586	0.9950442	1.0000000	2.093E+02	3.432E+00
α_2	1.54E-03	9.04E-03	7.56E-03	2.16E-02	0.00E+00	1.924E+00	2.108E+02
α_3	2.85E-04	4.93E-03	3.49E-03	1.45E-02	0.00E+00	1.049E+00	2.117E+02
α_4	1.37E-06	1.80E-03	6.19E-04	7.58E-03	0.00E+00	3.822E-01	2.124E+02
α_5	3.13E-20	3.61E-04	3.36E-07	2.10E-03	0.00E+00	7.674E-02	2.127E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9697997	0.9845088	0.9857927	0.9948290	1.0000000	2.437E+02	3.835E+00
α_2	9.85E-04	6.87E-03	5.60E-03	1.71E-02	0.00E+00	1.701E+00	2.459E+02

α_3	3.85E-04	4.88E-03	3.62E-03	1.36E-02	0.00E+00	1.207E+00	2.463E+02
α_4	2.21E-05	2.41E-03	1.26E-03	8.67E-03	0.00E+00	5.960E-01	2.470E+02
α_5	3.50E-09	8.93E-04	1.19E-04	4.48E-03	0.00E+00	2.211E-01	2.473E+02
α_6	3.49E-15	4.43E-04	4.49E-06	2.56E-03	0.00E+00	1.098E-01	2.474E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744282	0.9854882	0.9862956	0.9937890	1.0000000	3.903E+02	5.747E+00
α_2	1.16E-03	5.66E-03	4.86E-03	1.29E-02	0.00E+00	2.243E+00	3.938E+02
α_3	5.52E-04	4.11E-03	3.32E-03	1.04E-02	0.00E+00	1.630E+00	3.944E+02
α_4	1.70E-04	2.73E-03	1.96E-03	7.95E-03	0.00E+00	1.083E+00	3.950E+02
α_5	1.03E-05	1.43E-03	7.20E-04	5.24E-03	0.00E+00	5.654E-01	3.955E+02
α_6	2.66E-10	4.84E-04	4.47E-05	2.52E-03	0.00E+00	1.916E-01	3.959E+02
α_7	6.02E-41	8.79E-05	3.27E-12	3.85E-04	0.00E+00	3.480E-02	3.960E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9756133	0.9861783	0.9869514	0.9940933	1.0000000	4.085E+02	5.726E+00
α_2	8.78E-04	4.87E-03	4.10E-03	1.15E-02	0.00E+00	2.018E+00	4.122E+02
α_3	3.47E-04	3.36E-03	2.60E-03	8.96E-03	0.00E+00	1.391E+00	4.129E+02
α_4	1.53E-04	2.56E-03	1.82E-03	7.51E-03	0.00E+00	1.062E+00	4.132E+02
α_5	2.99E-05	1.70E-03	9.91E-04	5.76E-03	0.00E+00	7.026E-01	4.135E+02
α_6	3.31E-07	8.44E-04	2.59E-04	3.67E-03	0.00E+00	3.497E-01	4.139E+02
α_7	1.27E-15	2.60E-04	2.39E-06	1.50E-03	0.00E+00	1.078E-01	4.141E+02
α_8	2.66E-17	2.29E-04	9.68E-07	1.33E-03	0.00E+00	9.469E-02	4.142E+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	9.85E-01	9.83E-01	9.84E-01	9.85E-01	9.85E-01	9.86E-01
α_2	1.13E-02	1.10E-02	1.13E-02	9.04E-03	6.87E-03	5.66E-03	4.87E-03
α_3		3.57E-03	3.62E-03	4.93E-03	4.88E-03	4.11E-03	3.36E-03
α_4			2.08E-03	1.80E-03	2.41E-03	2.73E-03	2.56E-03
α_5				3.61E-04	8.93E-04	1.43E-03	1.70E-03
α_6					4.43E-04	4.84E-04	8.44E-04
α_7						8.79E-05	2.60E-04
α_8							2.29E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.85E-01	9.83E-01	9.84E-01	9.85E-01	9.85E-01	9.86E-01
Beta	1.13E-02	1.45E-02	1.70E-02	1.61E-02	1.55E-02	1.45E-02	1.38E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	18.50	18.50	18.50	18.50	18.50	18.50	18.50
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

2.2.3.3 COMBINED HPCI AND RCIC TURBINE-DRIVEN PUMPS FAIL TO RUN LESS THAN AND > 1 HOUR: HCI-RCI-TDP-FHRH

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: 2006 through 2020

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	0.9621582	0.9903359	0.9958036	0.9999706	1.0000000	4.801E+01	4.685E-01
α_2	2.70E-05	9.66E-03	4.20E-03	3.78E-02	0.00E+00	4.685E-01	4.801E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9620153	0.9866830	0.9902707	0.9990805	1.0000000	8.358E+01	1.128E+00
α_2	3.36E-04	1.00E-02	6.54E-03	3.17E-02	0.00E+00	8.512E-01	8.386E+01
α_3	1.63E-07	3.27E-03	6.99E-04	1.53E-02	0.00E+00	2.768E-01	8.443E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9616034	0.9839754	0.9866183	0.9973197	1.0000000	1.163E+02	1.894E+00
α_2	9.21E-04	1.07E-02	8.05E-03	2.93E-02	0.00E+00	1.260E+00	1.169E+02
α_3	3.70E-06	3.41E-03	1.25E-03	1.41E-02	0.00E+00	4.024E-01	1.178E+02
α_4	1.36E-08	1.96E-03	2.92E-04	9.70E-03	0.00E+00	2.315E-01	1.179E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686431	0.9843901	0.9858376	0.9952055	1.0000000	2.164E+02	3.432E+00
α_2	1.49E-03	8.75E-03	7.31E-03	2.09E-02	0.00E+00	1.924E+00	2.179E+02
α_3	2.76E-04	4.77E-03	3.38E-03	1.40E-02	0.00E+00	1.049E+00	2.188E+02
α_4	1.32E-06	1.74E-03	5.99E-04	7.33E-03	0.00E+00	3.822E-01	2.195E+02
α_5	3.03E-20	3.49E-04	3.25E-07	2.03E-03	0.00E+00	7.674E-02	2.198E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706371	0.9849407	0.9861898	0.9949743	1.0000000	2.508E+02	3.835E+00

α_2	9.57E-04	6.68E-03	5.44E-03	1.66E-02	0.00E+00	1.701E+00	2.530E+02
α_3	3.74E-04	4.74E-03	3.52E-03	1.33E-02	0.00E+00	1.207E+00	2.534E+02
α_4	2.14E-05	2.34E-03	1.23E-03	8.43E-03	0.00E+00	5.960E-01	2.541E+02
α_5	3.40E-09	8.68E-04	1.16E-04	4.36E-03	0.00E+00	2.211E-01	2.544E+02
α_6	3.39E-15	4.31E-04	4.36E-06	2.49E-03	0.00E+00	1.098E-01	2.545E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748722	0.9857438	0.9865374	0.9938981	1.0000000	3.974E+02	5.747E+00
α_2	1.14E-03	5.56E-03	4.77E-03	1.27E-02	0.00E+00	2.243E+00	4.009E+02
α_3	5.42E-04	4.04E-03	3.26E-03	1.02E-02	0.00E+00	1.630E+00	4.015E+02
α_4	1.67E-04	2.69E-03	1.92E-03	7.81E-03	0.00E+00	1.083E+00	4.021E+02
α_5	1.01E-05	1.40E-03	7.07E-04	5.15E-03	0.00E+00	5.654E-01	4.026E+02
α_6	2.61E-10	4.75E-04	4.39E-05	2.48E-03	0.00E+00	1.916E-01	4.030E+02
α_7	5.91E-41	8.63E-05	3.21E-12	3.79E-04	0.00E+00	3.480E-02	4.031E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9760269	0.9864113	0.9871717	0.9941974	1.0000000	4.156E+02	5.726E+00
α_2	8.63E-04	4.79E-03	4.03E-03	1.13E-02	0.00E+00	2.018E+00	4.193E+02
α_3	3.41E-04	3.30E-03	2.56E-03	8.80E-03	0.00E+00	1.391E+00	4.200E+02
α_4	1.50E-04	2.52E-03	1.79E-03	7.38E-03	0.00E+00	1.062E+00	4.203E+02
α_5	2.94E-05	1.67E-03	9.74E-04	5.66E-03	0.00E+00	7.026E-01	4.206E+02
α_6	3.26E-07	8.30E-04	2.55E-04	3.61E-03	0.00E+00	3.497E-01	4.210E+02
α_7	1.25E-15	2.56E-04	2.35E-06	1.48E-03	0.00E+00	1.078E-01	4.212E+02
α_8	2.62E-17	2.25E-04	9.52E-07	1.31E-03	0.00E+00	9.469E-02	4.213E+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	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.66E-03	1.00E-02	1.07E-02	8.75E-03	6.68E-03	5.56E-03	4.79E-03
α_3		3.27E-03	3.41E-03	4.77E-03	4.74E-03	4.04E-03	3.30E-03
α_4			1.96E-03	1.74E-03	2.34E-03	2.69E-03	2.52E-03
α_5				3.49E-04	8.68E-04	1.40E-03	1.67E-03
α_6					4.31E-04	4.75E-04	8.30E-04
α_7						8.63E-05	2.56E-04
α_8							2.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.66E-03	1.33E-02	1.60E-02	1.56E-02	1.51E-02	1.43E-02	1.36E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	25.60	25.60	25.60	25.60	25.60	25.60	25.60
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

2.2.3.4 COMBINED HPCI AND RCIC TURBINE-DRIVEN PUMPS FAIL TO RUN >1H: HCI-RCI-TDP-RH

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: 2006 through 2020

Total Number of Independent Failure Events: 7.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9389691	0.9843727	0.9931626	0.9999527	1.0000000	2.951E+01	4.685E-01
α_2	4.41E-05	1.56E-02	6.84E-03	6.10E-02	0.00E+00	4.685E-01	2.951E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514870	0.9829619	0.9875242	0.9988253	1.0000000	6.508E+01	1.128E+00
α_2	4.31E-04	1.29E-02	8.39E-03	4.05E-02	0.00E+00	8.512E-01	6.536E+01
α_3	2.09E-07	4.18E-03	8.96E-04	1.96E-02	0.00E+00	2.768E-01	6.593E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9545324	0.9810010	0.9841180	0.9968157	1.0000000	9.778E+01	1.894E+00
α_2	1.09E-03	1.26E-02	9.56E-03	3.47E-02	0.00E+00	1.260E+00	9.841E+01
α_3	4.39E-06	4.04E-03	1.48E-03	1.67E-02	0.00E+00	4.024E-01	9.927E+01
α_4	1.61E-08	2.32E-03	3.46E-04	1.15E-02	0.00E+00	2.315E-01	9.944E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9657802	0.9829560	0.9845270	0.9947609	1.0000000	1.979E+02	3.432E+00
α_2	1.63E-03	9.56E-03	7.99E-03	2.28E-02	0.00E+00	1.924E+00	1.994E+02
α_3	3.02E-04	5.21E-03	3.69E-03	1.53E-02	0.00E+00	1.049E+00	2.003E+02
α_4	1.44E-06	1.90E-03	6.54E-04	8.01E-03	0.00E+00	3.822E-01	2.010E+02
α_5	3.31E-20	3.81E-04	3.55E-07	2.21E-03	0.00E+00	7.674E-02	2.013E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9683501	0.9837610	0.9851049	0.9945722	1.0000000	2.323E+02	3.835E+00
α_2	1.03E-03	7.20E-03	5.87E-03	1.79E-02	0.00E+00	1.701E+00	2.345E+02

α_3	4.03E-04	5.11E-03	3.80E-03	1.43E-02	0.00E+00	1.207E+00	2.349E+02
α_4	2.31E-05	2.52E-03	1.33E-03	9.09E-03	0.00E+00	5.960E-01	2.356E+02
α_5	3.67E-09	9.36E-04	1.25E-04	4.70E-03	0.00E+00	2.211E-01	2.359E+02
α_6	3.66E-15	4.65E-04	4.71E-06	2.68E-03	0.00E+00	1.098E-01	2.360E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736734	0.9850581	0.9858887	0.9935993	1.0000000	3.789E+02	5.747E+00
α_2	1.19E-03	5.83E-03	5.00E-03	1.33E-02	0.00E+00	2.243E+00	3.824E+02
α_3	5.68E-04	4.24E-03	3.41E-03	1.07E-02	0.00E+00	1.630E+00	3.830E+02
α_4	1.75E-04	2.82E-03	2.01E-03	8.19E-03	0.00E+00	1.083E+00	3.836E+02
α_5	1.06E-05	1.47E-03	7.41E-04	5.40E-03	0.00E+00	5.654E-01	3.841E+02
α_6	2.74E-10	4.98E-04	4.60E-05	2.60E-03	0.00E+00	1.916E-01	3.845E+02
α_7	6.20E-41	9.05E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.846E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749260	0.9857872	0.9865815	0.9939244	1.0000000	3.971E+02	5.726E+00
α_2	9.03E-04	5.01E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.008E+02
α_3	3.56E-04	3.45E-03	2.67E-03	9.21E-03	0.00E+00	1.391E+00	4.015E+02
α_4	1.57E-04	2.64E-03	1.87E-03	7.72E-03	0.00E+00	1.062E+00	4.018E+02
α_5	3.08E-05	1.74E-03	1.02E-03	5.92E-03	0.00E+00	7.026E-01	4.021E+02
α_6	3.41E-07	8.68E-04	2.66E-04	3.78E-03	0.00E+00	3.497E-01	4.025E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.027E+02
α_8	2.74E-17	2.35E-04	9.96E-07	1.37E-03	0.00E+00	9.469E-02	4.028E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.56E-02	1.29E-02	1.26E-02	9.56E-03	7.20E-03	5.83E-03	5.01E-03
α_3		4.18E-03	4.04E-03	5.21E-03	5.11E-03	4.24E-03	3.45E-03
α_4			2.32E-03	1.90E-03	2.52E-03	2.82E-03	2.64E-03
α_5				3.81E-04	9.36E-04	1.47E-03	1.74E-03
α_6					4.65E-04	4.98E-04	8.68E-04
α_7						9.05E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.56E-02	1.70E-02	1.90E-02	1.70E-02	1.62E-02	1.49E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	7.10	7.10	7.10	7.10	7.10	7.10	7.10
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 Motor-Operated Valves

2.3.1 Pooled Motor-Operated Valves

2.3.1.1 MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE ALL SYSTEMS: ALL-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: 2006 through 2020

Total Number of Independent Failure Events: 349.0

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9878532	0.9963917	0.9978635	0.9999331	0.9985816	1.984E+02	7.185E-01
α_2	6.92E-05	3.61E-03	2.14E-03	1.21E-02	1.42E-03	7.185E-01	1.984E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9859688	0.9941876	0.9951724	0.9990425	0.9971591	3.212E+02	1.878E+00
α_2	6.48E-04	4.96E-03	3.98E-03	1.26E-02	2.84E-03	1.601E+00	3.215E+02
α_3	4.25E-08	8.57E-04	1.82E-04	4.02E-03	0.00E+00	2.768E-01	3.228E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9845527	0.9923579	0.9930817	0.9976840	0.9957326	4.407E+02	3.394E+00
α_2	1.58E-03	6.21E-03	5.49E-03	1.33E-02	4.27E-03	2.760E+00	4.413E+02
α_3	9.80E-07	9.06E-04	3.31E-04	3.76E-03	0.00E+00	4.024E-01	4.437E+02
α_4	3.60E-09	5.21E-04	7.74E-05	2.58E-03	0.00E+00	2.315E-01	4.438E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9853698	0.9919479	0.9924571	0.9967827	0.9962031	6.281E+02	5.099E+00
α_2	1.44E-03	5.01E-03	4.50E-03	1.03E-02	2.85E-03	3.174E+00	6.301E+02
α_3	2.62E-04	2.31E-03	1.82E-03	6.07E-03	9.49E-04	1.466E+00	6.318E+02
α_4	4.58E-07	6.04E-04	2.08E-04	2.55E-03	0.00E+00	3.822E-01	6.328E+02
α_5	1.05E-20	1.21E-04	1.13E-07	7.03E-04	0.00E+00	7.674E-02	6.332E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9866914	0.9924875	0.9929146	0.9968156	0.9965039	7.498E+02	5.675E+00
α_2	9.54E-04	3.71E-03	3.29E-03	7.93E-03	2.10E-03	2.805E+00	7.526E+02
α_3	3.78E-04	2.41E-03	1.98E-03	5.88E-03	1.16E-03	1.818E+00	7.536E+02
α_4	1.85E-05	9.54E-04	5.66E-04	3.21E-03	2.37E-04	7.210E-01	7.547E+02
α_5	1.14E-09	2.93E-04	3.91E-05	1.47E-03	0.00E+00	2.211E-01	7.552E+02
α_6	1.14E-15	1.45E-04	1.47E-06	8.38E-04	0.00E+00	1.098E-01	7.553E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9870727	0.9921708	0.9925011	0.9961470	0.9967189	9.836E+02	7.761E+00
α_2	9.65E-04	3.29E-03	2.96E-03	6.74E-03	1.66E-03	3.263E+00	9.881E+02
α_3	4.97E-04	2.34E-03	2.02E-03	5.30E-03	1.13E-03	2.323E+00	9.890E+02
α_4	1.32E-04	1.36E-03	1.04E-03	3.66E-03	4.26E-04	1.344E+00	9.900E+02
α_5	5.94E-06	6.10E-04	3.23E-04	2.19E-03	6.41E-05	6.047E-01	9.907E+02
α_6	1.06E-10	1.93E-04	1.78E-05	1.01E-03	0.00E+00	1.916E-01	9.911E+02
α_7	2.40E-41	3.51E-05	1.30E-12	1.54E-04	0.00E+00	3.480E-02	9.913E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9881464	0.9927903	0.9930895	0.9964242	0.9968870	1.089E+03	7.908E+00
α_2	7.41E-04	2.72E-03	2.43E-03	5.72E-03	1.38E-03	2.987E+00	1.094E+03
α_3	3.67E-04	1.93E-03	1.63E-03	4.49E-03	1.03E-03	2.113E+00	1.095E+03
α_4	1.42E-04	1.31E-03	1.02E-03	3.45E-03	5.29E-04	1.433E+00	1.095E+03
α_5	2.10E-05	7.38E-04	4.66E-04	2.38E-03	1.53E-04	8.098E-01	1.096E+03
α_6	1.70E-07	3.30E-04	1.06E-04	1.42E-03	1.82E-05	3.625E-01	1.097E+03
α_7	4.80E-16	9.83E-05	9.01E-07	5.68E-04	0.00E+00	1.078E-01	1.097E+03
α_8	1.00E-17	8.63E-05	3.65E-07	5.02E-04	0.00E+00	9.469E-02	1.097E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.96E-01	9.94E-01	9.92E-01	9.92E-01	9.92E-01	9.92E-01	9.93E-01
α_2	3.61E-03	4.96E-03	6.21E-03	5.01E-03	3.71E-03	3.29E-03	2.72E-03
α_3		8.57E-04	9.06E-04	2.31E-03	2.41E-03	2.34E-03	1.93E-03
α_4			5.21E-04	6.04E-04	9.54E-04	1.36E-03	1.31E-03
α_5				1.21E-04	2.93E-04	6.10E-04	7.38E-04
α_6					1.45E-04	1.93E-04	3.30E-04
α_7						3.51E-05	9.83E-05
α_8							8.63E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.96E-01	9.94E-01	9.92E-01	9.92E-01	9.92E-01	9.92E-01	9.93E-01
Beta	3.61E-03	5.81E-03	7.64E-03	8.05E-03	7.51E-03	7.83E-03	7.21E-03
Gamma		1.47E-01	1.87E-01	3.77E-01	5.06E-01	5.80E-01	6.22E-01

Delta			3.65E-01	2.38E-01	3.66E-01	4.84E-01	5.71E-01
Epsilon				1.67E-01	3.15E-01	3.82E-01	4.90E-01
Mu					3.32E-01	2.72E-01	4.11E-01
Omega						1.54E-01	3.58E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	174.50	261.75	349.00	436.25	523.50	610.75	698.00
N_1	1.5000	1.5000	1.0000	1.0417	1.0417	1.0127	0.9645
N_2	0.2500	0.7500	1.5000	1.2500	1.1042	1.0197	0.9691
N_3		0.0000	0.0000	0.4167	0.6111	0.6933	0.7230
N_4			0.0000	0.0000	0.1250	0.2616	0.3706
N_5				0.0000	0.0000	0.0394	0.1073
N_6					0.0000	0.0000	0.0127
N_7						0.0000	0.0000
N_8							0.0000

2.3.1.2 MOTOR-OPERATED VALVES FAIL TO OPEN ALL SYSTEMS: ALL-MOV-CC

Components/Valve MOV /Motor-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 207.2

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9920038	0.9979636	0.9991232	0.9999887	1.0000000	2.296E+02	4.685E-01
α_2	5.63E-06	2.04E-03	8.75E-04	8.00E-03	0.00E+00	4.685E-01	2.296E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9878596	0.9957641	0.9969248	0.9997087	1.0000000	2.652E+02	1.128E+00
α_2	1.06E-04	3.20E-03	2.07E-03	1.01E-02	0.00E+00	8.512E-01	2.655E+02
α_3	5.16E-08	1.04E-03	2.21E-04	4.88E-03	0.00E+00	2.768E-01	2.660E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9847948	0.9936831	0.9947401	0.9989528	1.0000000	2.979E+02	1.894E+00
α_2	3.61E-04	4.20E-03	3.16E-03	1.16E-02	0.00E+00	1.260E+00	2.985E+02
α_3	1.45E-06	1.34E-03	4.91E-04	5.56E-03	0.00E+00	4.024E-01	2.994E+02
α_4	5.34E-09	7.72E-04	1.15E-04	3.82E-03	0.00E+00	2.315E-01	2.995E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9827838	0.9914510	0.9922509	0.9973799	1.0000000	3.980E+02	3.432E+00
α_2	8.13E-04	4.79E-03	4.00E-03	1.15E-02	0.00E+00	1.924E+00	3.995E+02
α_3	1.51E-04	2.61E-03	1.85E-03	7.69E-03	0.00E+00	1.049E+00	4.004E+02
α_4	7.23E-07	9.52E-04	3.28E-04	4.02E-03	0.00E+00	3.822E-01	4.011E+02
α_5	1.66E-20	1.91E-04	1.78E-07	1.11E-03	0.00E+00	7.674E-02	4.014E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9828238	0.9912094	0.9919465	0.9970720	1.0000000	4.324E+02	3.835E+00
α_2	5.58E-04	3.90E-03	3.17E-03	9.73E-03	0.00E+00	1.701E+00	4.346E+02
α_3	2.18E-04	2.77E-03	2.05E-03	7.75E-03	0.00E+00	1.207E+00	4.350E+02
α_4	1.25E-05	1.37E-03	7.16E-04	4.92E-03	0.00E+00	5.960E-01	4.357E+02

α_5	1.98E-09	5.07E-04	6.77E-05	2.54E-03	0.00E+00	2.211E-01	4.360E+02
α_6	1.98E-15	2.52E-04	2.55E-06	1.45E-03	0.00E+00	1.098E-01	4.361E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9826572	0.9901712	0.9907272	0.9958011	1.0000000	5.790E+02	5.747E+00
α_2	7.84E-04	3.84E-03	3.29E-03	8.76E-03	0.00E+00	2.243E+00	5.825E+02
α_3	3.74E-04	2.79E-03	2.24E-03	7.05E-03	0.00E+00	1.630E+00	5.831E+02
α_4	1.15E-04	1.85E-03	1.32E-03	5.39E-03	0.00E+00	1.083E+00	5.837E+02
α_5	6.98E-06	9.67E-04	4.87E-04	3.55E-03	0.00E+00	5.654E-01	5.842E+02
α_6	1.80E-10	3.28E-04	3.03E-05	1.71E-03	0.00E+00	1.916E-01	5.846E+02
α_7	4.07E-41	5.95E-05	2.21E-12	2.61E-04	0.00E+00	3.480E-02	5.847E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9832232	0.9905040	0.9910391	0.9959522	1.0000000	5.972E+02	5.726E+00
α_2	6.03E-04	3.35E-03	2.82E-03	7.90E-03	0.00E+00	2.018E+00	6.009E+02
α_3	2.38E-04	2.31E-03	1.78E-03	6.16E-03	0.00E+00	1.391E+00	6.016E+02
α_4	1.05E-04	1.76E-03	1.25E-03	5.16E-03	0.00E+00	1.062E+00	6.019E+02
α_5	2.06E-05	1.17E-03	6.80E-04	3.96E-03	0.00E+00	7.026E-01	6.022E+02
α_6	2.28E-07	5.80E-04	1.78E-04	2.52E-03	0.00E+00	3.497E-01	6.026E+02
α_7	8.74E-16	1.79E-04	1.64E-06	1.03E-03	0.00E+00	1.078E-01	6.028E+02
α_8	1.83E-17	1.57E-04	6.65E-07	9.14E-04	0.00E+00	9.469E-02	6.029E+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	9.96E-01	9.94E-01	9.91E-01	9.91E-01	9.90E-01	9.91E-01
α_2	2.04E-03	3.20E-03	4.20E-03	4.79E-03	3.90E-03	3.84E-03	3.35E-03
α_3		1.04E-03	1.34E-03	2.61E-03	2.77E-03	2.79E-03	2.31E-03
α_4			7.72E-04	9.52E-04	1.37E-03	1.85E-03	1.76E-03
α_5				1.91E-04	5.07E-04	9.67E-04	1.17E-03
α_6					2.52E-04	3.28E-04	5.80E-04
α_7						5.95E-05	1.79E-04
α_8							1.57E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.98E-01	9.96E-01	9.94E-01	9.91E-01	9.91E-01	9.90E-01	9.91E-01
Beta	2.04E-03	4.24E-03	6.32E-03	8.55E-03	8.79E-03	9.83E-03	9.50E-03
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	207.20	207.20	207.20	207.20	207.20	207.20	207.20
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

2.3.1.3 MOTOR-OPERATED VALVES FAIL TO CLOSE ALL SYSTEMS: ALL-MOV-OO

Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 119.8

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9714627	0.9914999	0.9949390	0.9998379	0.9959448	8.381E+01	7.185E-01
α_2	1.64E-04	8.50E-03	5.06E-03	2.85E-02	4.06E-03	7.185E-01	8.381E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9701084	0.9875797	0.9896540	0.9979453	0.9918567	1.493E+02	1.878E+00
α_2	1.39E-03	1.06E-02	8.52E-03	2.69E-02	8.14E-03	1.601E+00	1.496E+02
α_3	9.11E-08	1.83E-03	3.90E-04	8.59E-03	0.00E+00	2.768E-01	1.509E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9681770	0.9842061	0.9856865	0.9951916	0.9877351	2.115E+02	3.394E+00
α_2	3.27E-03	1.28E-02	1.14E-02	2.75E-02	1.23E-02	2.760E+00	2.121E+02
α_3	2.03E-06	1.87E-03	6.86E-04	7.76E-03	0.00E+00	4.024E-01	2.145E+02
α_4	7.46E-09	1.08E-03	1.60E-04	5.33E-03	0.00E+00	2.315E-01	2.146E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733344	0.9852945	0.9862156	0.9941061	0.9890681	3.416E+02	5.099E+00
α_2	2.63E-03	9.15E-03	8.23E-03	1.88E-02	8.20E-03	3.174E+00	3.436E+02
α_3	4.79E-04	4.23E-03	3.32E-03	1.11E-02	2.73E-03	1.466E+00	3.453E+02
α_4	8.37E-07	1.10E-03	3.80E-04	4.65E-03	0.00E+00	3.822E-01	3.463E+02
α_5	1.92E-20	2.21E-04	2.06E-07	1.29E-03	0.00E+00	7.674E-02	3.467E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9756236	0.9862131	0.9869911	0.9941356	0.9899208	4.060E+02	5.675E+00
α_2	1.75E-03	6.81E-03	6.03E-03	1.45E-02	6.05E-03	2.805E+00	4.088E+02
α_3	6.94E-04	4.42E-03	3.64E-03	1.08E-02	3.35E-03	1.818E+00	4.098E+02
α_4	3.39E-05	1.75E-03	1.04E-03	5.89E-03	6.85E-04	7.210E-01	4.109E+02

α_5	2.10E-09	5.37E-04	7.18E-05	2.69E-03	0.00E+00	2.211E-01	4.114E+02
α_6	2.10E-15	2.67E-04	2.70E-06	1.54E-03	0.00E+00	1.098E-01	4.115E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783274	0.9868503	0.9873946	0.9935151	0.9905307	5.825E+02	7.761E+00
α_2	1.62E-03	5.53E-03	4.98E-03	1.13E-02	4.79E-03	3.263E+00	5.870E+02
α_3	8.36E-04	3.94E-03	3.39E-03	8.90E-03	3.26E-03	2.323E+00	5.879E+02
α_4	2.21E-04	2.28E-03	1.75E-03	6.15E-03	1.23E-03	1.344E+00	5.889E+02
α_5	9.98E-06	1.02E-03	5.43E-04	3.67E-03	1.85E-04	6.047E-01	5.896E+02
α_6	1.78E-10	3.25E-04	3.00E-05	1.69E-03	0.00E+00	1.916E-01	5.900E+02
α_7	4.04E-41	5.90E-05	2.19E-12	2.59E-04	0.00E+00	3.480E-02	5.902E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9796578	0.9876142	0.9881225	0.9938444	0.9910084	6.306E+02	7.908E+00
α_2	1.27E-03	4.68E-03	4.17E-03	9.81E-03	3.99E-03	2.987E+00	6.355E+02
α_3	6.31E-04	3.31E-03	2.81E-03	7.71E-03	2.98E-03	2.113E+00	6.364E+02
α_4	2.44E-04	2.24E-03	1.75E-03	5.93E-03	1.53E-03	1.433E+00	6.371E+02
α_5	3.61E-05	1.27E-03	8.01E-04	4.09E-03	4.42E-04	8.098E-01	6.377E+02
α_6	2.93E-07	5.68E-04	1.83E-04	2.44E-03	5.24E-05	3.625E-01	6.381E+02
α_7	8.26E-16	1.69E-04	1.55E-06	9.75E-04	0.00E+00	1.078E-01	6.384E+02
α_8	1.73E-17	1.48E-04	6.28E-07	8.63E-04	0.00E+00	9.469E-02	6.384E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.91E-01	9.88E-01	9.84E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01
α_2	8.50E-03	1.06E-02	1.28E-02	9.15E-03	6.81E-03	5.53E-03	4.68E-03
α_3		1.83E-03	1.87E-03	4.23E-03	4.42E-03	3.94E-03	3.31E-03
α_4			1.08E-03	1.10E-03	1.75E-03	2.28E-03	2.24E-03
α_5				2.21E-04	5.37E-04	1.02E-03	1.27E-03
α_6					2.67E-04	3.25E-04	5.68E-04
α_7						5.90E-05	1.69E-04
α_8							1.48E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.91E-01	9.88E-01	9.84E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01
Beta	8.50E-03	1.24E-02	1.58E-02	1.47E-02	1.38E-02	1.31E-02	1.24E-02
Gamma		1.47E-01	1.87E-01	3.77E-01	5.06E-01	5.80E-01	6.22E-01
Delta			3.65E-01	2.38E-01	3.66E-01	4.84E-01	5.71E-01
Epsilon				1.67E-01	3.15E-01	3.82E-01	4.90E-01
Mu					3.32E-01	2.72E-01	4.11E-01
Omega						1.54E-01	3.58E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	59.90	89.85	119.80	149.75	179.70	209.65	239.60
N_1	1.5000	1.5000	1.0000	1.0417	1.0417	1.0127	0.9645
N_2	0.2500	0.7500	1.5000	1.2500	1.1042	1.0197	0.9691
N_3		0.0000	0.0000	0.4167	0.6111	0.6933	0.7230
N_4			0.0000	0.0000	0.1250	0.2616	0.3706
N_5				0.0000	0.0000	0.0394	0.1073
N_6					0.0000	0.0000	0.0127
N_7						0.0000	0.0000
N_8							0.0000

2.3.1.4 MOTOR-OPERATED VALVES SPURIOUS OPERATION ALL SYSTEMS: ALL-MOV-SO

Components/Valve/Motor-Operated Valve
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 32.0

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9051104	0.9631777	0.9706300	0.9957058	0.9411765	3.841E+01	1.469E+00
α_2	4.29E-03	3.68E-02	2.94E-02	9.49E-02	5.88E-02	1.469E+00	3.841E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9417877	0.9746984	0.9783649	0.9950733	0.9600000	8.198E+01	2.128E+00
α_2	3.39E-04	1.01E-02	6.59E-03	3.19E-02	0.00E+00	8.512E-01	8.326E+01
α_3	1.35E-03	1.52E-02	1.15E-02	4.15E-02	4.00E-02	1.277E+00	8.283E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9515716	0.9769561	0.9794439	0.9938440	0.9696970	1.227E+02	2.894E+00
α_2	8.66E-04	1.00E-02	7.58E-03	2.76E-02	0.00E+00	1.260E+00	1.243E+02
α_3	3.48E-06	3.20E-03	1.18E-03	1.33E-02	0.00E+00	4.024E-01	1.252E+02
α_4	8.09E-04	9.81E-03	7.36E-03	2.72E-02	3.03E-02	1.231E+00	1.243E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9646720	0.9811615	0.9825064	0.9930526	0.9756098	2.308E+02	4.432E+00
α_2	1.39E-03	8.18E-03	6.83E-03	1.96E-02	0.00E+00	1.924E+00	2.333E+02
α_3	2.58E-04	4.46E-03	3.16E-03	1.31E-02	0.00E+00	1.049E+00	2.342E+02
α_4	1.38E-04	3.75E-03	2.47E-03	1.17E-02	1.22E-02	8.822E-01	2.344E+02
α_5	1.94E-05	2.45E-03	1.26E-03	8.94E-03	1.22E-02	5.767E-01	2.347E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680767	0.9826116	0.9837537	0.9932326	0.9795918	2.732E+02	4.835E+00
α_2	8.76E-04	6.12E-03	4.98E-03	1.52E-02	0.00E+00	1.701E+00	2.764E+02

α_3	3.42E-04	4.34E-03	3.23E-03	1.21E-02	0.00E+00	1.207E+00	2.768E+02
α_4	9.92E-05	3.04E-03	1.96E-03	9.66E-03	5.10E-03	8.460E-01	2.772E+02
α_5	5.03E-05	2.59E-03	1.54E-03	8.72E-03	1.02E-02	7.211E-01	2.773E+02
α_6	6.32E-07	1.29E-03	4.13E-04	5.57E-03	5.10E-03	3.598E-01	2.777E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736281	0.9844727	0.9852077	0.9927952	0.9824561	4.278E+02	6.747E+00
α_2	1.06E-03	5.16E-03	4.43E-03	1.18E-02	0.00E+00	2.243E+00	4.323E+02
α_3	5.03E-04	3.75E-03	3.02E-03	9.49E-03	0.00E+00	1.630E+00	4.329E+02
α_4	2.19E-04	2.78E-03	2.06E-03	7.78E-03	2.19E-03	1.208E+00	4.333E+02
α_5	9.49E-05	2.16E-03	1.46E-03	6.62E-03	6.58E-03	9.404E-01	4.336E+02
α_6	9.52E-06	1.30E-03	6.59E-04	4.79E-03	6.58E-03	5.666E-01	4.340E+02
α_7	1.06E-11	3.68E-04	1.92E-05	2.00E-03	2.19E-03	1.598E-01	4.344E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751835	0.9854029	0.9860974	0.9932448	0.9846154	4.540E+02	6.726E+00
α_2	7.89E-04	4.38E-03	3.69E-03	1.03E-02	0.00E+00	2.018E+00	4.587E+02
α_3	3.12E-04	3.02E-03	2.34E-03	8.05E-03	0.00E+00	1.391E+00	4.594E+02
α_4	1.65E-04	2.44E-03	1.77E-03	7.01E-03	9.62E-04	1.125E+00	4.596E+02
α_5	9.38E-05	2.07E-03	1.41E-03	6.29E-03	3.85E-03	9.526E-01	4.598E+02
α_6	3.10E-05	1.57E-03	9.36E-04	5.28E-03	5.77E-03	7.247E-01	4.600E+02
α_7	3.64E-07	7.77E-04	2.46E-04	3.35E-03	3.85E-03	3.578E-01	4.604E+02
α_8	7.27E-12	3.41E-04	1.68E-05	1.86E-03	9.62E-04	1.572E-01	4.606E+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	9.75E-01	9.77E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01
α_2	3.68E-02	1.01E-02	1.00E-02	8.18E-03	6.12E-03	5.16E-03	4.38E-03
α_3		1.52E-02	3.20E-03	4.46E-03	4.34E-03	3.75E-03	3.02E-03
α_4			9.81E-03	3.75E-03	3.04E-03	2.78E-03	2.44E-03
α_5				2.45E-03	2.59E-03	2.16E-03	2.07E-03
α_6					1.29E-03	1.30E-03	1.57E-03
α_7						3.68E-04	7.77E-04
α_8							3.41E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.63E-01	9.75E-01	9.77E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01
Beta	3.68E-02	2.53E-02	2.30E-02	1.88E-02	1.74E-02	1.55E-02	1.46E-02
Gamma		6.00E-01	5.65E-01	5.66E-01	6.48E-01	6.68E-01	7.00E-01
Delta			7.54E-01	5.82E-01	6.15E-01	6.38E-01	7.05E-01
Epsilon				3.95E-01	5.61E-01	5.80E-01	6.61E-01
Mu					3.33E-01	4.36E-01	5.65E-01
Omega						2.20E-01	4.15E-01

Sigma							3.05E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	16.00	24.00	32.00	40.00	48.00	56.00	64.00
N_1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_3		1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N_4			1.0000	0.5000	0.2500	0.1250	0.0625
N_5				0.5000	0.5000	0.3750	0.2500
N_6					0.2500	0.3750	0.3750
N_7						0.1250	0.2500
N_8							0.0625

2.3.1.5 MOTOR-OPERATED VALVES FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS: ALL-MOV-LK

Components/Valve/Motor-Operated Valve
Failure Modes/Leak (Internal)
Date Range: 2006 through 2020

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	0.9666157	0.9914784	0.9963029	0.9999740	1.0000000	5.451E+01	4.685E-01
α_2	2.38E-05	8.52E-03	3.69E-03	3.34E-02	0.00E+00	4.685E-01	5.451E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9647004	0.9876321	0.9909738	0.9991464	1.0000000	9.008E+01	1.128E+00
α_2	3.12E-04	9.33E-03	6.07E-03	2.95E-02	0.00E+00	8.512E-01	9.036E+01
α_3	1.51E-07	3.04E-03	6.49E-04	1.42E-02	0.00E+00	2.768E-01	9.093E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9635914	0.9848109	0.9873196	0.9974609	1.0000000	1.228E+02	1.894E+00
α_2	8.72E-04	1.01E-02	7.63E-03	2.78E-02	0.00E+00	1.260E+00	1.234E+02
α_3	3.51E-06	3.23E-03	1.18E-03	1.34E-02	0.00E+00	4.024E-01	1.243E+02
α_4	1.29E-08	1.86E-03	2.77E-04	9.19E-03	0.00E+00	2.315E-01	1.244E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9695384	0.9848383	0.9862454	0.9953442	1.0000000	2.229E+02	3.432E+00
α_2	1.45E-03	8.50E-03	7.10E-03	2.03E-02	0.00E+00	1.924E+00	2.244E+02
α_3	2.68E-04	4.63E-03	3.28E-03	1.36E-02	0.00E+00	1.049E+00	2.253E+02
α_4	1.28E-06	1.69E-03	5.82E-04	7.12E-03	0.00E+00	3.822E-01	2.260E+02
α_5	2.94E-20	3.39E-04	3.16E-07	1.97E-03	0.00E+00	7.674E-02	2.263E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9713593	0.9853155	0.9865392	0.9951002	1.0000000	2.573E+02	3.835E+00
α_2	9.33E-04	6.51E-03	5.30E-03	1.62E-02	0.00E+00	1.701E+00	2.595E+02
α_3	3.65E-04	4.62E-03	3.43E-03	1.29E-02	0.00E+00	1.207E+00	2.599E+02
α_4	2.09E-05	2.28E-03	1.20E-03	8.22E-03	0.00E+00	5.960E-01	2.606E+02

α_5	3.31E-09	8.47E-04	1.13E-04	4.25E-03	0.00E+00	2.211E-01	2.609E+02
α_6	3.31E-15	4.20E-04	4.26E-06	2.42E-03	0.00E+00	1.098E-01	2.610E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752691	0.9859700	0.9867514	0.9939920	1.0000000	4.039E+02	5.747E+00
α_2	1.12E-03	5.48E-03	4.69E-03	1.25E-02	0.00E+00	2.243E+00	4.074E+02
α_3	5.34E-04	3.98E-03	3.21E-03	1.01E-02	0.00E+00	1.630E+00	4.080E+02
α_4	1.64E-04	2.64E-03	1.89E-03	7.69E-03	0.00E+00	1.083E+00	4.086E+02
α_5	9.97E-06	1.38E-03	6.96E-04	5.07E-03	0.00E+00	5.654E-01	4.091E+02
α_6	2.57E-10	4.68E-04	4.32E-05	2.44E-03	0.00E+00	1.916E-01	4.095E+02
α_7	5.82E-41	8.50E-05	3.16E-12	3.73E-04	0.00E+00	3.480E-02	4.096E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763850	0.9866177	0.9873718	0.9942873	1.0000000	4.221E+02	5.726E+00
α_2	8.50E-04	4.72E-03	3.97E-03	1.11E-02	0.00E+00	2.018E+00	4.258E+02
α_3	3.36E-04	3.25E-03	2.52E-03	8.67E-03	0.00E+00	1.391E+00	4.265E+02
α_4	1.48E-04	2.48E-03	1.76E-03	7.27E-03	0.00E+00	1.062E+00	4.268E+02
α_5	2.90E-05	1.64E-03	9.59E-04	5.58E-03	0.00E+00	7.026E-01	4.271E+02
α_6	3.21E-07	8.17E-04	2.51E-04	3.55E-03	0.00E+00	3.497E-01	4.275E+02
α_7	1.23E-15	2.52E-04	2.31E-06	1.46E-03	0.00E+00	1.078E-01	4.277E+02
α_8	2.58E-17	2.21E-04	9.37E-07	1.29E-03	0.00E+00	9.469E-02	4.278E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	8.52E-03	9.33E-03	1.01E-02	8.50E-03	6.51E-03	5.48E-03	4.72E-03
α_3		3.04E-03	3.23E-03	4.63E-03	4.62E-03	3.98E-03	3.25E-03
α_4			1.86E-03	1.69E-03	2.28E-03	2.64E-03	2.48E-03
α_5				3.39E-04	8.47E-04	1.38E-03	1.64E-03
α_6					4.20E-04	4.68E-04	8.17E-04
α_7						8.50E-05	2.52E-04
α_8							2.21E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	8.52E-03	1.24E-02	1.52E-02	1.52E-02	1.47E-02	1.40E-02	1.34E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	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

2.3.2 Containment Spray Motor-Operated Valves

2.3.2.1 CSS MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: CSS-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 24.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9612834	0.9901115	0.9957085	0.9999699	1.0000000	4.691E+01	4.685E-01
α_2	2.77E-05	9.89E-03	4.29E-03	3.87E-02	0.00E+00	4.685E-01	4.691E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9615139	0.9865078	0.9901416	0.9990683	1.0000000	8.248E+01	1.128E+00
α_2	3.41E-04	1.02E-02	6.63E-03	3.21E-02	0.00E+00	8.512E-01	8.276E+01
α_3	1.65E-07	3.31E-03	7.08E-04	1.55E-02	0.00E+00	2.768E-01	8.333E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9612453	0.9838248	0.9864918	0.9972942	1.0000000	1.152E+02	1.894E+00
α_2	9.30E-04	1.08E-02	8.13E-03	2.96E-02	0.00E+00	1.260E+00	1.158E+02
α_3	3.73E-06	3.44E-03	1.26E-03	1.42E-02	0.00E+00	4.024E-01	1.167E+02
α_4	1.37E-08	1.98E-03	2.95E-04	9.79E-03	0.00E+00	2.315E-01	1.168E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9684864	0.9843116	0.9857662	0.9951812	1.0000000	2.153E+02	3.432E+00
α_2	1.50E-03	8.80E-03	7.35E-03	2.10E-02	0.00E+00	1.924E+00	2.168E+02
α_3	2.78E-04	4.79E-03	3.40E-03	1.41E-02	0.00E+00	1.049E+00	2.177E+02
α_4	1.33E-06	1.75E-03	6.02E-04	7.37E-03	0.00E+00	3.822E-01	2.184E+02
α_5	3.05E-20	3.51E-04	3.27E-07	2.04E-03	0.00E+00	7.674E-02	2.187E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9705104	0.9848753	0.9861298	0.9949523	1.0000000	2.497E+02	3.835E+00
α_2	9.62E-04	6.71E-03	5.46E-03	1.67E-02	0.00E+00	1.701E+00	2.519E+02
α_3	3.76E-04	4.76E-03	3.54E-03	1.33E-02	0.00E+00	1.207E+00	2.523E+02
α_4	2.15E-05	2.35E-03	1.23E-03	8.47E-03	0.00E+00	5.960E-01	2.530E+02
α_5	3.41E-09	8.72E-04	1.17E-04	4.37E-03	0.00E+00	2.211E-01	2.533E+02
α_6	3.41E-15	4.33E-04	4.38E-06	2.50E-03	0.00E+00	1.098E-01	2.534E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748039	0.9857048	0.9865005	0.9938815	1.0000000	3.963E+02	5.747E+00
α_2	1.14E-03	5.58E-03	4.78E-03	1.27E-02	0.00E+00	2.243E+00	3.998E+02
α_3	5.44E-04	4.05E-03	3.27E-03	1.03E-02	0.00E+00	1.630E+00	4.004E+02
α_4	1.68E-04	2.69E-03	1.93E-03	7.84E-03	0.00E+00	1.083E+00	4.010E+02
α_5	1.02E-05	1.41E-03	7.09E-04	5.17E-03	0.00E+00	5.654E-01	4.015E+02
α_6	2.62E-10	4.77E-04	4.40E-05	2.48E-03	0.00E+00	1.916E-01	4.019E+02
α_7	5.93E-41	8.66E-05	3.22E-12	3.80E-04	0.00E+00	3.480E-02	4.020E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9759647	0.9863757	0.9871381	0.9941818	1.0000000	4.145E+02	5.726E+00
α_2	8.66E-04	4.80E-03	4.04E-03	1.13E-02	0.00E+00	2.018E+00	4.182E+02
α_3	3.42E-04	3.31E-03	2.56E-03	8.83E-03	0.00E+00	1.391E+00	4.189E+02
α_4	1.50E-04	2.53E-03	1.80E-03	7.40E-03	0.00E+00	1.062E+00	4.192E+02
α_5	2.95E-05	1.67E-03	9.77E-04	5.68E-03	0.00E+00	7.026E-01	4.195E+02
α_6	3.27E-07	8.32E-04	2.55E-04	3.62E-03	0.00E+00	3.497E-01	4.199E+02
α_7	1.25E-15	2.57E-04	2.35E-06	1.48E-03	0.00E+00	1.078E-01	4.201E+02
α_8	2.62E-17	2.25E-04	9.54E-07	1.31E-03	0.00E+00	9.469E-02	4.202E+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	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.89E-03	1.02E-02	1.08E-02	8.80E-03	6.71E-03	5.58E-03	4.80E-03
α_3		3.31E-03	3.44E-03	4.79E-03	4.76E-03	4.05E-03	3.31E-03
α_4			1.98E-03	1.75E-03	2.35E-03	2.69E-03	2.53E-03
α_5				3.51E-04	8.72E-04	1.41E-03	1.67E-03
α_6					4.33E-04	4.77E-04	8.32E-04
α_7						8.66E-05	2.57E-04
α_8							2.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.89E-03	1.35E-02	1.62E-02	1.57E-02	1.51E-02	1.43E-02	1.36E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	24.50	24.50	24.50	24.50	24.50	24.50	24.50
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

2.3.2.2 CSS MOTOR-OPERATED VALVES FAIL TO OPEN: CSS-MOV-CC

Systems/Clean Water/Containment spray recirculation
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

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	0.9509830	0.9874663	0.9945389	0.9999620	1.0000000	3.691E+01	4.685E-01
α_2	3.52E-05	1.25E-02	5.46E-03	4.90E-02	0.00E+00	4.685E-01	3.691E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9563263	0.9846748	0.9887899	0.9989407	1.0000000	7.248E+01	1.128E+00
α_2	3.88E-04	1.16E-02	7.54E-03	3.65E-02	0.00E+00	8.512E-01	7.276E+01
α_3	1.88E-07	3.76E-03	8.05E-04	1.76E-02	0.00E+00	2.768E-01	7.333E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9576496	0.9823141	0.9852225	0.9970385	1.0000000	1.052E+02	1.894E+00
α_2	1.02E-03	1.18E-02	8.89E-03	3.23E-02	0.00E+00	1.260E+00	1.058E+02
α_3	4.09E-06	3.76E-03	1.38E-03	1.56E-02	0.00E+00	4.024E-01	1.067E+02
α_4	1.50E-08	2.16E-03	3.22E-04	1.07E-02	0.00E+00	2.315E-01	1.068E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9669859	0.9835602	0.9850771	0.9949484	1.0000000	2.053E+02	3.432E+00
α_2	1.57E-03	9.22E-03	7.70E-03	2.20E-02	0.00E+00	1.924E+00	2.068E+02
α_3	2.91E-04	5.02E-03	3.56E-03	1.48E-02	0.00E+00	1.049E+00	2.077E+02
α_4	1.39E-06	1.83E-03	6.31E-04	7.72E-03	0.00E+00	3.822E-01	2.084E+02
α_5	3.19E-20	3.68E-04	3.43E-07	2.14E-03	0.00E+00	7.674E-02	2.087E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693065	0.9842544	0.9855587	0.9947433	1.0000000	2.397E+02	3.835E+00
α_2	1.00E-03	6.98E-03	5.69E-03	1.74E-02	0.00E+00	1.701E+00	2.419E+02
α_3	3.91E-04	4.96E-03	3.68E-03	1.39E-02	0.00E+00	1.207E+00	2.423E+02
α_4	2.24E-05	2.45E-03	1.28E-03	8.82E-03	0.00E+00	5.960E-01	2.430E+02

α_5	3.55E-09	9.08E-04	1.21E-04	4.55E-03	0.00E+00	2.211E-01	2.433E+02
α_6	3.55E-15	4.51E-04	4.56E-06	2.60E-03	0.00E+00	1.098E-01	2.434E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741677	0.9853401	0.9861556	0.9937256	1.0000000	3.863E+02	5.747E+00
α_2	1.17E-03	5.72E-03	4.91E-03	1.31E-02	0.00E+00	2.243E+00	3.898E+02
α_3	5.58E-04	4.16E-03	3.35E-03	1.05E-02	0.00E+00	1.630E+00	3.904E+02
α_4	1.72E-04	2.76E-03	1.98E-03	8.03E-03	0.00E+00	1.083E+00	3.910E+02
α_5	1.04E-05	1.44E-03	7.27E-04	5.30E-03	0.00E+00	5.654E-01	3.915E+02
α_6	2.68E-10	4.89E-04	4.51E-05	2.55E-03	0.00E+00	1.916E-01	3.919E+02
α_7	6.08E-41	8.88E-05	3.30E-12	3.89E-04	0.00E+00	3.480E-02	3.920E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753763	0.9860436	0.9868240	0.9940338	1.0000000	4.045E+02	5.726E+00
α_2	8.87E-04	4.92E-03	4.14E-03	1.16E-02	0.00E+00	2.018E+00	4.082E+02
α_3	3.50E-04	3.39E-03	2.62E-03	9.04E-03	0.00E+00	1.391E+00	4.089E+02
α_4	1.54E-04	2.59E-03	1.84E-03	7.58E-03	0.00E+00	1.062E+00	4.092E+02
α_5	3.02E-05	1.71E-03	1.00E-03	5.82E-03	0.00E+00	7.026E-01	4.095E+02
α_6	3.35E-07	8.53E-04	2.62E-04	3.71E-03	0.00E+00	3.497E-01	4.099E+02
α_7	1.29E-15	2.63E-04	2.41E-06	1.52E-03	0.00E+00	1.078E-01	4.101E+02
α_8	2.69E-17	2.31E-04	9.78E-07	1.34E-03	0.00E+00	9.469E-02	4.102E+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	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.25E-02	1.16E-02	1.18E-02	9.22E-03	6.98E-03	5.72E-03	4.92E-03
α_3		3.76E-03	3.76E-03	5.02E-03	4.96E-03	4.16E-03	3.39E-03
α_4			2.16E-03	1.83E-03	2.45E-03	2.76E-03	2.59E-03
α_5				3.68E-04	9.08E-04	1.44E-03	1.71E-03
α_6					4.51E-04	4.89E-04	8.53E-04
α_7						8.88E-05	2.63E-04
α_8							2.31E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.25E-02	1.53E-02	1.77E-02	1.64E-02	1.57E-02	1.47E-02	1.40E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	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

2.3.2.3 CSS MOTOR-OPERATED VALVES FAIL TO CLOSE: CSS-MOV-OO

Systems/Clean Water/Containment spray recirculation
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

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	0.9443172	0.9857510	0.9937772	0.9999568	1.0000000	3.241E+01	4.685E-01
α_2	4.02E-05	1.42E-02	6.23E-03	5.57E-02	0.00E+00	4.685E-01	3.241E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9535058	0.9836769	0.9880528	0.9988760	1.0000000	6.798E+01	1.128E+00
α_2	4.13E-04	1.23E-02	8.04E-03	3.88E-02	0.00E+00	8.512E-01	6.826E+01
α_3	2.00E-07	4.01E-03	8.58E-04	1.88E-02	0.00E+00	2.768E-01	6.883E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9558071	0.9815382	0.9845699	0.9969069	1.0000000	1.007E+02	1.894E+00
α_2	1.06E-03	1.23E-02	9.29E-03	3.37E-02	0.00E+00	1.260E+00	1.013E+02
α_3	4.27E-06	3.92E-03	1.44E-03	1.62E-02	0.00E+00	4.024E-01	1.022E+02
α_4	1.57E-08	2.26E-03	3.37E-04	1.12E-02	0.00E+00	2.315E-01	1.023E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9662631	0.9831980	0.9847473	0.9948360	1.0000000	2.008E+02	3.432E+00
α_2	1.60E-03	9.42E-03	7.87E-03	2.25E-02	0.00E+00	1.924E+00	2.023E+02
α_3	2.97E-04	5.14E-03	3.64E-03	1.51E-02	0.00E+00	1.049E+00	2.032E+02
α_4	1.42E-06	1.87E-03	6.45E-04	7.89E-03	0.00E+00	3.822E-01	2.039E+02
α_5	3.26E-20	3.76E-04	3.50E-07	2.18E-03	0.00E+00	7.674E-02	2.042E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9687319	0.9839580	0.9852861	0.9946434	1.0000000	2.352E+02	3.835E+00
α_2	1.02E-03	7.12E-03	5.80E-03	1.77E-02	0.00E+00	1.701E+00	2.374E+02
α_3	3.98E-04	5.05E-03	3.75E-03	1.41E-02	0.00E+00	1.207E+00	2.378E+02
α_4	2.29E-05	2.49E-03	1.31E-03	8.98E-03	0.00E+00	5.960E-01	2.385E+02

α_5	3.62E-09	9.25E-04	1.24E-04	4.64E-03	0.00E+00	2.211E-01	2.388E+02
α_6	3.61E-15	4.59E-04	4.65E-06	2.65E-03	0.00E+00	1.098E-01	2.389E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738649	0.9851699	0.9859945	0.9936476	1.0000000	3.818E+02	5.747E+00
α_2	1.18E-03	5.79E-03	4.96E-03	1.32E-02	0.00E+00	2.243E+00	3.853E+02
α_3	5.64E-04	4.20E-03	3.39E-03	1.06E-02	0.00E+00	1.630E+00	3.859E+02
α_4	1.74E-04	2.79E-03	2.00E-03	8.13E-03	0.00E+00	1.083E+00	3.865E+02
α_5	1.05E-05	1.46E-03	7.36E-04	5.36E-03	0.00E+00	5.654E-01	3.870E+02
α_6	2.71E-10	4.94E-04	4.57E-05	2.58E-03	0.00E+00	1.916E-01	3.874E+02
α_7	6.15E-41	8.98E-05	3.34E-12	3.94E-04	0.00E+00	3.480E-02	3.875E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751044	0.9858888	0.9866776	0.9939688	1.0000000	4.000E+02	5.726E+00
α_2	8.97E-04	4.97E-03	4.19E-03	1.17E-02	0.00E+00	2.018E+00	4.037E+02
α_3	3.54E-04	3.43E-03	2.65E-03	9.14E-03	0.00E+00	1.391E+00	4.044E+02
α_4	1.56E-04	2.62E-03	1.86E-03	7.67E-03	0.00E+00	1.062E+00	4.047E+02
α_5	3.06E-05	1.73E-03	1.01E-03	5.88E-03	0.00E+00	7.026E-01	4.050E+02
α_6	3.38E-07	8.62E-04	2.65E-04	3.75E-03	0.00E+00	3.497E-01	4.054E+02
α_7	1.30E-15	2.66E-04	2.44E-06	1.54E-03	0.00E+00	1.078E-01	4.056E+02
α_8	2.72E-17	2.33E-04	9.89E-07	1.36E-03	0.00E+00	9.469E-02	4.057E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.42E-02	1.23E-02	1.23E-02	9.42E-03	7.12E-03	5.79E-03	4.97E-03
α_3		4.01E-03	3.92E-03	5.14E-03	5.05E-03	4.20E-03	3.43E-03
α_4			2.26E-03	1.87E-03	2.49E-03	2.79E-03	2.62E-03
α_5				3.76E-04	9.25E-04	1.46E-03	1.73E-03
α_6					4.59E-04	4.94E-04	8.62E-04
α_7						8.98E-05	2.66E-04
α_8							2.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.42E-02	1.63E-02	1.85E-02	1.68E-02	1.60E-02	1.48E-02	1.41E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	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

2.3.3 BWR Residual Heat Removal Motor-Operated Valves

2.3.3.1 BWR RHR MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: BWR-RHR-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 85.6

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693917	0.9917135	0.9958630	0.9999489	0.9980938	6.605E+01	5.519E-01
α_2	5.40E-05	8.29E-03	4.13E-03	3.06E-02	1.91E-03	5.519E-01	6.605E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9705055	0.9889365	0.9914243	0.9988713	0.9961803	1.232E+02	1.378E+00
α_2	5.75E-04	8.84E-03	6.39E-03	2.55E-02	3.82E-03	1.101E+00	1.235E+02
α_3	1.11E-07	2.22E-03	4.74E-04	1.04E-02	0.00E+00	2.768E-01	1.243E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9702804	0.9866777	0.9884341	0.9970629	0.9942595	1.773E+02	2.394E+00
α_2	1.48E-03	9.79E-03	8.04E-03	2.41E-02	5.74E-03	1.760E+00	1.779E+02
α_3	2.43E-06	2.24E-03	8.21E-04	9.28E-03	0.00E+00	4.024E-01	1.793E+02
α_4	8.92E-09	1.29E-03	1.92E-04	6.38E-03	0.00E+00	2.315E-01	1.794E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740631	0.9864716	0.9875298	0.9952691	0.9938674	2.989E+02	4.099E+00
α_2	1.91E-03	8.28E-03	7.22E-03	1.82E-02	5.37E-03	2.508E+00	3.005E+02
α_3	2.57E-04	3.74E-03	2.72E-03	1.07E-02	7.67E-04	1.132E+00	3.018E+02
α_4	9.58E-07	1.26E-03	4.34E-04	5.32E-03	0.00E+00	3.822E-01	3.026E+02
α_5	2.20E-20	2.53E-04	2.36E-07	1.47E-03	0.00E+00	7.674E-02	3.029E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9758831	0.9869893	0.9878845	0.9950477	0.9935503	3.547E+02	4.675E+00
α_2	1.42E-03	6.57E-03	5.68E-03	1.48E-02	5.06E-03	2.361E+00	3.570E+02
α_3	3.86E-04	3.82E-03	2.95E-03	1.02E-02	1.28E-03	1.374E+00	3.580E+02
α_4	1.72E-05	1.70E-03	9.05E-04	6.07E-03	1.07E-04	6.098E-01	3.587E+02
α_5	2.41E-09	6.15E-04	8.22E-05	3.09E-03	0.00E+00	2.211E-01	3.591E+02
α_6	2.40E-15	3.06E-04	3.09E-06	1.76E-03	0.00E+00	1.098E-01	3.592E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783040	0.9872278	0.9878394	0.9940741	0.9933221	5.226E+02	6.761E+00
α_2	1.52E-03	5.60E-03	4.99E-03	1.18E-02	4.76E-03	2.967E+00	5.264E+02
α_3	5.83E-04	3.55E-03	2.95E-03	8.57E-03	1.64E-03	1.878E+00	5.275E+02
α_4	1.43E-04	2.12E-03	1.54E-03	6.09E-03	2.59E-04	1.122E+00	5.283E+02
α_5	7.89E-06	1.07E-03	5.42E-04	3.93E-03	1.52E-05	5.677E-01	5.288E+02
α_6	1.99E-10	3.62E-04	3.34E-05	1.89E-03	0.00E+00	1.916E-01	5.292E+02
α_7	4.50E-41	6.57E-05	2.44E-12	2.88E-04	0.00E+00	3.480E-02	5.293E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9794694	0.9878610	0.9884302	0.9943122	0.9931774	5.622E+02	6.908E+00
α_2	1.25E-03	4.90E-03	4.34E-03	1.05E-02	4.45E-03	2.790E+00	5.663E+02
α_3	4.38E-04	3.02E-03	2.46E-03	7.51E-03	1.89E-03	1.718E+00	5.674E+02
α_4	1.38E-04	2.00E-03	1.45E-03	5.71E-03	4.28E-04	1.136E+00	5.680E+02
α_5	2.30E-05	1.25E-03	7.35E-04	4.23E-03	4.90E-05	7.111E-01	5.684E+02
α_6	2.44E-07	6.15E-04	1.89E-04	2.67E-03	2.23E-06	3.501E-01	5.687E+02
α_7	9.26E-16	1.89E-04	1.74E-06	1.09E-03	0.00E+00	1.078E-01	5.690E+02
α_8	1.94E-17	1.66E-04	7.05E-07	9.69E-04	0.00E+00	9.469E-02	5.690E+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	9.89E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.88E-01
α_2	8.29E-03	8.84E-03	9.79E-03	8.28E-03	6.57E-03	5.60E-03	4.90E-03
α_3		2.22E-03	2.24E-03	3.74E-03	3.82E-03	3.55E-03	3.02E-03
α_4			1.29E-03	1.26E-03	1.70E-03	2.12E-03	2.00E-03
α_5				2.53E-04	6.15E-04	1.07E-03	1.25E-03
α_6					3.06E-04	3.62E-04	6.15E-04
α_7						6.57E-05	1.89E-04
α_8							1.66E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.89E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.88E-01
Beta	8.29E-03	1.11E-02	1.33E-02	1.35E-02	1.30E-02	1.28E-02	1.21E-02
Gamma		2.01E-01	2.65E-01	3.88E-01	4.95E-01	5.61E-01	5.96E-01

Delta			3.65E-01	2.88E-01	4.06E-01	5.05E-01	5.83E-01
Epsilon				1.67E-01	3.52E-01	4.14E-01	5.27E-01
Mu					3.32E-01	2.85E-01	4.37E-01
Omega						1.54E-01	3.66E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	42.80	64.20	85.60	107.00	128.40	149.80	171.20
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

2.3.3.2 BWR RHR MOTOR-OPERATED VALVES FAIL TO OPEN: BWR-RHR-MOV-CC

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: 2006 through 2020

Total Number of Independent Failure Events: 53.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757865	0.9938255	0.9973353	0.9999811	1.0000000	7.541E+01	4.685E-01
α_2	1.72E-05	6.17E-03	2.67E-03	2.42E-02	0.00E+00	4.685E-01	7.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712525	0.9899378	0.9926611	0.9993063	1.0000000	1.110E+02	1.128E+00
α_2	2.53E-04	7.59E-03	4.94E-03	2.40E-02	0.00E+00	8.512E-01	1.113E+02
α_3	1.23E-07	2.47E-03	5.27E-04	1.16E-02	0.00E+00	2.768E-01	1.118E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9687875	0.9869917	0.9891444	0.9978285	1.0000000	1.437E+02	1.894E+00
α_2	7.46E-04	8.65E-03	6.53E-03	2.38E-02	0.00E+00	1.260E+00	1.443E+02
α_3	3.00E-06	2.76E-03	1.01E-03	1.15E-02	0.00E+00	4.024E-01	1.452E+02
α_4	1.10E-08	1.59E-03	2.37E-04	7.87E-03	0.00E+00	2.315E-01	1.453E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9721001	0.9861198	0.9874109	0.9957402	1.0000000	2.438E+02	3.432E+00
α_2	1.32E-03	7.78E-03	6.50E-03	1.86E-02	0.00E+00	1.924E+00	2.453E+02
α_3	2.45E-04	4.24E-03	3.00E-03	1.25E-02	0.00E+00	1.049E+00	2.462E+02
α_4	1.17E-06	1.55E-03	5.33E-04	6.52E-03	0.00E+00	3.822E-01	2.469E+02
α_5	2.69E-20	3.10E-04	2.89E-07	1.80E-03	0.00E+00	7.674E-02	2.472E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734772	0.9864036	0.9875387	0.9954610	1.0000000	2.782E+02	3.835E+00
α_2	8.64E-04	6.03E-03	4.91E-03	1.50E-02	0.00E+00	1.701E+00	2.804E+02

α_3	3.37E-04	4.28E-03	3.18E-03	1.20E-02	0.00E+00	1.207E+00	2.808E+02
α_4	1.94E-05	2.11E-03	1.11E-03	7.61E-03	0.00E+00	5.960E-01	2.815E+02
α_5	3.07E-09	7.84E-04	1.05E-04	3.93E-03	0.00E+00	2.211E-01	2.818E+02
α_6	3.06E-15	3.89E-04	3.94E-06	2.24E-03	0.00E+00	1.098E-01	2.819E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9764700	0.9866510	0.9874005	0.9942902	1.0000000	4.248E+02	5.747E+00
α_2	1.07E-03	5.21E-03	4.47E-03	1.19E-02	0.00E+00	2.243E+00	4.283E+02
α_3	5.08E-04	3.78E-03	3.05E-03	9.57E-03	0.00E+00	1.630E+00	4.289E+02
α_4	1.56E-04	2.52E-03	1.80E-03	7.32E-03	0.00E+00	1.083E+00	4.295E+02
α_5	9.49E-06	1.31E-03	6.62E-04	4.82E-03	0.00E+00	5.654E-01	4.300E+02
α_6	2.44E-10	4.45E-04	4.11E-05	2.32E-03	0.00E+00	1.916E-01	4.304E+02
α_7	5.54E-41	8.08E-05	3.01E-12	3.54E-04	0.00E+00	3.480E-02	4.305E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9774856	0.9872410	0.9879605	0.9945491	1.0000000	4.430E+02	5.726E+00
α_2	8.11E-04	4.50E-03	3.79E-03	1.06E-02	0.00E+00	2.018E+00	4.467E+02
α_3	3.20E-04	3.10E-03	2.40E-03	8.27E-03	0.00E+00	1.391E+00	4.474E+02
α_4	1.41E-04	2.37E-03	1.68E-03	6.93E-03	0.00E+00	1.062E+00	4.477E+02
α_5	2.76E-05	1.57E-03	9.15E-04	5.32E-03	0.00E+00	7.026E-01	4.480E+02
α_6	3.06E-07	7.79E-04	2.39E-04	3.39E-03	0.00E+00	3.497E-01	4.484E+02
α_7	1.18E-15	2.40E-04	2.21E-06	1.39E-03	0.00E+00	1.078E-01	4.486E+02
α_8	2.46E-17	2.11E-04	8.94E-07	1.23E-03	0.00E+00	9.469E-02	4.487E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
α_2	6.17E-03	7.59E-03	8.65E-03	7.78E-03	6.03E-03	5.21E-03	4.50E-03
α_3		2.47E-03	2.76E-03	4.24E-03	4.28E-03	3.78E-03	3.10E-03
α_4			1.59E-03	1.55E-03	2.11E-03	2.52E-03	2.37E-03
α_5				3.10E-04	7.84E-04	1.31E-03	1.57E-03
α_6					3.89E-04	4.45E-04	7.79E-04
α_7						8.08E-05	2.40E-04
α_8							2.11E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
Beta	6.17E-03	1.01E-02	1.30E-02	1.39E-02	1.36E-02	1.33E-02	1.28E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	53.00	53.00	53.00	53.00	53.00	53.00	53.00
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

2.3.3.3 BWR RHR MOTOR-OPERATED VALVES FAIL TO CLOSE: BWR-RHR-MOV-OO

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: 2006 through 2020

Total Number of Independent Failure Events: 29.6

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9473314	0.9857024	0.9928196	0.9999118	0.9946978	3.805E+01	5.519E-01
α_2	9.40E-05	1.43E-02	7.18E-03	5.27E-02	5.30E-03	5.519E-01	3.805E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9556220	0.9833080	0.9870256	0.9982835	0.9893390	8.118E+01	1.378E+00
α_2	8.71E-04	1.33E-02	9.66E-03	3.84E-02	1.07E-02	1.101E+00	8.146E+01
α_3	1.67E-07	3.35E-03	7.17E-04	1.57E-02	0.00E+00	2.768E-01	8.228E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9569271	0.9806450	0.9831764	0.9957170	0.9839228	1.213E+02	2.394E+00
α_2	2.15E-03	1.42E-02	1.17E-02	3.49E-02	1.61E-02	1.760E+00	1.219E+02
α_3	3.53E-06	3.25E-03	1.19E-03	1.35E-02	0.00E+00	4.024E-01	1.233E+02
α_4	1.30E-08	1.87E-03	2.79E-04	9.27E-03	0.00E+00	2.315E-01	1.234E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9663174	0.9824069	0.9837669	0.9938419	0.9827772	2.289E+02	4.099E+00
α_2	2.49E-03	1.08E-02	9.40E-03	2.37E-02	1.51E-02	2.508E+00	2.305E+02
α_3	3.35E-04	4.86E-03	3.54E-03	1.39E-02	2.15E-03	1.132E+00	2.318E+02
α_4	1.25E-06	1.64E-03	5.65E-04	6.92E-03	0.00E+00	3.822E-01	2.326E+02
α_5	2.86E-20	3.29E-04	3.07E-07	1.91E-03	0.00E+00	7.674E-02	2.329E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9685599	0.9830200	0.9841739	0.9935264	0.9818444	2.707E+02	4.675E+00
α_2	1.86E-03	8.57E-03	7.42E-03	1.92E-02	1.43E-02	2.361E+00	2.730E+02

α_3	5.05E-04	4.99E-03	3.85E-03	1.34E-02	3.60E-03	1.374E+00	2.740E+02
α_4	2.24E-05	2.21E-03	1.18E-03	7.92E-03	3.00E-04	6.098E-01	2.747E+02
α_5	3.14E-09	8.03E-04	1.07E-04	4.03E-03	0.00E+00	2.211E-01	2.751E+02
α_6	3.14E-15	3.99E-04	4.04E-06	2.30E-03	0.00E+00	1.098E-01	2.752E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733923	0.9843262	0.9850665	0.9927257	0.9811638	4.246E+02	6.761E+00
α_2	1.86E-03	6.88E-03	6.13E-03	1.44E-02	1.34E-02	2.967E+00	4.284E+02
α_3	7.15E-04	4.35E-03	3.62E-03	1.05E-02	4.62E-03	1.878E+00	4.295E+02
α_4	1.75E-04	2.60E-03	1.89E-03	7.47E-03	7.31E-04	1.122E+00	4.303E+02
α_5	9.69E-06	1.32E-03	6.66E-04	4.83E-03	4.30E-05	5.677E-01	4.308E+02
α_6	2.44E-10	4.44E-04	4.10E-05	2.31E-03	0.00E+00	1.916E-01	4.312E+02
α_7	5.53E-41	8.07E-05	3.00E-12	3.54E-04	0.00E+00	3.480E-02	4.313E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744672	0.9848866	0.9855860	0.9929109	0.9807216	4.502E+02	6.908E+00
α_2	1.56E-03	6.10E-03	5.40E-03	1.30E-02	1.26E-02	2.790E+00	4.543E+02
α_3	5.46E-04	3.76E-03	3.07E-03	9.35E-03	5.35E-03	1.718E+00	4.554E+02
α_4	1.72E-04	2.49E-03	1.81E-03	7.11E-03	1.21E-03	1.136E+00	4.560E+02
α_5	2.87E-05	1.56E-03	9.15E-04	5.26E-03	1.38E-04	7.111E-01	4.564E+02
α_6	3.03E-07	7.66E-04	2.35E-04	3.33E-03	6.29E-06	3.501E-01	4.567E+02
α_7	1.15E-15	2.36E-04	2.16E-06	1.36E-03	0.00E+00	1.078E-01	4.570E+02
α_8	2.41E-17	2.07E-04	8.77E-07	1.21E-03	0.00E+00	9.469E-02	4.570E+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	9.83E-01	9.81E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
α_2	1.43E-02	1.33E-02	1.42E-02	1.08E-02	8.57E-03	6.88E-03	6.10E-03
α_3		3.35E-03	3.25E-03	4.86E-03	4.99E-03	4.35E-03	3.76E-03
α_4			1.87E-03	1.64E-03	2.21E-03	2.60E-03	2.49E-03
α_5				3.29E-04	8.03E-04	1.32E-03	1.56E-03
α_6					3.99E-04	4.44E-04	7.66E-04
α_7						8.07E-05	2.36E-04
α_8							2.07E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.83E-01	9.81E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
Beta	1.43E-02	1.67E-02	1.94E-02	1.76E-02	1.70E-02	1.57E-02	1.51E-02
Gamma		2.01E-01	2.65E-01	3.88E-01	4.95E-01	5.61E-01	5.96E-01
Delta			3.65E-01	2.88E-01	4.06E-01	5.05E-01	5.83E-01
Epsilon				1.67E-01	3.52E-01	4.14E-01	5.27E-01
Mu					3.32E-01	2.85E-01	4.37E-01
Omega						1.54E-01	3.66E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	14.80	22.20	29.60	37.00	44.40	51.80	59.20
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 Pressurizer Power-Operated Relief Valve Motor-Operated Block Valves

2.3.4.1 PRESSURIZER PORV BLOCK MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: PWR-RCS-MOV-FTOC

Plants/PWR
Systems/Clean Water/Reactor coolant
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: 2006 through 2020

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	0.9443172	0.9857510	0.9937772	0.9999568	1.0000000	3.241E+01	4.685E-01
α_2	4.02E-05	1.42E-02	6.23E-03	5.57E-02	0.00E+00	4.685E-01	3.241E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9535058	0.9836769	0.9880528	0.9988760	1.0000000	6.798E+01	1.128E+00
α_2	4.13E-04	1.23E-02	8.04E-03	3.88E-02	0.00E+00	8.512E-01	6.826E+01
α_3	2.00E-07	4.01E-03	8.58E-04	1.88E-02	0.00E+00	2.768E-01	6.883E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9558071	0.9815382	0.9845699	0.9969069	1.0000000	1.007E+02	1.894E+00
α_2	1.06E-03	1.23E-02	9.29E-03	3.37E-02	0.00E+00	1.260E+00	1.013E+02
α_3	4.27E-06	3.92E-03	1.44E-03	1.62E-02	0.00E+00	4.024E-01	1.022E+02
α_4	1.57E-08	2.26E-03	3.37E-04	1.12E-02	0.00E+00	2.315E-01	1.023E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9662631	0.9831980	0.9847473	0.9948360	1.0000000	2.008E+02	3.432E+00
α_2	1.60E-03	9.42E-03	7.87E-03	2.25E-02	0.00E+00	1.924E+00	2.023E+02
α_3	2.97E-04	5.14E-03	3.64E-03	1.51E-02	0.00E+00	1.049E+00	2.032E+02
α_4	1.42E-06	1.87E-03	6.45E-04	7.89E-03	0.00E+00	3.822E-01	2.039E+02
α_5	3.26E-20	3.76E-04	3.50E-07	2.18E-03	0.00E+00	7.674E-02	2.042E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9687319	0.9839580	0.9852861	0.9946434	1.0000000	2.352E+02	3.835E+00
α_2	1.02E-03	7.12E-03	5.80E-03	1.77E-02	0.00E+00	1.701E+00	2.374E+02
α_3	3.98E-04	5.05E-03	3.75E-03	1.41E-02	0.00E+00	1.207E+00	2.378E+02
α_4	2.29E-05	2.49E-03	1.31E-03	8.98E-03	0.00E+00	5.960E-01	2.385E+02
α_5	3.62E-09	9.25E-04	1.24E-04	4.64E-03	0.00E+00	2.211E-01	2.388E+02
α_6	3.61E-15	4.59E-04	4.65E-06	2.65E-03	0.00E+00	1.098E-01	2.389E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738649	0.9851699	0.9859945	0.9936476	1.0000000	3.818E+02	5.747E+00
α_2	1.18E-03	5.79E-03	4.96E-03	1.32E-02	0.00E+00	2.243E+00	3.853E+02
α_3	5.64E-04	4.20E-03	3.39E-03	1.06E-02	0.00E+00	1.630E+00	3.859E+02
α_4	1.74E-04	2.79E-03	2.00E-03	8.13E-03	0.00E+00	1.083E+00	3.865E+02
α_5	1.05E-05	1.46E-03	7.36E-04	5.36E-03	0.00E+00	5.654E-01	3.870E+02
α_6	2.71E-10	4.94E-04	4.57E-05	2.58E-03	0.00E+00	1.916E-01	3.874E+02
α_7	6.15E-41	8.98E-05	3.34E-12	3.94E-04	0.00E+00	3.480E-02	3.875E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9751044	0.9858888	0.9866776	0.9939688	1.0000000	4.000E+02	5.726E+00
α_2	8.97E-04	4.97E-03	4.19E-03	1.17E-02	0.00E+00	2.018E+00	4.037E+02
α_3	3.54E-04	3.43E-03	2.65E-03	9.14E-03	0.00E+00	1.391E+00	4.044E+02
α_4	1.56E-04	2.62E-03	1.86E-03	7.67E-03	0.00E+00	1.062E+00	4.047E+02
α_5	3.06E-05	1.73E-03	1.01E-03	5.88E-03	0.00E+00	7.026E-01	4.050E+02
α_6	3.38E-07	8.62E-04	2.65E-04	3.75E-03	0.00E+00	3.497E-01	4.054E+02
α_7	1.30E-15	2.66E-04	2.44E-06	1.54E-03	0.00E+00	1.078E-01	4.056E+02
α_8	2.72E-17	2.33E-04	9.89E-07	1.36E-03	0.00E+00	9.469E-02	4.057E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.42E-02	1.23E-02	1.23E-02	9.42E-03	7.12E-03	5.79E-03	4.97E-03
α_3		4.01E-03	3.92E-03	5.14E-03	5.05E-03	4.20E-03	3.43E-03
α_4			2.26E-03	1.87E-03	2.49E-03	2.79E-03	2.62E-03
α_5				3.76E-04	9.25E-04	1.46E-03	1.73E-03
α_6					4.59E-04	4.94E-04	8.62E-04
α_7						8.98E-05	2.66E-04
α_8							2.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.42E-02	1.63E-02	1.85E-02	1.68E-02	1.60E-02	1.48E-02	1.41E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01

Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	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

2.3.4.2 PRESSURIZER PORV BLOCK MOTOR-OPERATED VALVES FAIL TO OPEN: PWR-RCS-MOV-CC

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

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	0.9319869	0.9825706	0.9923504	0.9999473	1.0000000	2.641E+01	4.685E-01
α_2	4.94E-05	1.74E-02	7.65E-03	6.80E-02	0.00E+00	4.685E-01	2.641E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9491259	0.9821250	0.9869099	0.9987658	1.0000000	6.198E+01	1.128E+00
α_2	4.53E-04	1.35E-02	8.81E-03	4.25E-02	0.00E+00	8.512E-01	6.226E+01
α_3	2.19E-07	4.39E-03	9.41E-04	2.06E-02	0.00E+00	2.768E-01	6.283E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9530858	0.9803911	0.9836046	0.9967121	1.0000000	9.468E+01	1.894E+00
α_2	1.13E-03	1.30E-02	9.87E-03	3.58E-02	0.00E+00	1.260E+00	9.531E+01
α_3	4.53E-06	4.17E-03	1.53E-03	1.73E-02	0.00E+00	4.024E-01	9.617E+01
α_4	1.66E-08	2.40E-03	3.58E-04	1.19E-02	0.00E+00	2.315E-01	9.634E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9652486	0.9826895	0.9842843	0.9946781	1.0000000	1.948E+02	3.432E+00
α_2	1.65E-03	9.70E-03	8.11E-03	2.32E-02	0.00E+00	1.924E+00	1.963E+02
α_3	3.06E-04	5.29E-03	3.75E-03	1.55E-02	0.00E+00	1.049E+00	1.972E+02
α_4	1.47E-06	1.93E-03	6.65E-04	8.13E-03	0.00E+00	3.822E-01	1.979E+02
α_5	3.36E-20	3.87E-04	3.61E-07	2.25E-03	0.00E+00	7.674E-02	1.982E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679315	0.9835450	0.9849062	0.9944998	1.0000000	2.292E+02	3.835E+00
α_2	1.05E-03	7.30E-03	5.95E-03	1.82E-02	0.00E+00	1.701E+00	2.314E+02
α_3	4.09E-04	5.18E-03	3.85E-03	1.45E-02	0.00E+00	1.207E+00	2.318E+02
α_4	2.34E-05	2.56E-03	1.34E-03	9.21E-03	0.00E+00	5.960E-01	2.325E+02
α_5	3.71E-09	9.49E-04	1.27E-04	4.76E-03	0.00E+00	2.211E-01	2.328E+02
α_6	3.71E-15	4.71E-04	4.77E-06	2.72E-03	0.00E+00	1.098E-01	2.329E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734614	0.9849367	0.9857739	0.9935469	1.0000000	3.758E+02	5.747E+00
α_2	1.20E-03	5.88E-03	5.04E-03	1.34E-02	0.00E+00	2.243E+00	3.793E+02
α_3	5.73E-04	4.27E-03	3.44E-03	1.08E-02	0.00E+00	1.630E+00	3.799E+02
α_4	1.77E-04	2.84E-03	2.03E-03	8.26E-03	0.00E+00	1.083E+00	3.805E+02
α_5	1.07E-05	1.48E-03	7.47E-04	5.44E-03	0.00E+00	5.654E-01	3.810E+02
α_6	2.76E-10	5.02E-04	4.64E-05	2.62E-03	0.00E+00	1.916E-01	3.814E+02
α_7	6.25E-41	9.12E-05	3.39E-12	4.00E-04	0.00E+00	3.480E-02	3.815E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747326	0.9856770	0.9864773	0.9938818	1.0000000	3.940E+02	5.726E+00
α_2	9.10E-04	5.05E-03	4.25E-03	1.19E-02	0.00E+00	2.018E+00	3.977E+02
α_3	3.59E-04	3.48E-03	2.69E-03	9.28E-03	0.00E+00	1.391E+00	3.984E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.78E-03	0.00E+00	1.062E+00	3.987E+02
α_5	3.10E-05	1.76E-03	1.03E-03	5.97E-03	0.00E+00	7.026E-01	3.990E+02
α_6	3.44E-07	8.75E-04	2.69E-04	3.80E-03	0.00E+00	3.497E-01	3.994E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.996E+02
α_8	2.76E-17	2.37E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	3.997E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.74E-02	1.35E-02	1.30E-02	9.70E-03	7.30E-03	5.88E-03	5.05E-03
α_3		4.39E-03	4.17E-03	5.29E-03	5.18E-03	4.27E-03	3.48E-03
α_4			2.40E-03	1.93E-03	2.56E-03	2.84E-03	2.66E-03
α_5				3.87E-04	9.49E-04	1.48E-03	1.76E-03
α_6					4.71E-04	5.02E-04	8.75E-04
α_7						9.12E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.74E-02	1.79E-02	1.96E-02	1.73E-02	1.65E-02	1.51E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

2.3.4.3 PRESSURIZER PORV BLOCK MOTOR-OPERATED VALVES FAIL TO CLOSE: PWR-RCS-MOV-OO

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

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	0.9344075	0.9831957	0.9926358	0.9999492	1.0000000	2.741E+01	4.685E-01
α_2	4.76E-05	1.68E-02	7.37E-03	6.56E-02	0.00E+00	4.685E-01	2.741E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9499123	0.9824038	0.9871113	0.9987856	1.0000000	6.298E+01	1.128E+00
α_2	4.46E-04	1.33E-02	8.67E-03	4.18E-02	0.00E+00	8.512E-01	6.326E+01
α_3	2.16E-07	4.32E-03	9.26E-04	2.03E-02	0.00E+00	2.768E-01	6.383E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9535624	0.9805921	0.9837738	0.9967462	1.0000000	9.568E+01	1.894E+00
α_2	1.12E-03	1.29E-02	9.77E-03	3.55E-02	0.00E+00	1.260E+00	9.631E+01
α_3	4.49E-06	4.12E-03	1.52E-03	1.71E-02	0.00E+00	4.024E-01	9.717E+01
α_4	1.65E-08	2.37E-03	3.54E-04	1.17E-02	0.00E+00	2.315E-01	9.734E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9654219	0.9827764	0.9843634	0.9947051	1.0000000	1.958E+02	3.432E+00
α_2	1.64E-03	9.66E-03	8.07E-03	2.31E-02	0.00E+00	1.924E+00	1.973E+02
α_3	3.05E-04	5.26E-03	3.73E-03	1.55E-02	0.00E+00	1.049E+00	1.982E+02
α_4	1.46E-06	1.92E-03	6.61E-04	8.09E-03	0.00E+00	3.822E-01	1.989E+02
α_5	3.35E-20	3.85E-04	3.59E-07	2.24E-03	0.00E+00	7.674E-02	1.992E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680677	0.9836153	0.9849709	0.9945233	1.0000000	2.302E+02	3.835E+00
α_2	1.04E-03	7.27E-03	5.92E-03	1.81E-02	0.00E+00	1.701E+00	2.324E+02

α_3	4.07E-04	5.16E-03	3.83E-03	1.44E-02	0.00E+00	1.207E+00	2.328E+02
α_4	2.33E-05	2.55E-03	1.34E-03	9.17E-03	0.00E+00	5.960E-01	2.335E+02
α_5	3.70E-09	9.45E-04	1.26E-04	4.74E-03	0.00E+00	2.211E-01	2.338E+02
α_6	3.69E-15	4.69E-04	4.75E-06	2.71E-03	0.00E+00	1.098E-01	2.339E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735302	0.9849761	0.9858111	0.9935639	1.0000000	3.768E+02	5.747E+00
α_2	1.20E-03	5.86E-03	5.03E-03	1.34E-02	0.00E+00	2.243E+00	3.803E+02
α_3	5.72E-04	4.26E-03	3.43E-03	1.08E-02	0.00E+00	1.630E+00	3.809E+02
α_4	1.76E-04	2.83E-03	2.03E-03	8.23E-03	0.00E+00	1.083E+00	3.815E+02
α_5	1.07E-05	1.48E-03	7.45E-04	5.43E-03	0.00E+00	5.654E-01	3.820E+02
α_6	2.75E-10	5.01E-04	4.63E-05	2.61E-03	0.00E+00	1.916E-01	3.824E+02
α_7	6.23E-41	9.10E-05	3.38E-12	3.99E-04	0.00E+00	3.480E-02	3.825E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747953	0.9857127	0.9865111	0.9938970	1.0000000	3.950E+02	5.726E+00
α_2	9.08E-04	5.04E-03	4.24E-03	1.19E-02	0.00E+00	2.018E+00	3.987E+02
α_3	3.58E-04	3.47E-03	2.69E-03	9.26E-03	0.00E+00	1.391E+00	3.994E+02
α_4	1.58E-04	2.65E-03	1.88E-03	7.76E-03	0.00E+00	1.062E+00	3.997E+02
α_5	3.09E-05	1.75E-03	1.02E-03	5.95E-03	0.00E+00	7.026E-01	4.000E+02
α_6	3.43E-07	8.73E-04	2.68E-04	3.80E-03	0.00E+00	3.497E-01	4.004E+02
α_7	1.32E-15	2.69E-04	2.47E-06	1.55E-03	0.00E+00	1.078E-01	4.006E+02
α_8	2.75E-17	2.36E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	4.007E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.68E-02	1.33E-02	1.29E-02	9.66E-03	7.27E-03	5.86E-03	5.04E-03
α_3		4.32E-03	4.12E-03	5.26E-03	5.16E-03	4.26E-03	3.47E-03
α_4			2.37E-03	1.92E-03	2.55E-03	2.83E-03	2.65E-03
α_5				3.85E-04	9.45E-04	1.48E-03	1.75E-03
α_6					4.69E-04	5.01E-04	8.73E-04
α_7						9.10E-05	2.69E-04
α_8							2.36E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.68E-02	1.76E-02	1.94E-02	1.72E-02	1.64E-02	1.50E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	5.00	5.00	5.00	5.00	5.00	5.00	5.00
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

2.3.5 Auxiliary Feedwater Motor-Operated Valves

2.3.5.1 AFW MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: AFW-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 56.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9767335	0.9940679	0.9974409	0.9999818	1.0000000	7.851E+01	4.685E-01
α_2	1.65E-05	5.93E-03	2.56E-03	2.33E-02	0.00E+00	4.685E-01	7.851E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9720222	0.9902086	0.9928599	0.9993250	1.0000000	1.141E+02	1.128E+00
α_2	2.46E-04	7.39E-03	4.80E-03	2.34E-02	0.00E+00	8.512E-01	1.144E+02
α_3	1.20E-07	2.40E-03	5.13E-04	1.13E-02	0.00E+00	2.768E-01	1.149E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694361	0.9872629	0.9893720	0.9978741	1.0000000	1.468E+02	1.894E+00
α_2	7.31E-04	8.47E-03	6.39E-03	2.33E-02	0.00E+00	1.260E+00	1.474E+02
α_3	2.94E-06	2.71E-03	9.93E-04	1.12E-02	0.00E+00	4.024E-01	1.483E+02
α_4	1.08E-08	1.56E-03	2.32E-04	7.71E-03	0.00E+00	2.315E-01	1.484E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724448	0.9862917	0.9875671	0.9957884	1.0000000	2.469E+02	3.432E+00
α_2	1.31E-03	7.69E-03	6.42E-03	1.84E-02	0.00E+00	1.924E+00	2.484E+02
α_3	2.42E-04	4.19E-03	2.97E-03	1.23E-02	0.00E+00	1.049E+00	2.493E+02
α_4	1.16E-06	1.53E-03	5.26E-04	6.44E-03	0.00E+00	3.822E-01	2.500E+02
α_5	2.66E-20	3.07E-04	2.85E-07	1.78E-03	0.00E+00	7.674E-02	2.503E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9737589	0.9865514	0.9876744	0.9955109	1.0000000	2.813E+02	3.835E+00
α_2	8.55E-04	5.97E-03	4.86E-03	1.49E-02	0.00E+00	1.701E+00	2.835E+02
α_3	3.34E-04	4.23E-03	3.15E-03	1.18E-02	0.00E+00	1.207E+00	2.839E+02
α_4	1.91E-05	2.09E-03	1.10E-03	7.53E-03	0.00E+00	5.960E-01	2.846E+02
α_5	3.03E-09	7.75E-04	1.04E-04	3.89E-03	0.00E+00	2.211E-01	2.849E+02
α_6	3.03E-15	3.85E-04	3.90E-06	2.22E-03	0.00E+00	1.098E-01	2.850E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9766375	0.9867465	0.9874907	0.9943259	1.0000000	4.279E+02	5.747E+00
α_2	1.06E-03	5.17E-03	4.43E-03	1.18E-02	0.00E+00	2.243E+00	4.314E+02
α_3	5.04E-04	3.76E-03	3.03E-03	9.51E-03	0.00E+00	1.630E+00	4.320E+02
α_4	1.55E-04	2.50E-03	1.79E-03	7.27E-03	0.00E+00	1.083E+00	4.326E+02
α_5	9.42E-06	1.30E-03	6.57E-04	4.79E-03	0.00E+00	5.654E-01	4.331E+02
α_6	2.43E-10	4.42E-04	4.08E-05	2.30E-03	0.00E+00	1.916E-01	4.335E+02
α_7	5.50E-41	8.03E-05	2.98E-12	3.52E-04	0.00E+00	3.480E-02	4.336E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9776385	0.9873285	0.9880431	0.9945867	1.0000000	4.461E+02	5.726E+00
α_2	8.05E-04	4.47E-03	3.76E-03	1.05E-02	0.00E+00	2.018E+00	4.498E+02
α_3	3.18E-04	3.08E-03	2.38E-03	8.21E-03	0.00E+00	1.391E+00	4.505E+02
α_4	1.40E-04	2.35E-03	1.67E-03	6.89E-03	0.00E+00	1.062E+00	4.508E+02
α_5	2.74E-05	1.55E-03	9.08E-04	5.28E-03	0.00E+00	7.026E-01	4.511E+02
α_6	3.04E-07	7.74E-04	2.38E-04	3.37E-03	0.00E+00	3.497E-01	4.515E+02
α_7	1.17E-15	2.39E-04	2.19E-06	1.38E-03	0.00E+00	1.078E-01	4.517E+02
α_8	2.44E-17	2.10E-04	8.88E-07	1.22E-03	0.00E+00	9.469E-02	4.518E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
α_2	5.93E-03	7.39E-03	8.47E-03	7.69E-03	5.97E-03	5.17E-03	4.47E-03
α_3		2.40E-03	2.71E-03	4.19E-03	4.23E-03	3.76E-03	3.08E-03
α_4			1.56E-03	1.53E-03	2.09E-03	2.50E-03	2.35E-03
α_5				3.07E-04	7.75E-04	1.30E-03	1.55E-03
α_6					3.85E-04	4.42E-04	7.74E-04
α_7						8.03E-05	2.39E-04
α_8							2.10E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
Beta	5.93E-03	9.79E-03	1.27E-02	1.37E-02	1.34E-02	1.33E-02	1.27E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	56.10	56.10	56.10	56.10	56.10	56.10	56.10
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

2.3.5.2 AFW MOTOR-OPERATED VALVES FAIL TO OPEN: AFW-MOV-CC

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 31.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9662487	0.9913844	0.9962619	0.9999737	1.0000000	5.391E+01	4.685E-01
α_2	2.41E-05	8.62E-03	3.74E-03	3.37E-02	0.00E+00	4.685E-01	5.391E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9644684	0.9875502	0.9909137	0.9991407	1.0000000	8.948E+01	1.128E+00
α_2	3.14E-04	9.39E-03	6.11E-03	2.97E-02	0.00E+00	8.512E-01	8.976E+01
α_3	1.52E-07	3.06E-03	6.53E-04	1.43E-02	0.00E+00	2.768E-01	9.033E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9634165	0.9847374	0.9872580	0.9974485	1.0000000	1.222E+02	1.894E+00
α_2	8.77E-04	1.02E-02	7.67E-03	2.79E-02	0.00E+00	1.260E+00	1.228E+02
α_3	3.52E-06	3.24E-03	1.19E-03	1.34E-02	0.00E+00	4.024E-01	1.237E+02
α_4	1.29E-08	1.87E-03	2.78E-04	9.24E-03	0.00E+00	2.315E-01	1.238E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694579	0.9847980	0.9862088	0.9953318	1.0000000	2.223E+02	3.432E+00
α_2	1.45E-03	8.52E-03	7.12E-03	2.04E-02	0.00E+00	1.924E+00	2.238E+02
α_3	2.69E-04	4.65E-03	3.29E-03	1.37E-02	0.00E+00	1.049E+00	2.247E+02
α_4	1.29E-06	1.69E-03	5.83E-04	7.14E-03	0.00E+00	3.822E-01	2.254E+02
α_5	2.95E-20	3.40E-04	3.17E-07	1.97E-03	0.00E+00	7.674E-02	2.257E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712936	0.9852817	0.9865081	0.9950888	1.0000000	2.567E+02	3.835E+00
α_2	9.36E-04	6.53E-03	5.32E-03	1.63E-02	0.00E+00	1.701E+00	2.589E+02
α_3	3.65E-04	4.63E-03	3.44E-03	1.30E-02	0.00E+00	1.207E+00	2.593E+02
α_4	2.10E-05	2.29E-03	1.20E-03	8.24E-03	0.00E+00	5.960E-01	2.600E+02

α_5	3.32E-09	8.49E-04	1.13E-04	4.26E-03	0.00E+00	2.211E-01	2.603E+02
α_6	3.31E-15	4.21E-04	4.26E-06	2.43E-03	0.00E+00	1.098E-01	2.604E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752330	0.9859494	0.9867319	0.9939830	1.0000000	4.033E+02	5.747E+00
α_2	1.12E-03	5.48E-03	4.70E-03	1.25E-02	0.00E+00	2.243E+00	4.068E+02
α_3	5.34E-04	3.98E-03	3.21E-03	1.01E-02	0.00E+00	1.630E+00	4.074E+02
α_4	1.65E-04	2.65E-03	1.89E-03	7.70E-03	0.00E+00	1.083E+00	4.080E+02
α_5	9.99E-06	1.38E-03	6.97E-04	5.08E-03	0.00E+00	5.654E-01	4.085E+02
α_6	2.57E-10	4.68E-04	4.33E-05	2.44E-03	0.00E+00	1.916E-01	4.089E+02
α_7	5.83E-41	8.51E-05	3.16E-12	3.73E-04	0.00E+00	3.480E-02	4.090E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9763517	0.9865989	0.9873541	0.9942791	1.0000000	4.215E+02	5.726E+00
α_2	8.51E-04	4.72E-03	3.98E-03	1.11E-02	0.00E+00	2.018E+00	4.252E+02
α_3	3.36E-04	3.25E-03	2.52E-03	8.68E-03	0.00E+00	1.391E+00	4.259E+02
α_4	1.48E-04	2.49E-03	1.77E-03	7.28E-03	0.00E+00	1.062E+00	4.262E+02
α_5	2.90E-05	1.64E-03	9.61E-04	5.59E-03	0.00E+00	7.026E-01	4.265E+02
α_6	3.21E-07	8.19E-04	2.51E-04	3.56E-03	0.00E+00	3.497E-01	4.269E+02
α_7	1.23E-15	2.52E-04	2.32E-06	1.46E-03	0.00E+00	1.078E-01	4.271E+02
α_8	2.58E-17	2.22E-04	9.39E-07	1.29E-03	0.00E+00	9.469E-02	4.272E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	8.62E-03	9.39E-03	1.02E-02	8.52E-03	6.53E-03	5.48E-03	4.72E-03
α_3		3.06E-03	3.24E-03	4.65E-03	4.63E-03	3.98E-03	3.25E-03
α_4			1.87E-03	1.69E-03	2.29E-03	2.65E-03	2.49E-03
α_5				3.40E-04	8.49E-04	1.38E-03	1.64E-03
α_6					4.21E-04	4.68E-04	8.19E-04
α_7						8.51E-05	2.52E-04
α_8							2.22E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.91E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	8.62E-03	1.24E-02	1.53E-02	1.52E-02	1.47E-02	1.41E-02	1.34E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	31.50	31.50	31.50	31.50	31.50	31.50	31.50
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

2.3.5.3 AFW MOTOR-OPERATED VALVES FAIL TO CLOSE: AFW-MOV-OO

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Motor-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 21.6

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9587708	0.9894669	0.9954242	0.9999680	1.0000000	4.401E+01	4.685E-01
α_2	2.95E-05	1.05E-02	4.58E-03	4.12E-02	0.00E+00	4.685E-01	4.401E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9601459	0.9860230	0.9897844	0.9990346	1.0000000	7.958E+01	1.128E+00
α_2	3.53E-04	1.05E-02	6.87E-03	3.33E-02	0.00E+00	8.512E-01	7.986E+01
α_3	1.71E-07	3.43E-03	7.34E-04	1.61E-02	0.00E+00	2.768E-01	8.043E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9602635	0.9834140	0.9861468	0.9972247	1.0000000	1.123E+02	1.894E+00
α_2	9.53E-04	1.10E-02	8.34E-03	3.03E-02	0.00E+00	1.260E+00	1.129E+02
α_3	3.83E-06	3.52E-03	1.29E-03	1.46E-02	0.00E+00	4.024E-01	1.138E+02
α_4	1.41E-08	2.03E-03	3.02E-04	1.00E-02	0.00E+00	2.315E-01	1.139E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680655	0.9841009	0.9855695	0.9951160	1.0000000	2.124E+02	3.432E+00
α_2	1.52E-03	8.91E-03	7.45E-03	2.13E-02	0.00E+00	1.924E+00	2.139E+02
α_3	2.81E-04	4.86E-03	3.44E-03	1.43E-02	0.00E+00	1.049E+00	2.148E+02
α_4	1.35E-06	1.77E-03	6.10E-04	7.47E-03	0.00E+00	3.822E-01	2.155E+02
α_5	3.09E-20	3.56E-04	3.31E-07	2.07E-03	0.00E+00	7.674E-02	2.158E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9701712	0.9847004	0.9859688	0.9948934	1.0000000	2.468E+02	3.835E+00
α_2	9.73E-04	6.79E-03	5.53E-03	1.69E-02	0.00E+00	1.701E+00	2.490E+02
α_3	3.80E-04	4.82E-03	3.58E-03	1.35E-02	0.00E+00	1.207E+00	2.494E+02
α_4	2.18E-05	2.38E-03	1.25E-03	8.57E-03	0.00E+00	5.960E-01	2.501E+02

α_5	3.45E-09	8.82E-04	1.18E-04	4.42E-03	0.00E+00	2.211E-01	2.504E+02
α_6	3.45E-15	4.38E-04	4.43E-06	2.53E-03	0.00E+00	1.098E-01	2.505E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746219	0.9856009	0.9864023	0.9938371	1.0000000	3.934E+02	5.747E+00
α_2	1.15E-03	5.62E-03	4.82E-03	1.28E-02	0.00E+00	2.243E+00	3.969E+02
α_3	5.48E-04	4.08E-03	3.29E-03	1.03E-02	0.00E+00	1.630E+00	3.975E+02
α_4	1.69E-04	2.71E-03	1.94E-03	7.89E-03	0.00E+00	1.083E+00	3.981E+02
α_5	1.02E-05	1.42E-03	7.14E-04	5.20E-03	0.00E+00	5.654E-01	3.986E+02
α_6	2.64E-10	4.80E-04	4.43E-05	2.50E-03	0.00E+00	1.916E-01	3.990E+02
α_7	5.97E-41	8.72E-05	3.24E-12	3.82E-04	0.00E+00	3.480E-02	3.991E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757939	0.9862810	0.9870485	0.9941372	1.0000000	4.116E+02	5.726E+00
α_2	8.72E-04	4.84E-03	4.07E-03	1.14E-02	0.00E+00	2.018E+00	4.153E+02
α_3	3.44E-04	3.33E-03	2.58E-03	8.89E-03	0.00E+00	1.391E+00	4.160E+02
α_4	1.51E-04	2.54E-03	1.81E-03	7.45E-03	0.00E+00	1.062E+00	4.163E+02
α_5	2.97E-05	1.68E-03	9.84E-04	5.72E-03	0.00E+00	7.026E-01	4.166E+02
α_6	3.29E-07	8.38E-04	2.57E-04	3.64E-03	0.00E+00	3.497E-01	4.170E+02
α_7	1.26E-15	2.58E-04	2.37E-06	1.49E-03	0.00E+00	1.078E-01	4.172E+02
α_8	2.64E-17	2.27E-04	9.61E-07	1.32E-03	0.00E+00	9.469E-02	4.173E+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	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.05E-02	1.05E-02	1.10E-02	8.91E-03	6.79E-03	5.62E-03	4.84E-03
α_3		3.43E-03	3.52E-03	4.86E-03	4.82E-03	4.08E-03	3.33E-03
α_4			2.03E-03	1.77E-03	2.38E-03	2.71E-03	2.54E-03
α_5				3.56E-04	8.82E-04	1.42E-03	1.68E-03
α_6					4.38E-04	4.80E-04	8.38E-04
α_7						8.72E-05	2.58E-04
α_8							2.27E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.05E-02	1.40E-02	1.66E-02	1.59E-02	1.53E-02	1.44E-02	1.37E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	21.60	21.60	21.60	21.60	21.60	21.60	21.60
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 High Pressure Safety Injection Motor-Operated Valves

2.3.6.1 HPSI MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: HPI-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 25.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9620803	0.9903159	0.9957923	0.9999705	1.0000000	4.791E+01	4.685E-01
α_2	2.71E-05	9.68E-03	4.20E-03	3.79E-02	0.00E+00	4.685E-01	4.791E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9619709	0.9866673	0.9902591	0.9990794	1.0000000	8.348E+01	1.128E+00
α_2	3.37E-04	1.01E-02	6.55E-03	3.18E-02	0.00E+00	8.512E-01	8.376E+01
α_3	1.63E-07	3.27E-03	7.00E-04	1.54E-02	0.00E+00	2.768E-01	8.433E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9615712	0.9839618	0.9866069	0.9973174	1.0000000	1.162E+02	1.894E+00
α_2	9.22E-04	1.07E-02	8.06E-03	2.93E-02	0.00E+00	1.260E+00	1.168E+02
α_3	3.70E-06	3.41E-03	1.25E-03	1.41E-02	0.00E+00	4.024E-01	1.177E+02
α_4	1.36E-08	1.96E-03	2.92E-04	9.71E-03	0.00E+00	2.315E-01	1.178E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686290	0.9843830	0.9858312	0.9952033	1.0000000	2.163E+02	3.432E+00
α_2	1.49E-03	8.76E-03	7.32E-03	2.09E-02	0.00E+00	1.924E+00	2.178E+02
α_3	2.76E-04	4.77E-03	3.38E-03	1.40E-02	0.00E+00	1.049E+00	2.187E+02
α_4	1.32E-06	1.74E-03	5.99E-04	7.34E-03	0.00E+00	3.822E-01	2.194E+02
α_5	3.03E-20	3.49E-04	3.25E-07	2.03E-03	0.00E+00	7.674E-02	2.197E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9706256	0.9849348	0.9861844	0.9949723	1.0000000	2.507E+02	3.835E+00
α_2	9.58E-04	6.68E-03	5.44E-03	1.66E-02	0.00E+00	1.701E+00	2.529E+02
α_3	3.74E-04	4.74E-03	3.52E-03	1.33E-02	0.00E+00	1.207E+00	2.533E+02
α_4	2.15E-05	2.34E-03	1.23E-03	8.44E-03	0.00E+00	5.960E-01	2.540E+02
α_5	3.40E-09	8.69E-04	1.16E-04	4.36E-03	0.00E+00	2.211E-01	2.543E+02
α_6	3.39E-15	4.31E-04	4.37E-06	2.49E-03	0.00E+00	1.098E-01	2.544E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748660	0.9857402	0.9865341	0.9938966	1.0000000	3.973E+02	5.747E+00
α_2	1.14E-03	5.57E-03	4.77E-03	1.27E-02	0.00E+00	2.243E+00	4.008E+02
α_3	5.42E-04	4.04E-03	3.26E-03	1.02E-02	0.00E+00	1.630E+00	4.014E+02
α_4	1.67E-04	2.69E-03	1.92E-03	7.82E-03	0.00E+00	1.083E+00	4.020E+02
α_5	1.01E-05	1.40E-03	7.07E-04	5.15E-03	0.00E+00	5.654E-01	4.025E+02
α_6	2.61E-10	4.75E-04	4.39E-05	2.48E-03	0.00E+00	1.916E-01	4.029E+02
α_7	5.91E-41	8.63E-05	3.21E-12	3.79E-04	0.00E+00	3.480E-02	4.030E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9760213	0.9864080	0.9871687	0.9941960	1.0000000	4.155E+02	5.726E+00
α_2	8.64E-04	4.79E-03	4.03E-03	1.13E-02	0.00E+00	2.018E+00	4.192E+02
α_3	3.41E-04	3.30E-03	2.56E-03	8.81E-03	0.00E+00	1.391E+00	4.199E+02
α_4	1.50E-04	2.52E-03	1.79E-03	7.39E-03	0.00E+00	1.062E+00	4.202E+02
α_5	2.94E-05	1.67E-03	9.74E-04	5.66E-03	0.00E+00	7.026E-01	4.205E+02
α_6	3.26E-07	8.30E-04	2.55E-04	3.61E-03	0.00E+00	3.497E-01	4.209E+02
α_7	1.25E-15	2.56E-04	2.35E-06	1.48E-03	0.00E+00	1.078E-01	4.211E+02
α_8	2.62E-17	2.25E-04	9.52E-07	1.31E-03	0.00E+00	9.469E-02	4.212E+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	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.68E-03	1.01E-02	1.07E-02	8.76E-03	6.68E-03	5.57E-03	4.79E-03
α_3		3.27E-03	3.41E-03	4.77E-03	4.74E-03	4.04E-03	3.30E-03
α_4			1.96E-03	1.74E-03	2.34E-03	2.69E-03	2.52E-03
α_5				3.49E-04	8.69E-04	1.40E-03	1.67E-03
α_6					4.31E-04	4.75E-04	8.30E-04
α_7						8.63E-05	2.56E-04
α_8							2.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.87E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.68E-03	1.33E-02	1.60E-02	1.56E-02	1.51E-02	1.43E-02	1.36E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01

Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	25.50	25.50	25.50	25.50	25.50	25.50	25.50
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

2.3.6.2 HPSI MOTOR-OPERATED VALVES FAIL TO OPEN: HPI-MOV-CC

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: 2006 through 2020

Total Number of Independent Failure Events: 13.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496433	0.9871218	0.9943862	0.9999610	1.0000000	3.591E+01	4.685E-01
α_2	3.62E-05	1.29E-02	5.62E-03	5.04E-02	0.00E+00	4.685E-01	3.591E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9557294	0.9844638	0.9886341	0.9989260	1.0000000	7.148E+01	1.128E+00
α_2	3.93E-04	1.17E-02	7.64E-03	3.70E-02	0.00E+00	8.512E-01	7.176E+01
α_3	1.90E-07	3.81E-03	8.16E-04	1.79E-02	0.00E+00	2.768E-01	7.233E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9572536	0.9821474	0.9850823	0.9970102	1.0000000	1.042E+02	1.894E+00
α_2	1.03E-03	1.19E-02	8.98E-03	3.26E-02	0.00E+00	1.260E+00	1.048E+02
α_3	4.12E-06	3.79E-03	1.39E-03	1.57E-02	0.00E+00	4.024E-01	1.057E+02
α_4	1.51E-08	2.18E-03	3.25E-04	1.08E-02	0.00E+00	2.315E-01	1.058E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9668280	0.9834810	0.9850051	0.9949238	1.0000000	2.043E+02	3.432E+00
α_2	1.58E-03	9.26E-03	7.74E-03	2.21E-02	0.00E+00	1.924E+00	2.058E+02
α_3	2.92E-04	5.05E-03	3.58E-03	1.48E-02	0.00E+00	1.049E+00	2.067E+02
α_4	1.40E-06	1.84E-03	6.34E-04	7.76E-03	0.00E+00	3.822E-01	2.074E+02
α_5	3.21E-20	3.69E-04	3.44E-07	2.15E-03	0.00E+00	7.674E-02	2.077E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9691806	0.9841894	0.9854990	0.9947214	1.0000000	2.387E+02	3.835E+00
α_2	1.01E-03	7.01E-03	5.71E-03	1.75E-02	0.00E+00	1.701E+00	2.409E+02
α_3	3.93E-04	4.98E-03	3.70E-03	1.39E-02	0.00E+00	1.207E+00	2.413E+02

α_4	2.25E-05	2.46E-03	1.29E-03	8.85E-03	0.00E+00	5.960E-01	2.420E+02
α_5	3.57E-09	9.12E-04	1.22E-04	4.57E-03	0.00E+00	2.211E-01	2.423E+02
α_6	3.56E-15	4.53E-04	4.58E-06	2.61E-03	0.00E+00	1.098E-01	2.424E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741021	0.9853026	0.9861201	0.9937096	1.0000000	3.853E+02	5.747E+00
α_2	1.17E-03	5.74E-03	4.92E-03	1.31E-02	0.00E+00	2.243E+00	3.888E+02
α_3	5.59E-04	4.17E-03	3.36E-03	1.05E-02	0.00E+00	1.630E+00	3.894E+02
α_4	1.72E-04	2.77E-03	1.98E-03	8.06E-03	0.00E+00	1.083E+00	3.900E+02
α_5	1.05E-05	1.45E-03	7.29E-04	5.31E-03	0.00E+00	5.654E-01	3.905E+02
α_6	2.69E-10	4.90E-04	4.53E-05	2.55E-03	0.00E+00	1.916E-01	3.909E+02
α_7	6.10E-41	8.90E-05	3.31E-12	3.90E-04	0.00E+00	3.480E-02	3.910E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753164	0.9860095	0.9867917	0.9940250	1.0000000	4.035E+02	5.726E+00
α_2	8.89E-04	4.93E-03	4.15E-03	1.16E-02	0.00E+00	2.018E+00	4.072E+02
α_3	3.51E-04	3.40E-03	2.63E-03	9.06E-03	0.00E+00	1.391E+00	4.079E+02
α_4	1.54E-04	2.60E-03	1.84E-03	7.60E-03	0.00E+00	1.062E+00	4.082E+02
α_5	3.03E-05	1.72E-03	1.00E-03	5.83E-03	0.00E+00	7.026E-01	4.085E+02
α_6	3.36E-07	8.55E-04	2.62E-04	3.72E-03	0.00E+00	3.497E-01	4.089E+02
α_7	1.29E-15	2.64E-04	2.42E-06	1.52E-03	0.00E+00	1.078E-01	4.091E+02
α_8	2.69E-17	2.31E-04	9.80E-07	1.35E-03	0.00E+00	9.469E-02	4.092E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.29E-02	1.17E-02	1.19E-02	9.26E-03	7.01E-03	5.74E-03	4.93E-03
α_3		3.81E-03	3.79E-03	5.05E-03	4.98E-03	4.17E-03	3.40E-03
α_4			2.18E-03	1.84E-03	2.46E-03	2.77E-03	2.60E-03
α_5				3.69E-04	9.12E-04	1.45E-03	1.72E-03
α_6					4.53E-04	4.90E-04	8.55E-04
α_7						8.90E-05	2.64E-04
α_8							2.31E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.29E-02	1.55E-02	1.79E-02	1.65E-02	1.58E-02	1.47E-02	1.40E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	13.50	13.50	13.50	13.50	13.50	13.50	13.50
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

2.3.6.3 HPSI MOTOR-OPERATED VALVES FAIL TO CLOSE: HPI-MOV-OO

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: 2006 through 2020

Total Number of Independent Failure Events: 9.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9434630	0.9855309	0.9936793	0.9999562	1.0000000	3.191E+01	4.685E-01
α_2	4.08E-05	1.45E-02	6.32E-03	5.65E-02	0.00E+00	4.685E-01	3.191E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9531698	0.9835580	0.9879649	0.9988675	1.0000000	6.748E+01	1.128E+00
α_2	4.16E-04	1.24E-02	8.09E-03	3.91E-02	0.00E+00	8.512E-01	6.776E+01
α_3	2.02E-07	4.03E-03	8.64E-04	1.89E-02	0.00E+00	2.768E-01	6.833E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9555925	0.9814478	0.9844938	0.9968916	1.0000000	1.002E+02	1.894E+00
α_2	1.07E-03	1.23E-02	9.33E-03	3.39E-02	0.00E+00	1.260E+00	1.008E+02
α_3	4.29E-06	3.94E-03	1.45E-03	1.63E-02	0.00E+00	4.024E-01	1.017E+02
α_4	1.57E-08	2.27E-03	3.38E-04	1.12E-02	0.00E+00	2.315E-01	1.018E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9661808	0.9831568	0.9847098	0.9948232	1.0000000	2.003E+02	3.432E+00
α_2	1.61E-03	9.44E-03	7.89E-03	2.26E-02	0.00E+00	1.924E+00	2.018E+02
α_3	2.98E-04	5.15E-03	3.65E-03	1.51E-02	0.00E+00	1.049E+00	2.027E+02
α_4	1.43E-06	1.88E-03	6.47E-04	7.91E-03	0.00E+00	3.822E-01	2.034E+02
α_5	3.27E-20	3.77E-04	3.51E-07	2.19E-03	0.00E+00	7.674E-02	2.037E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686667	0.9839243	0.9852552	0.9946321	1.0000000	2.347E+02	3.835E+00
α_2	1.02E-03	7.13E-03	5.81E-03	1.78E-02	0.00E+00	1.701E+00	2.369E+02
α_3	3.99E-04	5.06E-03	3.76E-03	1.42E-02	0.00E+00	1.207E+00	2.373E+02

α_4	2.29E-05	2.50E-03	1.31E-03	9.00E-03	0.00E+00	5.960E-01	2.380E+02
α_5	3.63E-09	9.27E-04	1.24E-04	4.65E-03	0.00E+00	2.211E-01	2.383E+02
α_6	3.62E-15	4.60E-04	4.66E-06	2.65E-03	0.00E+00	1.098E-01	2.384E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738309	0.9851508	0.9859764	0.9936393	1.0000000	3.813E+02	5.747E+00
α_2	1.19E-03	5.80E-03	4.97E-03	1.32E-02	0.00E+00	2.243E+00	3.848E+02
α_3	5.65E-04	4.21E-03	3.39E-03	1.06E-02	0.00E+00	1.630E+00	3.854E+02
α_4	1.74E-04	2.80E-03	2.00E-03	8.14E-03	0.00E+00	1.083E+00	3.860E+02
α_5	1.06E-05	1.46E-03	7.37E-04	5.37E-03	0.00E+00	5.654E-01	3.865E+02
α_6	2.72E-10	4.95E-04	4.57E-05	2.58E-03	0.00E+00	1.916E-01	3.869E+02
α_7	6.16E-41	8.99E-05	3.34E-12	3.94E-04	0.00E+00	3.480E-02	3.870E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750738	0.9858714	0.9866611	0.9939612	1.0000000	3.995E+02	5.726E+00
α_2	8.98E-04	4.98E-03	4.19E-03	1.18E-02	0.00E+00	2.018E+00	4.032E+02
α_3	3.54E-04	3.43E-03	2.66E-03	9.15E-03	0.00E+00	1.391E+00	4.039E+02
α_4	1.56E-04	2.62E-03	1.86E-03	7.68E-03	0.00E+00	1.062E+00	4.042E+02
α_5	3.06E-05	1.73E-03	1.01E-03	5.89E-03	0.00E+00	7.026E-01	4.045E+02
α_6	3.39E-07	8.63E-04	2.65E-04	3.75E-03	0.00E+00	3.497E-01	4.049E+02
α_7	1.30E-15	2.66E-04	2.44E-06	1.54E-03	0.00E+00	1.078E-01	4.051E+02
α_8	2.72E-17	2.34E-04	9.90E-07	1.36E-03	0.00E+00	9.469E-02	4.052E+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	9.84E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.45E-02	1.24E-02	1.23E-02	9.44E-03	7.13E-03	5.80E-03	4.98E-03
α_3		4.03E-03	3.94E-03	5.15E-03	5.06E-03	4.21E-03	3.43E-03
α_4			2.27E-03	1.88E-03	2.50E-03	2.80E-03	2.62E-03
α_5				3.77E-04	9.27E-04	1.46E-03	1.73E-03
α_6					4.60E-04	4.95E-04	8.63E-04
α_7						8.99E-05	2.66E-04
α_8							2.34E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.84E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.45E-02	1.64E-02	1.86E-02	1.68E-02	1.61E-02	1.48E-02	1.41E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	9.50	9.50	9.50	9.50	9.50	9.50	9.50
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

2.3.7 PWR Residual Heat Removal Motor-Operated Valves

2.3.7.1 PWR RHR MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: PWR-RHR-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 50.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747913	0.9935713	0.9972245	0.9999803	1.0000000	7.241E+01	4.685E-01
α_2	1.79E-05	6.43E-03	2.78E-03	2.52E-02	0.00E+00	4.685E-01	7.241E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9704662	0.9896612	0.9924578	0.9992871	1.0000000	1.080E+02	1.128E+00
α_2	2.60E-04	7.80E-03	5.07E-03	2.47E-02	0.00E+00	8.512E-01	1.083E+02
α_3	1.26E-07	2.54E-03	5.42E-04	1.19E-02	0.00E+00	2.768E-01	1.088E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9681311	0.9867179	0.9889148	0.9977824	1.0000000	1.407E+02	1.894E+00
α_2	7.62E-04	8.84E-03	6.67E-03	2.43E-02	0.00E+00	1.260E+00	1.413E+02
α_3	3.06E-06	2.82E-03	1.04E-03	1.17E-02	0.00E+00	4.024E-01	1.422E+02
α_4	1.13E-08	1.62E-03	2.42E-04	8.04E-03	0.00E+00	2.315E-01	1.423E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9717554	0.9859493	0.9872559	0.9956875	1.0000000	2.408E+02	3.432E+00
α_2	1.34E-03	7.88E-03	6.58E-03	1.88E-02	0.00E+00	1.924E+00	2.423E+02
α_3	2.48E-04	4.29E-03	3.04E-03	1.26E-02	0.00E+00	1.049E+00	2.432E+02
α_4	1.19E-06	1.56E-03	5.39E-04	6.60E-03	0.00E+00	3.822E-01	2.439E+02
α_5	2.73E-20	3.14E-04	2.93E-07	1.82E-03	0.00E+00	7.674E-02	2.442E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9731875	0.9862574	0.9874044	0.9954118	1.0000000	2.752E+02	3.835E+00
α_2	8.73E-04	6.10E-03	4.96E-03	1.52E-02	0.00E+00	1.701E+00	2.774E+02
α_3	3.41E-04	4.33E-03	3.21E-03	1.21E-02	0.00E+00	1.207E+00	2.778E+02
α_4	1.96E-05	2.14E-03	1.12E-03	7.70E-03	0.00E+00	5.960E-01	2.785E+02
α_5	3.10E-09	7.92E-04	1.06E-04	3.97E-03	0.00E+00	2.211E-01	2.788E+02
α_6	3.09E-15	3.93E-04	3.98E-06	2.27E-03	0.00E+00	1.098E-01	2.789E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9762995	0.9865574	0.9873071	0.9942494	1.0000000	4.218E+02	5.747E+00
α_2	1.07E-03	5.25E-03	4.50E-03	1.20E-02	0.00E+00	2.243E+00	4.253E+02
α_3	5.11E-04	3.81E-03	3.07E-03	9.64E-03	0.00E+00	1.630E+00	4.259E+02
α_4	1.58E-04	2.53E-03	1.81E-03	7.37E-03	0.00E+00	1.083E+00	4.265E+02
α_5	9.56E-06	1.32E-03	6.67E-04	4.86E-03	0.00E+00	5.654E-01	4.270E+02
α_6	2.46E-10	4.48E-04	4.14E-05	2.34E-03	0.00E+00	1.916E-01	4.274E+02
α_7	5.57E-41	8.14E-05	3.03E-12	3.57E-04	0.00E+00	3.480E-02	4.275E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9773348	0.9871551	0.9878794	0.9945122	1.0000000	4.400E+02	5.726E+00
α_2	8.16E-04	4.53E-03	3.81E-03	1.07E-02	0.00E+00	2.018E+00	4.437E+02
α_3	3.22E-04	3.12E-03	2.42E-03	8.32E-03	0.00E+00	1.391E+00	4.444E+02
α_4	1.42E-04	2.38E-03	1.69E-03	6.98E-03	0.00E+00	1.062E+00	4.447E+02
α_5	2.78E-05	1.58E-03	9.21E-04	5.35E-03	0.00E+00	7.026E-01	4.450E+02
α_6	3.08E-07	7.85E-04	2.41E-04	3.41E-03	0.00E+00	3.497E-01	4.454E+02
α_7	1.18E-15	2.42E-04	2.22E-06	1.40E-03	0.00E+00	1.078E-01	4.456E+02
α_8	2.47E-17	2.12E-04	9.00E-07	1.24E-03	0.00E+00	9.469E-02	4.457E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
α_2	6.43E-03	7.80E-03	8.84E-03	7.88E-03	6.10E-03	5.25E-03	4.53E-03
α_3		2.54E-03	2.82E-03	4.29E-03	4.33E-03	3.81E-03	3.12E-03
α_4			1.62E-03	1.56E-03	2.14E-03	2.53E-03	2.38E-03
α_5				3.14E-04	7.92E-04	1.32E-03	1.58E-03
α_6					3.93E-04	4.48E-04	7.85E-04
α_7						8.14E-05	2.42E-04
α_8							2.12E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
Beta	6.43E-03	1.03E-02	1.33E-02	1.41E-02	1.37E-02	1.34E-02	1.28E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01

Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	50.00	50.00	50.00	50.00	50.00	50.00	50.00
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

2.3.7.2 PWR RHR MOTOR-OPERATED VALVES FAIL TO OPEN: PWR-RHR-MOV-CC

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: 2006 through 2020

Total Number of Independent Failure Events: 29.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9646285	0.9909692	0.9960808	0.9999725	1.0000000	5.141E+01	4.685E-01
α_2	2.52E-05	9.03E-03	3.92E-03	3.54E-02	0.00E+00	4.685E-01	5.141E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9634712	0.9871969	0.9906491	0.9991162	1.0000000	8.698E+01	1.128E+00
α_2	3.23E-04	9.66E-03	6.29E-03	3.05E-02	0.00E+00	8.512E-01	8.726E+01
α_3	1.57E-07	3.14E-03	6.72E-04	1.47E-02	0.00E+00	2.768E-01	8.783E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9626696	0.9844236	0.9869945	0.9973954	1.0000000	1.197E+02	1.894E+00
α_2	8.95E-04	1.04E-02	7.83E-03	2.85E-02	0.00E+00	1.260E+00	1.203E+02
α_3	3.60E-06	3.31E-03	1.22E-03	1.37E-02	0.00E+00	4.024E-01	1.212E+02
α_4	1.32E-08	1.90E-03	2.84E-04	9.43E-03	0.00E+00	2.315E-01	1.213E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9691179	0.9846278	0.9860539	0.9952791	1.0000000	2.198E+02	3.432E+00
α_2	1.47E-03	8.62E-03	7.20E-03	2.06E-02	0.00E+00	1.924E+00	2.213E+02
α_3	2.72E-04	4.70E-03	3.33E-03	1.38E-02	0.00E+00	1.049E+00	2.222E+02
α_4	1.30E-06	1.71E-03	5.90E-04	7.22E-03	0.00E+00	3.822E-01	2.229E+02
α_5	2.98E-20	3.44E-04	3.20E-07	2.00E-03	0.00E+00	7.674E-02	2.232E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9710218	0.9851391	0.9863771	0.9950409	1.0000000	2.542E+02	3.835E+00
α_2	9.45E-04	6.59E-03	5.37E-03	1.64E-02	0.00E+00	1.701E+00	2.564E+02

α_3	3.69E-04	4.68E-03	3.48E-03	1.31E-02	0.00E+00	1.207E+00	2.568E+02
α_4	2.12E-05	2.31E-03	1.21E-03	8.32E-03	0.00E+00	5.960E-01	2.575E+02
α_5	3.35E-09	8.57E-04	1.15E-04	4.30E-03	0.00E+00	2.211E-01	2.578E+02
α_6	3.35E-15	4.25E-04	4.31E-06	2.45E-03	0.00E+00	1.098E-01	2.579E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750813	0.9858630	0.9866502	0.9939452	1.0000000	4.008E+02	5.747E+00
α_2	1.13E-03	5.52E-03	4.73E-03	1.26E-02	0.00E+00	2.243E+00	4.043E+02
α_3	5.38E-04	4.01E-03	3.23E-03	1.01E-02	0.00E+00	1.630E+00	4.049E+02
α_4	1.66E-04	2.66E-03	1.91E-03	7.75E-03	0.00E+00	1.083E+00	4.055E+02
α_5	1.01E-05	1.39E-03	7.01E-04	5.11E-03	0.00E+00	5.654E-01	4.060E+02
α_6	2.59E-10	4.71E-04	4.35E-05	2.46E-03	0.00E+00	1.916E-01	4.064E+02
α_7	5.86E-41	8.56E-05	3.18E-12	3.75E-04	0.00E+00	3.480E-02	4.065E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9762173	0.9865200	0.9872746	0.9942448	1.0000000	4.190E+02	5.726E+00
α_2	8.56E-04	4.75E-03	4.00E-03	1.12E-02	0.00E+00	2.018E+00	4.227E+02
α_3	3.38E-04	3.27E-03	2.53E-03	8.73E-03	0.00E+00	1.391E+00	4.234E+02
α_4	1.49E-04	2.50E-03	1.78E-03	7.32E-03	0.00E+00	1.062E+00	4.237E+02
α_5	2.92E-05	1.65E-03	9.66E-04	5.62E-03	0.00E+00	7.026E-01	4.240E+02
α_6	3.23E-07	8.23E-04	2.53E-04	3.58E-03	0.00E+00	3.497E-01	4.244E+02
α_7	1.24E-15	2.54E-04	2.33E-06	1.47E-03	0.00E+00	1.078E-01	4.246E+02
α_8	2.59E-17	2.23E-04	9.44E-07	1.30E-03	0.00E+00	9.469E-02	4.247E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.91E-01	9.87E-01	9.84E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	9.03E-03	9.66E-03	1.04E-02	8.62E-03	6.59E-03	5.52E-03	4.75E-03
α_3		3.14E-03	3.31E-03	4.70E-03	4.68E-03	4.01E-03	3.27E-03
α_4			1.90E-03	1.71E-03	2.31E-03	2.66E-03	2.50E-03
α_5				3.44E-04	8.57E-04	1.39E-03	1.65E-03
α_6					4.25E-04	4.71E-04	8.23E-04
α_7						8.56E-05	2.54E-04
α_8							2.23E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.91E-01	9.87E-01	9.84E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	9.03E-03	1.28E-02	1.56E-02	1.54E-02	1.49E-02	1.41E-02	1.35E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	29.00	29.00	29.00	29.00	29.00	29.00	29.00
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

2.3.7.3 PWR RHR MOTOR-OPERATED VALVES FAIL TO CLOSE: PWR-RHR-MOV-OO

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: 2006 through 2020

Total Number of Independent Failure Events: 15.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9522532	0.9877928	0.9946787	0.9999630	1.0000000	3.791E+01	4.685E-01
α_2	3.43E-05	1.22E-02	5.32E-03	4.77E-02	0.00E+00	4.685E-01	3.791E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9569072	0.9848802	0.9889415	0.9989551	1.0000000	7.348E+01	1.128E+00
α_2	3.82E-04	1.14E-02	7.44E-03	3.60E-02	0.00E+00	8.512E-01	7.376E+01
α_3	1.85E-07	3.71E-03	7.94E-04	1.74E-02	0.00E+00	2.768E-01	7.433E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9580384	0.9824778	0.9853600	0.9970662	1.0000000	1.062E+02	1.894E+00
α_2	1.01E-03	1.17E-02	8.81E-03	3.20E-02	0.00E+00	1.260E+00	1.068E+02
α_3	4.05E-06	3.72E-03	1.37E-03	1.54E-02	0.00E+00	4.024E-01	1.077E+02
α_4	1.49E-08	2.14E-03	3.19E-04	1.06E-02	0.00E+00	2.315E-01	1.078E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9671424	0.9836385	0.9851485	0.9949727	1.0000000	2.063E+02	3.432E+00
α_2	1.56E-03	9.17E-03	7.67E-03	2.19E-02	0.00E+00	1.924E+00	2.078E+02
α_3	2.90E-04	5.00E-03	3.54E-03	1.47E-02	0.00E+00	1.049E+00	2.087E+02
α_4	1.39E-06	1.82E-03	6.28E-04	7.69E-03	0.00E+00	3.822E-01	2.094E+02
α_5	3.18E-20	3.66E-04	3.41E-07	2.13E-03	0.00E+00	7.674E-02	2.097E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694313	0.9843187	0.9856179	0.9947650	1.0000000	2.407E+02	3.835E+00
α_2	9.97E-04	6.96E-03	5.67E-03	1.73E-02	0.00E+00	1.701E+00	2.429E+02

α_3	3.89E-04	4.94E-03	3.67E-03	1.38E-02	0.00E+00	1.207E+00	2.433E+02
α_4	2.23E-05	2.44E-03	1.28E-03	8.78E-03	0.00E+00	5.960E-01	2.440E+02
α_5	3.54E-09	9.04E-04	1.21E-04	4.53E-03	0.00E+00	2.211E-01	2.443E+02
α_6	3.53E-15	4.49E-04	4.54E-06	2.59E-03	0.00E+00	1.098E-01	2.444E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742294	0.9853774	0.9861908	0.9937416	1.0000000	3.873E+02	5.747E+00
α_2	1.17E-03	5.71E-03	4.89E-03	1.30E-02	0.00E+00	2.243E+00	3.908E+02
α_3	5.56E-04	4.15E-03	3.34E-03	1.05E-02	0.00E+00	1.630E+00	3.914E+02
α_4	1.71E-04	2.76E-03	1.97E-03	8.01E-03	0.00E+00	1.083E+00	3.920E+02
α_5	1.04E-05	1.44E-03	7.25E-04	5.28E-03	0.00E+00	5.654E-01	3.925E+02
α_6	2.68E-10	4.87E-04	4.50E-05	2.54E-03	0.00E+00	1.916E-01	3.929E+02
α_7	6.06E-41	8.85E-05	3.29E-12	3.88E-04	0.00E+00	3.480E-02	3.930E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754360	0.9860775	0.9868561	0.9940496	1.0000000	4.055E+02	5.726E+00
α_2	8.85E-04	4.91E-03	4.13E-03	1.16E-02	0.00E+00	2.018E+00	4.092E+02
α_3	3.49E-04	3.38E-03	2.62E-03	9.02E-03	0.00E+00	1.391E+00	4.099E+02
α_4	1.54E-04	2.58E-03	1.83E-03	7.56E-03	0.00E+00	1.062E+00	4.102E+02
α_5	3.02E-05	1.71E-03	9.98E-04	5.80E-03	0.00E+00	7.026E-01	4.105E+02
α_6	3.34E-07	8.50E-04	2.61E-04	3.70E-03	0.00E+00	3.497E-01	4.109E+02
α_7	1.28E-15	2.62E-04	2.41E-06	1.51E-03	0.00E+00	1.078E-01	4.111E+02
α_8	2.68E-17	2.30E-04	9.75E-07	1.34E-03	0.00E+00	9.469E-02	4.112E+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	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.22E-02	1.14E-02	1.17E-02	9.17E-03	6.96E-03	5.71E-03	4.91E-03
α_3		3.71E-03	3.72E-03	5.00E-03	4.94E-03	4.15E-03	3.38E-03
α_4			2.14E-03	1.82E-03	2.44E-03	2.76E-03	2.58E-03
α_5				3.66E-04	9.04E-04	1.44E-03	1.71E-03
α_6					4.49E-04	4.87E-04	8.50E-04
α_7						8.85E-05	2.62E-04
α_8							2.30E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.22E-02	1.51E-02	1.75E-02	1.64E-02	1.57E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	15.50	15.50	15.50	15.50	15.50	15.50	15.50
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

2.3.8 High Pressure Coolant Injection and Reactor Core Isolation Cooling Motor-Operated Valves

2.3.8.1 COMBINED HPCI/RCIC MOTOR-OPERATED VALVES FAIL TO OPEN/CLOSE: HCI-RCI-MOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 53.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9758181	0.9938336	0.9973389	0.9999811	1.0000000	7.551E+01	4.685E-01
α_2	1.72E-05	6.17E-03	2.66E-03	2.42E-02	0.00E+00	4.685E-01	7.551E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712780	0.9899468	0.9926677	0.9993069	1.0000000	1.111E+02	1.128E+00
α_2	2.53E-04	7.59E-03	4.93E-03	2.40E-02	0.00E+00	8.512E-01	1.114E+02
α_3	1.23E-07	2.47E-03	5.27E-04	1.16E-02	0.00E+00	2.768E-01	1.119E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9688088	0.9870006	0.9891519	0.9978300	1.0000000	1.438E+02	1.894E+00
α_2	7.46E-04	8.65E-03	6.53E-03	2.38E-02	0.00E+00	1.260E+00	1.444E+02
α_3	3.00E-06	2.76E-03	1.01E-03	1.14E-02	0.00E+00	4.024E-01	1.453E+02
α_4	1.10E-08	1.59E-03	2.37E-04	7.87E-03	0.00E+00	2.315E-01	1.454E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9721113	0.9861254	0.9874160	0.9957419	1.0000000	2.439E+02	3.432E+00
α_2	1.32E-03	7.78E-03	6.50E-03	1.86E-02	0.00E+00	1.924E+00	2.454E+02
α_3	2.45E-04	4.24E-03	3.00E-03	1.25E-02	0.00E+00	1.049E+00	2.463E+02
α_4	1.17E-06	1.55E-03	5.32E-04	6.52E-03	0.00E+00	3.822E-01	2.470E+02
α_5	2.69E-20	3.10E-04	2.89E-07	1.80E-03	0.00E+00	7.674E-02	2.473E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734866	0.9864084	0.9875431	0.9954627	1.0000000	2.783E+02	3.835E+00
α_2	8.64E-04	6.03E-03	4.91E-03	1.50E-02	0.00E+00	1.701E+00	2.805E+02
α_3	3.37E-04	4.28E-03	3.18E-03	1.20E-02	0.00E+00	1.207E+00	2.809E+02
α_4	1.94E-05	2.11E-03	1.11E-03	7.61E-03	0.00E+00	5.960E-01	2.816E+02
α_5	3.07E-09	7.84E-04	1.05E-04	3.93E-03	0.00E+00	2.211E-01	2.819E+02
α_6	3.06E-15	3.89E-04	3.94E-06	2.24E-03	0.00E+00	1.098E-01	2.820E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9764754	0.9866541	0.9874034	0.9942916	1.0000000	4.249E+02	5.747E+00
α_2	1.06E-03	5.21E-03	4.47E-03	1.19E-02	0.00E+00	2.243E+00	4.284E+02
α_3	5.08E-04	3.78E-03	3.05E-03	9.57E-03	0.00E+00	1.630E+00	4.290E+02
α_4	1.56E-04	2.51E-03	1.80E-03	7.32E-03	0.00E+00	1.083E+00	4.296E+02
α_5	9.49E-06	1.31E-03	6.62E-04	4.82E-03	0.00E+00	5.654E-01	4.301E+02
α_6	2.44E-10	4.45E-04	4.11E-05	2.32E-03	0.00E+00	1.916E-01	4.305E+02
α_7	5.53E-41	8.08E-05	3.01E-12	3.54E-04	0.00E+00	3.480E-02	4.306E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9774906	0.9872438	0.9879631	0.9945503	1.0000000	4.431E+02	5.726E+00
α_2	8.10E-04	4.50E-03	3.78E-03	1.06E-02	0.00E+00	2.018E+00	4.468E+02
α_3	3.20E-04	3.10E-03	2.40E-03	8.27E-03	0.00E+00	1.391E+00	4.475E+02
α_4	1.41E-04	2.37E-03	1.68E-03	6.93E-03	0.00E+00	1.062E+00	4.478E+02
α_5	2.76E-05	1.57E-03	9.14E-04	5.32E-03	0.00E+00	7.026E-01	4.481E+02
α_6	3.06E-07	7.79E-04	2.39E-04	3.39E-03	0.00E+00	3.497E-01	4.485E+02
α_7	1.17E-15	2.40E-04	2.20E-06	1.39E-03	0.00E+00	1.078E-01	4.487E+02
α_8	2.46E-17	2.11E-04	8.94E-07	1.23E-03	0.00E+00	9.469E-02	4.488E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
α_2	6.17E-03	7.59E-03	8.65E-03	7.78E-03	6.03E-03	5.21E-03	4.50E-03
α_3		2.47E-03	2.76E-03	4.24E-03	4.28E-03	3.78E-03	3.10E-03
α_4			1.59E-03	1.55E-03	2.11E-03	2.51E-03	2.37E-03
α_5				3.10E-04	7.84E-04	1.31E-03	1.57E-03
α_6					3.89E-04	4.45E-04	7.79E-04
α_7						8.08E-05	2.40E-04
α_8							2.11E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.86E-01	9.87E-01	9.87E-01
Beta	6.17E-03	1.01E-02	1.30E-02	1.39E-02	1.36E-02	1.33E-02	1.28E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01

Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	53.10	53.10	53.10	53.10	53.10	53.10	53.10
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

2.3.8.2 COMBINED HPCI AND RCIC MOTOR-OPERATED VALVES FAIL TO OPEN: HCI-RCI-MOV-CC

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: 2006 through 2020

Total Number of Independent Failure Events: 34.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677834	0.9917775	0.9964393	0.9999749	1.0000000	5.651E+01	4.685E-01
α_2	2.30E-05	8.22E-03	3.56E-03	3.22E-02	0.00E+00	4.685E-01	5.651E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9654573	0.9878975	0.9911688	0.9991648	1.0000000	9.208E+01	1.128E+00
α_2	3.05E-04	9.13E-03	5.94E-03	2.88E-02	0.00E+00	8.512E-01	9.236E+01
α_3	1.48E-07	2.97E-03	6.35E-04	1.39E-02	0.00E+00	2.768E-01	9.293E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9641622	0.9850507	0.9875208	0.9975014	1.0000000	1.248E+02	1.894E+00
α_2	8.59E-04	9.94E-03	7.51E-03	2.74E-02	0.00E+00	1.260E+00	1.254E+02
α_3	3.45E-06	3.18E-03	1.17E-03	1.32E-02	0.00E+00	4.024E-01	1.263E+02
α_4	1.27E-08	1.83E-03	2.72E-04	9.05E-03	0.00E+00	2.315E-01	1.264E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9698036	0.9849711	0.9863662	0.9953853	1.0000000	2.249E+02	3.432E+00
α_2	1.43E-03	8.43E-03	7.04E-03	2.02E-02	0.00E+00	1.924E+00	2.264E+02
α_3	2.66E-04	4.59E-03	3.25E-03	1.35E-02	0.00E+00	1.049E+00	2.273E+02
α_4	1.27E-06	1.67E-03	5.77E-04	7.06E-03	0.00E+00	3.822E-01	2.280E+02
α_5	2.92E-20	3.36E-04	3.13E-07	1.95E-03	0.00E+00	7.674E-02	2.283E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9715761	0.9854271	0.9866417	0.9951377	1.0000000	2.593E+02	3.835E+00
α_2	9.26E-04	6.46E-03	5.26E-03	1.61E-02	0.00E+00	1.701E+00	2.615E+02

α_3	3.62E-04	4.59E-03	3.41E-03	1.28E-02	0.00E+00	1.207E+00	2.619E+02
α_4	2.08E-05	2.26E-03	1.19E-03	8.16E-03	0.00E+00	5.960E-01	2.626E+02
α_5	3.29E-09	8.40E-04	1.12E-04	4.21E-03	0.00E+00	2.211E-01	2.629E+02
α_6	3.28E-15	4.17E-04	4.22E-06	2.41E-03	0.00E+00	1.098E-01	2.630E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753888	0.9860381	0.9868159	0.9940253	1.0000000	4.059E+02	5.747E+00
α_2	1.11E-03	5.45E-03	4.67E-03	1.24E-02	0.00E+00	2.243E+00	4.094E+02
α_3	5.31E-04	3.96E-03	3.19E-03	1.00E-02	0.00E+00	1.630E+00	4.100E+02
α_4	1.64E-04	2.63E-03	1.88E-03	7.65E-03	0.00E+00	1.083E+00	4.106E+02
α_5	9.93E-06	1.37E-03	6.93E-04	5.05E-03	0.00E+00	5.654E-01	4.111E+02
α_6	2.56E-10	4.65E-04	4.30E-05	2.43E-03	0.00E+00	1.916E-01	4.115E+02
α_7	5.79E-41	8.45E-05	3.14E-12	3.71E-04	0.00E+00	3.480E-02	4.116E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9764993	0.9866800	0.9874306	0.9943088	1.0000000	4.241E+02	5.726E+00
α_2	8.46E-04	4.69E-03	3.95E-03	1.11E-02	0.00E+00	2.018E+00	4.278E+02
α_3	3.34E-04	3.23E-03	2.50E-03	8.63E-03	0.00E+00	1.391E+00	4.285E+02
α_4	1.47E-04	2.47E-03	1.76E-03	7.24E-03	0.00E+00	1.062E+00	4.288E+02
α_5	2.88E-05	1.63E-03	9.55E-04	5.55E-03	0.00E+00	7.026E-01	4.291E+02
α_6	3.19E-07	8.14E-04	2.50E-04	3.54E-03	0.00E+00	3.497E-01	4.295E+02
α_7	1.23E-15	2.51E-04	2.30E-06	1.45E-03	0.00E+00	1.078E-01	4.297E+02
α_8	2.56E-17	2.20E-04	9.33E-07	1.28E-03	0.00E+00	9.469E-02	4.298E+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	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
α_2	8.22E-03	9.13E-03	9.94E-03	8.43E-03	6.46E-03	5.45E-03	4.69E-03
α_3		2.97E-03	3.18E-03	4.59E-03	4.59E-03	3.96E-03	3.23E-03
α_4			1.83E-03	1.67E-03	2.26E-03	2.63E-03	2.47E-03
α_5				3.36E-04	8.40E-04	1.37E-03	1.63E-03
α_6					4.17E-04	4.65E-04	8.14E-04
α_7						8.45E-05	2.51E-04
α_8							2.20E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01
Beta	8.22E-03	1.21E-02	1.49E-02	1.50E-02	1.46E-02	1.40E-02	1.33E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	34.10	34.10	34.10	34.10	34.10	34.10	34.10
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

2.3.8.3 COMBINED HPCI AND RCIC MOTOR-OPERATED VALVES FAIL TO CLOSE: HCI-RCI-MOV-OO

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: 2006 through 2020

Total Number of Independent Failure Events: 16.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9528639	0.9879498	0.9947483	0.9999634	1.0000000	3.841E+01	4.685E-01
α_2	3.38E-05	1.21E-02	5.25E-03	4.71E-02	0.00E+00	4.685E-01	3.841E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9571920	0.9849809	0.9890158	0.9989621	1.0000000	7.398E+01	1.128E+00
α_2	3.80E-04	1.13E-02	7.39E-03	3.57E-02	0.00E+00	8.512E-01	7.426E+01
α_3	1.84E-07	3.69E-03	7.89E-04	1.73E-02	0.00E+00	2.768E-01	7.483E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582301	0.9825585	0.9854279	0.9970799	1.0000000	1.067E+02	1.894E+00
α_2	1.00E-03	1.16E-02	8.77E-03	3.19E-02	0.00E+00	1.260E+00	1.073E+02
α_3	4.03E-06	3.71E-03	1.36E-03	1.53E-02	0.00E+00	4.024E-01	1.082E+02
α_4	1.48E-08	2.13E-03	3.18E-04	1.06E-02	0.00E+00	2.315E-01	1.083E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9672200	0.9836774	0.9851839	0.9949847	1.0000000	2.068E+02	3.432E+00
α_2	1.56E-03	9.15E-03	7.65E-03	2.19E-02	0.00E+00	1.924E+00	2.083E+02
α_3	2.89E-04	4.99E-03	3.53E-03	1.47E-02	0.00E+00	1.049E+00	2.092E+02
α_4	1.38E-06	1.82E-03	6.27E-04	7.67E-03	0.00E+00	3.822E-01	2.099E+02
α_5	3.17E-20	3.65E-04	3.40E-07	2.12E-03	0.00E+00	7.674E-02	2.102E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9694933	0.9843507	0.9856473	0.9947758	1.0000000	2.412E+02	3.835E+00
α_2	9.95E-04	6.94E-03	5.65E-03	1.73E-02	0.00E+00	1.701E+00	2.434E+02

α_3	3.89E-04	4.93E-03	3.66E-03	1.38E-02	0.00E+00	1.207E+00	2.438E+02
α_4	2.23E-05	2.43E-03	1.28E-03	8.76E-03	0.00E+00	5.960E-01	2.445E+02
α_5	3.53E-09	9.02E-04	1.21E-04	4.53E-03	0.00E+00	2.211E-01	2.448E+02
α_6	3.52E-15	4.48E-04	4.54E-06	2.58E-03	0.00E+00	1.098E-01	2.449E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742614	0.9853960	0.9862084	0.9937495	1.0000000	3.878E+02	5.747E+00
α_2	1.17E-03	5.70E-03	4.89E-03	1.30E-02	0.00E+00	2.243E+00	3.913E+02
α_3	5.56E-04	4.14E-03	3.34E-03	1.05E-02	0.00E+00	1.630E+00	3.919E+02
α_4	1.71E-04	2.75E-03	1.97E-03	8.00E-03	0.00E+00	1.083E+00	3.925E+02
α_5	1.04E-05	1.44E-03	7.25E-04	5.28E-03	0.00E+00	5.654E-01	3.930E+02
α_6	2.67E-10	4.87E-04	4.50E-05	2.54E-03	0.00E+00	1.916E-01	3.934E+02
α_7	6.06E-41	8.84E-05	3.29E-12	3.88E-04	0.00E+00	3.480E-02	3.935E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754657	0.9860944	0.9868721	0.9940574	1.0000000	4.060E+02	5.726E+00
α_2	8.84E-04	4.90E-03	4.13E-03	1.16E-02	0.00E+00	2.018E+00	4.097E+02
α_3	3.49E-04	3.38E-03	2.62E-03	9.01E-03	0.00E+00	1.391E+00	4.104E+02
α_4	1.53E-04	2.58E-03	1.83E-03	7.56E-03	0.00E+00	1.062E+00	4.107E+02
α_5	3.01E-05	1.71E-03	9.97E-04	5.80E-03	0.00E+00	7.026E-01	4.110E+02
α_6	3.33E-07	8.49E-04	2.61E-04	3.69E-03	0.00E+00	3.497E-01	4.114E+02
α_7	1.28E-15	2.62E-04	2.40E-06	1.51E-03	0.00E+00	1.078E-01	4.116E+02
α_8	2.68E-17	2.30E-04	9.74E-07	1.34E-03	0.00E+00	9.469E-02	4.117E+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	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.21E-02	1.13E-02	1.16E-02	9.15E-03	6.94E-03	5.70E-03	4.90E-03
α_3		3.69E-03	3.71E-03	4.99E-03	4.93E-03	4.14E-03	3.38E-03
α_4			2.13E-03	1.82E-03	2.43E-03	2.75E-03	2.58E-03
α_5				3.65E-04	9.02E-04	1.44E-03	1.71E-03
α_6					4.48E-04	4.87E-04	8.49E-04
α_7						8.84E-05	2.62E-04
α_8							2.30E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.83E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.21E-02	1.50E-02	1.74E-02	1.63E-02	1.56E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	16.00	16.00	16.00	16.00	16.00	16.00	16.00
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

2.4 Air-Operated Valves

2.4.1 Pooled Air-Operated Valves

2.4.1.1 AIR-OPERATED VALVES FAIL TO OPEN/CLOSE ALL SYSTEMS: ALL-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: 2006 through 2020

Total Number of Independent Failure Events: 144.2

Total Number of Common-Cause Failure Events: 7

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9360427	0.9707572	0.9743515	0.9931812	0.9675561	8.304E+01	2.502E+00
α_2	6.82E-03	2.92E-02	2.57E-02	6.40E-02	3.24E-02	2.502E+00	8.304E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444540	0.9701143	0.9721643	0.9887748	0.9631974	1.469E+02	4.525E+00
α_2	6.86E-03	2.24E-02	2.04E-02	4.51E-02	2.76E-02	3.397E+00	1.480E+02
α_3	5.10E-04	7.45E-03	5.42E-03	2.13E-02	9.22E-03	1.128E+00	1.503E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9516595	0.9722370	0.9736964	0.9878410	0.9666796	2.083E+02	5.949E+00
α_2	4.65E-03	1.55E-02	1.40E-02	3.15E-02	1.70E-02	3.327E+00	2.110E+02
α_3	1.52E-03	8.95E-03	7.48E-03	2.14E-02	1.25E-02	1.918E+00	2.124E+02
α_4	5.84E-05	3.28E-03	1.92E-03	1.11E-02	3.88E-03	7.037E-01	2.136E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9622299	0.9768909	0.9778089	0.9884327	0.9698892	3.373E+02	7.979E+00
α_2	3.47E-03	1.07E-02	9.77E-03	2.11E-02	1.17E-02	3.695E+00	3.416E+02
α_3	1.74E-03	7.40E-03	6.48E-03	1.62E-02	9.98E-03	2.557E+00	3.427E+02
α_4	4.05E-04	3.99E-03	3.08E-03	1.07E-02	6.59E-03	1.378E+00	3.439E+02
α_5	3.99E-07	1.01E-03	3.11E-04	4.41E-03	1.81E-03	3.499E-01	3.449E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9655128	0.9784737	0.9792470	0.9887879	0.9723931	4.005E+02	8.810E+00
α_2	2.41E-03	8.09E-03	7.31E-03	1.65E-02	8.94E-03	3.313E+00	4.059E+02
α_3	1.52E-03	6.36E-03	5.58E-03	1.39E-02	7.75E-03	2.604E+00	4.067E+02
α_4	6.20E-04	4.23E-03	3.45E-03	1.05E-02	6.29E-03	1.730E+00	4.075E+02
α_5	8.29E-05	2.18E-03	1.44E-03	6.79E-03	3.73E-03	8.924E-01	4.084E+02
α_6	2.65E-08	6.62E-04	1.36E-04	3.13E-03	8.95E-04	2.710E-01	4.090E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9710731	0.9811395	0.9816811	0.9893452	0.9745794	5.758E+02	1.107E+01
α_2	2.01E-03	6.25E-03	5.70E-03	1.24E-02	6.80E-03	3.668E+00	5.832E+02
α_3	1.45E-03	5.21E-03	4.66E-03	1.08E-02	6.81E-03	3.055E+00	5.838E+02
α_4	6.75E-04	3.57E-03	3.03E-03	8.34E-03	4.85E-03	2.098E+00	5.848E+02
α_5	2.88E-04	2.51E-03	1.98E-03	6.58E-03	4.35E-03	1.476E+00	5.854E+02
α_6	1.35E-05	1.09E-03	6.02E-04	3.83E-03	2.15E-03	6.408E-01	5.863E+02
α_7	1.45E-13	2.25E-04	5.55E-06	1.27E-03	4.64E-04	1.319E-01	5.868E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728071	0.9822086	0.9827104	0.9898879	0.9766928	6.229E+02	1.128E+01
α_2	1.38E-03	4.90E-03	4.39E-03	1.02E-02	4.56E-03	3.106E+00	6.311E+02
α_3	1.33E-03	4.81E-03	4.30E-03	1.00E-02	6.95E-03	3.048E+00	6.312E+02
α_4	4.84E-04	2.96E-03	2.45E-03	7.15E-03	3.41E-03	1.875E+00	6.323E+02
α_5	3.52E-04	2.59E-03	2.09E-03	6.54E-03	3.95E-03	1.643E+00	6.326E+02
α_6	9.52E-05	1.65E-03	1.17E-03	4.87E-03	2.93E-03	1.048E+00	6.332E+02
α_7	7.68E-07	6.44E-04	2.39E-04	2.66E-03	1.26E-03	4.084E-01	6.338E+02
α_8	3.65E-12	2.43E-04	1.12E-05	1.33E-03	2.50E-04	1.542E-01	6.341E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.71E-01	9.70E-01	9.72E-01	9.77E-01	9.78E-01	9.81E-01	9.82E-01
α_2	2.92E-02	2.24E-02	1.55E-02	1.07E-02	8.09E-03	6.25E-03	4.90E-03
α_3		7.45E-03	8.95E-03	7.40E-03	6.36E-03	5.21E-03	4.81E-03
α_4			3.28E-03	3.99E-03	4.23E-03	3.57E-03	2.96E-03
α_5				1.01E-03	2.18E-03	2.51E-03	2.59E-03
α_6					6.62E-04	1.09E-03	1.65E-03
α_7						2.25E-04	6.44E-04
α_8							2.43E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.71E-01	9.70E-01	9.72E-01	9.77E-01	9.78E-01	9.81E-01	9.82E-01
Beta	2.92E-02	2.99E-02	2.78E-02	2.31E-02	2.15E-02	1.89E-02	1.78E-02
Gamma		2.49E-01	4.41E-01	5.37E-01	6.24E-01	6.69E-01	7.25E-01

Delta			2.68E-01	4.03E-01	5.26E-01	5.87E-01	6.27E-01
Epsilon				2.03E-01	4.02E-01	5.17E-01	6.34E-01
Mu					2.33E-01	3.44E-01	4.95E-01
Omega						1.71E-01	3.49E-01
Sigma							2.74E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	57.68	86.52	115.36	144.20	173.04	201.88	230.72
N_1	2.9506	2.3803	2.2954	2.2551	2.1924	2.1530	2.1907
N_2	2.0331	2.5456	2.0674	1.7707	1.6116	1.4245	1.0883
N_3		0.8512	1.5159	1.5076	1.3966	1.4257	1.6573
N_4			0.4722	0.9954	1.1343	1.0150	0.8133
N_5				0.2731	0.6713	0.9105	0.9408
N_6					0.1613	0.4492	0.6983
N_7						0.0971	0.3006
N_8							0.0595

2.4.1.2 AIR-OPERATED VALVES FAIL TO OPEN ALL SYSTEMS: ALL-AOV-CC

Components/Valve/Air-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 91.8

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9240894	0.9672293	0.9720572	0.9938322	0.9601899	6.078E+01	2.059E+00
α_2	6.17E-03	3.28E-02	2.79E-02	7.59E-02	3.98E-02	2.059E+00	6.078E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9442741	0.9725918	0.9752222	0.9919244	0.9642377	1.148E+02	3.234E+00
α_2	3.48E-03	1.80E-02	1.54E-02	4.16E-02	2.16E-02	2.124E+00	1.159E+02
α_3	6.23E-04	9.41E-03	6.82E-03	2.70E-02	1.42E-02	1.110E+00	1.169E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9512356	0.9739249	0.9757626	0.9903398	0.9672283	1.658E+02	4.439E+00
α_2	3.09E-03	1.40E-02	1.22E-02	3.13E-02	1.45E-02	2.388E+00	1.679E+02
α_3	7.74E-04	7.91E-03	6.09E-03	2.13E-02	1.22E-02	1.347E+00	1.689E+02
α_4	7.36E-05	4.13E-03	2.42E-03	1.40E-02	6.08E-03	7.037E-01	1.695E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9629138	0.9785016	0.9795884	0.9903700	0.9707791	2.844E+02	6.249E+00
α_2	2.64E-03	9.95E-03	8.85E-03	2.10E-02	1.01E-02	2.893E+00	2.878E+02
α_3	1.06E-03	6.46E-03	5.37E-03	1.56E-02	8.60E-03	1.878E+00	2.888E+02
α_4	2.65E-04	3.88E-03	2.82E-03	1.11E-02	7.73E-03	1.128E+00	2.895E+02
α_5	4.75E-07	1.20E-03	3.70E-04	5.23E-03	2.83E-03	3.499E-01	2.903E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9661832	0.9799661	0.9808871	0.9905977	0.9734132	3.372E+02	6.894E+00
α_2	1.85E-03	7.64E-03	6.71E-03	1.66E-02	8.07E-03	2.630E+00	3.415E+02
α_3	8.89E-04	5.44E-03	4.51E-03	1.31E-02	5.77E-03	1.871E+00	3.422E+02
α_4	3.88E-04	3.94E-03	3.03E-03	1.06E-02	6.60E-03	1.355E+00	3.428E+02
α_5	5.35E-05	2.23E-03	1.37E-03	7.34E-03	4.75E-03	7.674E-01	3.433E+02

α_6	3.16E-08	7.88E-04	1.61E-04	3.72E-03	1.40E-03	2.710E-01	3.438E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9717964	0.9823217	0.9829445	0.9907171	0.9753868	5.022E+02	9.038E+00
α_2	1.81E-03	6.26E-03	5.63E-03	1.29E-02	7.16E-03	3.200E+00	5.080E+02
α_3	8.42E-04	4.26E-03	3.63E-03	9.82E-03	4.11E-03	2.179E+00	5.090E+02
α_4	4.91E-04	3.37E-03	2.75E-03	8.37E-03	4.79E-03	1.723E+00	5.095E+02
α_5	1.95E-04	2.40E-03	1.79E-03	6.68E-03	4.94E-03	1.226E+00	5.100E+02
α_6	9.06E-06	1.13E-03	5.80E-04	4.12E-03	2.89E-03	5.783E-01	5.106E+02
α_7	1.66E-13	2.58E-04	6.37E-06	1.45E-03	7.26E-04	1.319E-01	5.111E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9732039	0.9831348	0.9837165	0.9910708	0.9769041	5.388E+02	9.242E+00
α_2	1.53E-03	5.54E-03	4.95E-03	1.16E-02	6.69E-03	3.037E+00	5.450E+02
α_3	5.70E-04	3.45E-03	2.86E-03	8.31E-03	3.27E-03	1.889E+00	5.461E+02
α_4	3.58E-04	2.85E-03	2.27E-03	7.32E-03	3.29E-03	1.563E+00	5.465E+02
α_5	2.31E-04	2.43E-03	1.86E-03	6.58E-03	4.13E-03	1.331E+00	5.467E+02
α_6	6.17E-05	1.63E-03	1.08E-03	5.07E-03	3.56E-03	8.918E-01	5.471E+02
α_7	4.75E-07	6.88E-04	2.33E-04	2.92E-03	1.77E-03	3.772E-01	5.476E+02
α_8	4.22E-12	2.81E-04	1.30E-05	1.54E-03	3.91E-04	1.542E-01	5.479E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.67E-01	9.73E-01	9.74E-01	9.79E-01	9.80E-01	9.82E-01	9.83E-01
α_2	3.28E-02	1.80E-02	1.40E-02	9.95E-03	7.64E-03	6.26E-03	5.54E-03
α_3		9.41E-03	7.91E-03	6.46E-03	5.44E-03	4.26E-03	3.45E-03
α_4			4.13E-03	3.88E-03	3.94E-03	3.37E-03	2.85E-03
α_5				1.20E-03	2.23E-03	2.40E-03	2.43E-03
α_6					7.88E-04	1.13E-03	1.63E-03
α_7						2.58E-04	6.88E-04
α_8							2.81E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.67E-01	9.73E-01	9.74E-01	9.79E-01	9.80E-01	9.82E-01	9.83E-01
Beta	3.28E-02	2.74E-02	2.61E-02	2.15E-02	2.00E-02	1.77E-02	1.69E-02
Gamma		3.43E-01	4.62E-01	5.37E-01	6.19E-01	6.46E-01	6.71E-01
Delta			3.43E-01	4.40E-01	5.61E-01	6.27E-01	6.96E-01
Epsilon				2.37E-01	4.34E-01	5.29E-01	6.38E-01
Mu					2.61E-01	3.67E-01	5.17E-01
Omega						1.86E-01	3.73E-01
Sigma							2.90E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	36.72	55.08	73.44	91.80	110.16	128.52	146.88
N_1	1.6515	1.7045	1.6869	1.7698	1.8329	1.8684	1.8763
N_2	1.5909	1.2727	1.1288	0.9693	0.9285	0.9569	1.0186
N_3		0.8333	0.9444	0.8287	0.6636	0.5491	0.4985
N_4			0.4722	0.7454	0.7593	0.6399	0.5007
N_5				0.2731	0.5463	0.6605	0.6283
N_6					0.1613	0.3867	0.5420
N_7						0.0971	0.2693
N_8							0.0595

2.4.1.3 AIR-OPERATED VALVES AOV FAIL TO CLOSE ALL SYSTEMS: ALL-AOV-OO

Components/Valve/Air-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 45.4

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9347992	0.9787140	0.9855949	0.9991237	0.9777831	4.187E+01	9.107E-01
α_2	8.73E-04	2.13E-02	1.44E-02	6.52E-02	2.22E-02	9.107E-01	4.187E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9394473	0.9726117	0.9761030	0.9938358	0.9558072	8.589E+01	2.419E+00
α_2	4.67E-03	2.41E-02	2.06E-02	5.54E-02	4.36E-02	2.124E+00	8.619E+01
α_3	3.05E-07	3.34E-03	7.95E-04	1.53E-02	6.11E-04	2.947E-01	8.802E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9478879	0.9740198	0.9763982	0.9920304	0.9607165	1.276E+02	3.404E+00
α_2	3.38E-03	1.68E-02	1.44E-02	3.84E-02	2.44E-02	2.198E+00	1.288E+02
α_3	3.59E-04	7.43E-03	5.12E-03	2.24E-02	1.49E-02	9.739E-01	1.300E+02
α_4	1.23E-08	1.77E-03	2.63E-04	8.75E-03	0.00E+00	2.315E-01	1.308E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9614961	0.9786576	0.9799618	0.9913617	0.9636614	2.367E+02	5.162E+00
α_2	2.83E-03	1.13E-02	9.95E-03	2.42E-02	1.68E-02	2.726E+00	2.392E+02
α_3	1.05E-03	7.14E-03	5.84E-03	1.77E-02	1.43E-02	1.728E+00	2.402E+02
α_4	3.07E-05	2.61E-03	1.43E-03	9.22E-03	5.25E-03	6.322E-01	2.413E+02
α_5	2.75E-20	3.17E-04	2.96E-07	1.84E-03	0.00E+00	7.674E-02	2.418E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9646066	0.9798781	0.9809854	0.9913663	0.9662393	2.801E+02	5.751E+00
α_2	1.83E-03	8.34E-03	7.23E-03	1.87E-02	1.20E-02	2.384E+00	2.834E+02
α_3	1.17E-03	6.79E-03	5.68E-03	1.62E-02	1.29E-02	1.940E+00	2.839E+02
α_4	1.62E-04	3.40E-03	2.33E-03	1.03E-02	6.61E-03	9.710E-01	2.848E+02

α_5	4.38E-07	1.21E-03	3.67E-04	5.28E-03	2.20E-03	3.461E-01	2.855E+02
α_6	3.02E-15	3.84E-04	3.89E-06	2.22E-03	0.00E+00	1.098E-01	2.857E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9711319	0.9824569	0.9831749	0.9913262	0.9691594	4.356E+02	7.779E+00
α_2	1.52E-03	6.11E-03	5.39E-03	1.32E-02	7.10E-03	2.711E+00	4.407E+02
α_3	1.30E-03	5.65E-03	4.93E-03	1.25E-02	1.33E-02	2.506E+00	4.409E+02
α_4	3.69E-04	3.29E-03	2.58E-03	8.63E-03	5.69E-03	1.458E+00	4.420E+02
α_5	5.35E-05	1.84E-03	1.17E-03	5.92E-03	3.80E-03	8.154E-01	4.426E+02
α_6	1.16E-08	5.73E-04	1.04E-04	2.76E-03	9.49E-04	2.541E-01	4.432E+02
α_7	5.38E-41	7.85E-05	2.92E-12	3.44E-04	0.00E+00	3.480E-02	4.434E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728282	0.9835011	0.9841787	0.9918465	0.9727831	4.630E+02	7.767E+00
α_2	8.33E-04	4.44E-03	3.76E-03	1.04E-02	9.31E-04	2.088E+00	4.687E+02
α_3	1.27E-03	5.42E-03	4.73E-03	1.19E-02	1.55E-02	2.549E+00	4.682E+02
α_4	2.95E-04	2.92E-03	2.25E-03	7.82E-03	4.17E-03	1.375E+00	4.694E+02
α_5	1.15E-04	2.16E-03	1.51E-03	6.42E-03	4.17E-03	1.015E+00	4.697E+02
α_6	4.51E-06	1.07E-03	4.95E-04	4.11E-03	2.08E-03	5.060E-01	4.702E+02
α_7	5.89E-13	2.95E-04	9.14E-06	1.65E-03	4.17E-04	1.391E-01	4.706E+02
α_8	2.34E-17	2.01E-04	8.52E-07	1.17E-03	0.00E+00	9.469E-02	4.706E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.79E-01	9.73E-01	9.74E-01	9.79E-01	9.80E-01	9.82E-01	9.84E-01
α_2	2.13E-02	2.41E-02	1.68E-02	1.13E-02	8.34E-03	6.11E-03	4.44E-03
α_3		3.34E-03	7.43E-03	7.14E-03	6.79E-03	5.65E-03	5.42E-03
α_4			1.77E-03	2.61E-03	3.40E-03	3.29E-03	2.92E-03
α_5				3.17E-04	1.21E-03	1.84E-03	2.16E-03
α_6					3.84E-04	5.73E-04	1.07E-03
α_7						7.85E-05	2.95E-04
α_8							2.01E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.79E-01	9.73E-01	9.74E-01	9.79E-01	9.80E-01	9.82E-01	9.84E-01
Beta	2.13E-02	2.74E-02	2.60E-02	2.13E-02	2.01E-02	1.75E-02	1.65E-02
Gamma		1.22E-01	3.54E-01	4.72E-01	5.85E-01	6.52E-01	7.31E-01
Delta			1.92E-01	2.91E-01	4.24E-01	5.06E-01	5.51E-01
Epsilon				1.08E-01	3.19E-01	4.31E-01	5.61E-01
Mu					2.41E-01	2.62E-01	4.22E-01
Omega						1.20E-01	3.16E-01
Sigma							4.05E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	18.16	27.24	36.32	45.40	54.48	63.56	72.64
N_1	1.2990	0.6757	0.6086	0.4854	0.3594	0.2845	0.3143
N_2	0.4421	1.2729	0.9386	0.8014	0.6831	0.4676	0.0698
N_3		0.0179	0.5714	0.6789	0.7330	0.8766	1.1588
N_4			0.0000	0.2500	0.3750	0.3750	0.3126
N_5				0.0000	0.1250	0.2500	0.3125
N_6					0.0000	0.0625	0.1563
N_7						0.0000	0.0313
N_8							0.0000

2.4.1.4 AIR-OPERATED VALVES SPURIOUS OPERATION ALL SYSTEMS: ALL-AOV-SO

Components/Valve/Air-Operated Valve
Failure Modes/Spurious Closing
Failure Modes/Spurious Opening
Failure Modes/Spurious Operation
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 29.0

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9281171	0.9722298	0.9779448	0.9967892	0.9666667	5.141E+01	1.469E+00
α_2	3.21E-03	2.78E-02	2.21E-02	7.19E-02	3.33E-02	1.469E+00	5.141E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9526442	0.9794605	0.9824637	0.9960137	0.9775281	1.015E+02	2.128E+00
α_2	1.29E-03	1.30E-02	1.01E-02	3.50E-02	1.12E-02	1.351E+00	1.023E+02
α_3	1.88E-04	7.50E-03	4.66E-03	2.45E-02	1.12E-02	7.768E-01	1.028E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9598206	0.9809090	0.9829814	0.9949116	0.9830508	1.487E+02	2.894E+00
α_2	1.19E-03	9.96E-03	7.90E-03	2.58E-02	4.24E-03	1.510E+00	1.501E+02
α_3	2.34E-04	5.95E-03	3.97E-03	1.84E-02	8.47E-03	9.024E-01	1.507E+02
α_4	1.02E-05	3.18E-03	1.40E-03	1.24E-02	4.24E-03	4.815E-01	1.511E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9689361	0.9834479	0.9846347	0.9939021	0.9863946	2.633E+02	4.432E+00
α_2	1.41E-03	7.65E-03	6.47E-03	1.80E-02	1.70E-03	2.049E+00	2.657E+02
α_3	5.74E-04	5.32E-03	4.15E-03	1.41E-02	5.10E-03	1.424E+00	2.663E+02
α_4	6.49E-05	2.83E-03	1.73E-03	9.34E-03	5.10E-03	7.572E-01	2.670E+02
α_5	8.70E-10	7.53E-04	8.01E-05	3.87E-03	1.70E-03	2.017E-01	2.676E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9719831	0.9847505	0.9857562	0.9940685	0.9886364	3.122E+02	4.835E+00
α_2	8.39E-04	5.56E-03	4.56E-03	1.37E-02	7.10E-04	1.764E+00	3.153E+02

α_3	5.15E-04	4.60E-03	3.60E-03	1.21E-02	2.84E-03	1.457E+00	3.156E+02
α_4	1.46E-04	3.06E-03	2.10E-03	9.26E-03	4.26E-03	9.710E-01	3.161E+02
α_5	4.23E-06	1.49E-03	6.41E-04	5.83E-03	2.84E-03	4.711E-01	3.166E+02
α_6	5.68E-11	5.43E-04	3.65E-05	2.91E-03	7.10E-04	1.723E-01	3.169E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9761218	0.9859444	0.9866118	0.9934819	0.9902439	4.733E+02	6.747E+00
α_2	9.84E-04	4.74E-03	4.07E-03	1.08E-02	3.05E-04	2.274E+00	4.778E+02
α_3	5.70E-04	3.72E-03	3.06E-03	9.13E-03	1.52E-03	1.786E+00	4.783E+02
α_4	3.02E-04	2.91E-03	2.25E-03	7.75E-03	3.05E-03	1.395E+00	4.787E+02
α_5	6.63E-05	1.83E-03	1.20E-03	5.73E-03	3.05E-03	8.779E-01	4.792E+02
α_6	2.73E-07	7.25E-04	2.21E-04	3.16E-03	1.52E-03	3.478E-01	4.797E+02
α_7	2.48E-23	1.38E-04	3.42E-08	7.86E-04	3.05E-04	6.605E-02	4.800E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9776946	0.9868832	0.9875095	0.9939272	0.9914530	5.060E+02	6.726E+00
α_2	7.21E-04	3.97E-03	3.34E-03	9.34E-03	1.34E-04	2.034E+00	5.107E+02
α_3	3.34E-04	2.89E-03	2.28E-03	7.56E-03	8.01E-04	1.484E+00	5.113E+02
α_4	2.29E-04	2.53E-03	1.92E-03	6.91E-03	2.00E-03	1.296E+00	5.114E+02
α_5	1.06E-04	1.98E-03	1.38E-03	5.89E-03	2.67E-03	1.015E+00	5.117E+02
α_6	9.54E-06	1.14E-03	5.89E-04	4.14E-03	2.00E-03	5.841E-01	5.122E+02
α_7	4.49E-10	3.93E-04	4.17E-05	2.02E-03	8.01E-04	2.016E-01	5.125E+02
α_8	1.92E-15	2.15E-04	2.23E-06	1.24E-03	1.34E-04	1.103E-01	5.126E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.72E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01
α_2	2.78E-02	1.30E-02	9.96E-03	7.65E-03	5.56E-03	4.74E-03	3.97E-03
α_3		7.50E-03	5.95E-03	5.32E-03	4.60E-03	3.72E-03	2.89E-03
α_4			3.18E-03	2.83E-03	3.06E-03	2.91E-03	2.53E-03
α_5				7.53E-04	1.49E-03	1.83E-03	1.98E-03
α_6					5.43E-04	7.25E-04	1.14E-03
α_7						1.38E-04	3.93E-04
α_8							2.15E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.72E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01
Beta	2.78E-02	2.05E-02	1.91E-02	1.66E-02	1.52E-02	1.41E-02	1.31E-02
Gamma		3.65E-01	4.78E-01	5.38E-01	6.35E-01	6.63E-01	6.98E-01
Delta			3.48E-01	4.02E-01	5.26E-01	6.01E-01	6.84E-01
Epsilon				2.10E-01	3.99E-01	4.81E-01	5.96E-01
Mu					2.68E-01	3.20E-01	4.69E-01
Omega						1.60E-01	3.48E-01

Sigma							3.54E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	29.00	43.50	58.00	72.50	87.00	101.50	116.00
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 Auxiliary Feedwater Air-Operated Valves

2.4.2.1 AFW AIR-OPERATED VALVES FAIL TO OPEN/CLOSE: AFW-AOV-FTOC

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: 2006 through 2020

Total Number of Independent Failure Events: 33.3

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9205546	0.9661657	0.9713630	0.9939743	0.9575071	5.621E+01	1.969E+00
α_2	6.03E-03	3.38E-02	2.86E-02	7.94E-02	4.25E-02	1.969E+00	5.621E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9444512	0.9733547	0.9761467	0.9927183	0.9647662	1.082E+02	2.961E+00
α_2	2.71E-03	1.67E-02	1.39E-02	4.02E-02	1.92E-02	1.851E+00	1.093E+02
α_3	6.62E-04	9.99E-03	7.24E-03	2.87E-02	1.60E-02	1.110E+00	1.100E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9532674	0.9758581	0.9778021	0.9918206	0.9708926	1.574E+02	3.894E+00
α_2	1.84E-03	1.14E-02	9.48E-03	2.77E-02	8.49E-03	1.843E+00	1.594E+02
α_3	8.17E-04	8.35E-03	6.43E-03	2.25E-02	1.37E-02	1.347E+00	1.599E+02
α_4	7.77E-05	4.36E-03	2.56E-03	1.48E-02	6.87E-03	7.037E-01	1.606E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9649987	0.9803097	0.9814418	0.9917410	0.9757050	2.741E+02	5.506E+00
α_2	1.63E-03	7.99E-03	6.85E-03	1.82E-02	3.63E-03	2.234E+00	2.774E+02
α_3	9.92E-04	6.42E-03	5.28E-03	1.57E-02	8.73E-03	1.794E+00	2.778E+02
α_4	2.75E-04	4.03E-03	2.93E-03	1.16E-02	8.73E-03	1.128E+00	2.785E+02
α_5	4.93E-07	1.25E-03	3.85E-04	5.44E-03	3.20E-03	3.499E-01	2.793E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686552	0.9820590	0.9830188	0.9921782	0.9793681	3.251E+02	5.940E+00

α_2	9.07E-04	5.61E-03	4.65E-03	1.36E-02	1.52E-03	1.856E+00	3.292E+02
α_3	7.39E-04	5.15E-03	4.19E-03	1.28E-02	4.87E-03	1.704E+00	3.294E+02
α_4	3.92E-04	4.05E-03	3.11E-03	1.09E-02	7.31E-03	1.341E+00	3.297E+02
α_5	5.56E-05	2.32E-03	1.42E-03	7.62E-03	5.35E-03	7.674E-01	3.303E+02
α_6	3.28E-08	8.19E-04	1.68E-04	3.87E-03	1.58E-03	2.710E-01	3.308E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9739640	0.9841510	0.9847945	0.9921281	0.9821589	4.884E+02	7.865E+00
α_2	9.90E-04	4.67E-03	4.02E-03	1.06E-02	6.27E-04	2.318E+00	4.939E+02
α_3	6.62E-04	3.89E-03	3.25E-03	9.31E-03	2.53E-03	1.930E+00	4.943E+02
α_4	4.78E-04	3.39E-03	2.75E-03	8.49E-03	5.06E-03	1.683E+00	4.945E+02
α_5	2.00E-04	2.47E-03	1.84E-03	6.88E-03	5.55E-03	1.224E+00	4.950E+02
α_6	9.33E-06	1.17E-03	5.98E-04	4.25E-03	3.26E-03	5.783E-01	4.956E+02
α_7	1.72E-13	2.66E-04	6.57E-06	1.50E-03	8.18E-04	1.319E-01	4.961E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757071	0.9852230	0.9858256	0.9926738	0.9843186	5.232E+02	7.848E+00
α_2	7.11E-04	3.87E-03	3.26E-03	9.08E-03	2.57E-04	2.053E+00	5.290E+02
α_3	3.69E-04	2.94E-03	2.34E-03	7.55E-03	1.26E-03	1.561E+00	5.295E+02
α_4	3.25E-04	2.80E-03	2.21E-03	7.31E-03	3.15E-03	1.489E+00	5.296E+02
α_5	2.34E-04	2.49E-03	1.90E-03	6.76E-03	4.58E-03	1.322E+00	5.297E+02
α_6	6.36E-05	1.68E-03	1.11E-03	5.23E-03	4.00E-03	8.914E-01	5.302E+02
α_7	4.90E-07	7.10E-04	2.40E-04	3.01E-03	1.99E-03	3.772E-01	5.307E+02
α_8	4.36E-12	2.90E-04	1.34E-05	1.59E-03	4.40E-04	1.542E-01	5.309E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.66E-01	9.73E-01	9.76E-01	9.80E-01	9.82E-01	9.84E-01	9.85E-01
α_2	3.38E-02	1.67E-02	1.14E-02	7.99E-03	5.61E-03	4.67E-03	3.87E-03
α_3		9.99E-03	8.35E-03	6.42E-03	5.15E-03	3.89E-03	2.94E-03
α_4			4.36E-03	4.03E-03	4.05E-03	3.39E-03	2.80E-03
α_5				1.25E-03	2.32E-03	2.47E-03	2.49E-03
α_6					8.19E-04	1.17E-03	1.68E-03
α_7						2.66E-04	7.10E-04
α_8							2.90E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.66E-01	9.73E-01	9.76E-01	9.80E-01	9.82E-01	9.84E-01	9.85E-01
Beta	3.38E-02	2.66E-02	2.41E-02	1.97E-02	1.79E-02	1.58E-02	1.48E-02
Gamma		3.75E-01	5.27E-01	5.94E-01	6.88E-01	7.05E-01	7.38E-01
Delta			3.43E-01	4.52E-01	5.83E-01	6.52E-01	7.31E-01
Epsilon				2.37E-01	4.36E-01	5.35E-01	6.48E-01
Mu					2.61E-01	3.67E-01	5.18E-01

Omega						1.86E-01	3.73E-01
Sigma							2.90E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	33.30	49.95	66.60	83.25	99.90	116.55	133.20
N_1	0.5000	0.2500	0.1111	0.0463	0.0185	0.0072	0.0027
N_2	1.5000	1.0000	0.5833	0.3102	0.1551	0.0745	0.0348
N_3		0.8333	0.9444	0.7454	0.4969	0.3003	0.1706
N_4			0.4722	0.7454	0.7454	0.6006	0.4264
N_5				0.2731	0.5463	0.6582	0.6198
N_6					0.1613	0.3867	0.5416
N_7						0.0971	0.2693
N_8							0.0595

2.4.2.2 AFW AIR-OPERATED VALVES FAIL TO OPEN: AFW-AOV-CC

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Air-Operated Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 16.1

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8879518	0.9519654	0.9591544	0.9913554	0.9171271	3.901E+01	1.969E+00
α_2	8.64E-03	4.80E-02	4.08E-02	1.12E-01	8.29E-02	1.969E+00	3.901E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9278945	0.9652993	0.9688785	0.9904709	0.9301144	8.238E+01	2.961E+00
α_2	3.54E-03	2.17E-02	1.81E-02	5.22E-02	3.81E-02	1.851E+00	8.349E+01
α_3	8.64E-04	1.30E-02	9.45E-03	3.73E-02	3.18E-02	1.110E+00	8.423E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9407305	0.9693128	0.9717453	0.9895650	0.9417098	1.230E+02	3.894E+00
α_2	2.34E-03	1.45E-02	1.21E-02	3.51E-02	1.70E-02	1.843E+00	1.250E+02
α_3	1.04E-03	1.06E-02	8.18E-03	2.85E-02	2.75E-02	1.347E+00	1.255E+02
α_4	9.89E-05	5.55E-03	3.25E-03	1.88E-02	1.38E-02	7.037E-01	1.262E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9586850	0.9767318	0.9780657	0.9902316	0.9510490	2.311E+02	5.506E+00
α_2	1.93E-03	9.44E-03	8.10E-03	2.15E-02	7.32E-03	2.234E+00	2.344E+02
α_3	1.17E-03	7.58E-03	6.25E-03	1.86E-02	1.76E-02	1.794E+00	2.348E+02
α_4	3.25E-04	4.77E-03	3.46E-03	1.37E-02	1.76E-02	1.128E+00	2.355E+02
α_5	5.83E-07	1.48E-03	4.55E-04	6.43E-03	6.45E-03	3.499E-01	2.363E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9629049	0.9787466	0.9798769	0.9907216	0.9582548	2.735E+02	5.940E+00
α_2	1.08E-03	6.64E-03	5.51E-03	1.61E-02	3.08E-03	1.856E+00	2.776E+02
α_3	8.76E-04	6.10E-03	4.97E-03	1.52E-02	9.85E-03	1.704E+00	2.778E+02
α_4	4.65E-04	4.80E-03	3.68E-03	1.30E-02	1.48E-02	1.341E+00	2.781E+02

α_5	6.59E-05	2.75E-03	1.69E-03	9.03E-03	1.08E-02	7.674E-01	2.787E+02
α_6	3.89E-08	9.70E-04	1.99E-04	4.58E-03	3.20E-03	2.710E-01	2.792E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9703912	0.9819627	0.9826923	0.9910394	0.9637913	4.282E+02	7.865E+00
α_2	1.13E-03	5.32E-03	4.58E-03	1.20E-02	1.27E-03	2.318E+00	4.337E+02
α_3	7.54E-04	4.43E-03	3.69E-03	1.06E-02	5.14E-03	1.930E+00	4.341E+02
α_4	5.44E-04	3.86E-03	3.13E-03	9.66E-03	1.03E-02	1.683E+00	4.343E+02
α_5	2.27E-04	2.81E-03	2.09E-03	7.82E-03	1.13E-02	1.224E+00	4.348E+02
α_6	1.06E-05	1.33E-03	6.80E-04	4.83E-03	6.61E-03	5.783E-01	4.354E+02
α_7	1.95E-13	3.02E-04	7.47E-06	1.70E-03	1.66E-03	1.319E-01	4.359E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9721074	0.9830237	0.9837131	0.9915720	0.9681009	4.544E+02	7.848E+00
α_2	8.17E-04	4.44E-03	3.75E-03	1.04E-02	5.24E-04	2.053E+00	4.602E+02
α_3	4.24E-04	3.38E-03	2.69E-03	8.67E-03	2.56E-03	1.561E+00	4.607E+02
α_4	3.74E-04	3.22E-03	2.54E-03	8.40E-03	6.41E-03	1.489E+00	4.608E+02
α_5	2.69E-04	2.86E-03	2.18E-03	7.77E-03	9.32E-03	1.322E+00	4.609E+02
α_6	7.31E-05	1.93E-03	1.27E-03	6.01E-03	8.14E-03	8.914E-01	4.614E+02
α_7	5.63E-07	8.16E-04	2.76E-04	3.46E-03	4.05E-03	3.772E-01	4.619E+02
α_8	5.01E-12	3.34E-04	1.54E-05	1.83E-03	8.95E-04	1.542E-01	4.621E+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	9.65E-01	9.69E-01	9.77E-01	9.79E-01	9.82E-01	9.83E-01
α_2	4.80E-02	2.17E-02	1.45E-02	9.44E-03	6.64E-03	5.32E-03	4.44E-03
α_3		1.30E-02	1.06E-02	7.58E-03	6.10E-03	4.43E-03	3.38E-03
α_4			5.55E-03	4.77E-03	4.80E-03	3.86E-03	3.22E-03
α_5				1.48E-03	2.75E-03	2.81E-03	2.86E-03
α_6					9.70E-04	1.33E-03	1.93E-03
α_7						3.02E-04	8.16E-04
α_8							3.34E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.52E-01	9.65E-01	9.69E-01	9.77E-01	9.79E-01	9.82E-01	9.83E-01
Beta	4.80E-02	3.47E-02	3.07E-02	2.33E-02	2.13E-02	1.80E-02	1.70E-02
Gamma		3.75E-01	5.27E-01	5.94E-01	6.88E-01	7.05E-01	7.38E-01
Delta			3.43E-01	4.52E-01	5.83E-01	6.52E-01	7.31E-01
Epsilon				2.37E-01	4.36E-01	5.35E-01	6.48E-01
Mu					2.61E-01	3.67E-01	5.18E-01
Omega						1.86E-01	3.73E-01
Sigma							2.90E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	16.10	24.15	32.20	40.25	48.30	56.35	64.40
N_1	0.5000	0.2500	0.1111	0.0463	0.0185	0.0072	0.0027
N_2	1.5000	1.0000	0.5833	0.3102	0.1551	0.0745	0.0348
N_3		0.8333	0.9444	0.7454	0.4969	0.3003	0.1706
N_4			0.4722	0.7454	0.7454	0.6006	0.4264
N_5				0.2731	0.5463	0.6582	0.6198
N_6					0.1613	0.3867	0.5416
N_7						0.0971	0.2693
N_8							0.0595

2.4.2.3 AFW AIR-OPERATED VALVES FAIL TO CLOSE: AFW-AOV-OO

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Air-Operated Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 15.2

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9518791	0.9876967	0.9946360	0.9999627	1.0000000	3.761E+01	4.685E-01
α_2	3.46E-05	1.23E-02	5.36E-03	4.81E-02	0.00E+00	4.685E-01	3.761E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9567346	0.9848192	0.9888965	0.9989508	1.0000000	7.318E+01	1.128E+00
α_2	3.84E-04	1.15E-02	7.47E-03	3.61E-02	0.00E+00	8.512E-01	7.346E+01
α_3	1.86E-07	3.73E-03	7.98E-04	1.75E-02	0.00E+00	2.768E-01	7.403E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9579225	0.9824290	0.9853190	0.9970580	1.0000000	1.059E+02	1.894E+00
α_2	1.01E-03	1.17E-02	8.84E-03	3.21E-02	0.00E+00	1.260E+00	1.065E+02
α_3	4.06E-06	3.73E-03	1.37E-03	1.55E-02	0.00E+00	4.024E-01	1.074E+02
α_4	1.49E-08	2.15E-03	3.20E-04	1.06E-02	0.00E+00	2.315E-01	1.075E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670956	0.9836151	0.9851272	0.9949654	1.0000000	2.060E+02	3.432E+00
α_2	1.56E-03	9.19E-03	7.68E-03	2.20E-02	0.00E+00	1.924E+00	2.075E+02
α_3	2.90E-04	5.01E-03	3.55E-03	1.47E-02	0.00E+00	1.049E+00	2.084E+02
α_4	1.39E-06	1.82E-03	6.29E-04	7.70E-03	0.00E+00	3.822E-01	2.091E+02
α_5	3.18E-20	3.66E-04	3.41E-07	2.13E-03	0.00E+00	7.674E-02	2.094E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9693940	0.9842995	0.9856002	0.9947585	1.0000000	2.404E+02	3.835E+00
α_2	9.98E-04	6.96E-03	5.67E-03	1.73E-02	0.00E+00	1.701E+00	2.426E+02
α_3	3.90E-04	4.94E-03	3.67E-03	1.38E-02	0.00E+00	1.207E+00	2.430E+02
α_4	2.24E-05	2.44E-03	1.28E-03	8.79E-03	0.00E+00	5.960E-01	2.437E+02

α_5	3.54E-09	9.05E-04	1.21E-04	4.54E-03	0.00E+00	2.211E-01	2.440E+02
α_6	3.54E-15	4.49E-04	4.55E-06	2.59E-03	0.00E+00	1.098E-01	2.441E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742101	0.9853663	0.9861803	0.9937368	1.0000000	3.870E+02	5.747E+00
α_2	1.17E-03	5.71E-03	4.90E-03	1.30E-02	0.00E+00	2.243E+00	3.905E+02
α_3	5.57E-04	4.15E-03	3.34E-03	1.05E-02	0.00E+00	1.630E+00	3.911E+02
α_4	1.72E-04	2.76E-03	1.97E-03	8.02E-03	0.00E+00	1.083E+00	3.917E+02
α_5	1.04E-05	1.44E-03	7.26E-04	5.29E-03	0.00E+00	5.654E-01	3.922E+02
α_6	2.68E-10	4.88E-04	4.51E-05	2.54E-03	0.00E+00	1.916E-01	3.926E+02
α_7	6.07E-41	8.86E-05	3.30E-12	3.89E-04	0.00E+00	3.480E-02	3.927E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754181	0.9860674	0.9868465	0.9940449	1.0000000	4.052E+02	5.726E+00
α_2	8.85E-04	4.91E-03	4.13E-03	1.16E-02	0.00E+00	2.018E+00	4.089E+02
α_3	3.49E-04	3.38E-03	2.62E-03	9.03E-03	0.00E+00	1.391E+00	4.096E+02
α_4	1.54E-04	2.58E-03	1.84E-03	7.57E-03	0.00E+00	1.062E+00	4.099E+02
α_5	3.02E-05	1.71E-03	9.99E-04	5.81E-03	0.00E+00	7.026E-01	4.102E+02
α_6	3.34E-07	8.51E-04	2.61E-04	3.70E-03	0.00E+00	3.497E-01	4.106E+02
α_7	1.28E-15	2.62E-04	2.41E-06	1.52E-03	0.00E+00	1.078E-01	4.108E+02
α_8	2.68E-17	2.30E-04	9.76E-07	1.34E-03	0.00E+00	9.469E-02	4.109E+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	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.23E-02	1.15E-02	1.17E-02	9.19E-03	6.96E-03	5.71E-03	4.91E-03
α_3		3.73E-03	3.73E-03	5.01E-03	4.94E-03	4.15E-03	3.38E-03
α_4			2.15E-03	1.82E-03	2.44E-03	2.76E-03	2.58E-03
α_5				3.66E-04	9.05E-04	1.44E-03	1.71E-03
α_6					4.49E-04	4.88E-04	8.51E-04
α_7						8.86E-05	2.62E-04
α_8							2.30E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.88E-01	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.23E-02	1.52E-02	1.76E-02	1.64E-02	1.57E-02	1.46E-02	1.39E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	15.20	15.20	15.20	15.20	15.20	15.20	15.20
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 Check Valves

2.5.1 Pooled Check Valves

2.5.1.1 CHECK VALVES FAIL TO OPEN ALL SYSTEMS: ALL-CKV-CC

Components/Valve/Check Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

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	0.9265716	0.9811696	0.9917194	0.9999431	1.0000000	2.441E+01	4.685E-01
α_2	5.35E-05	1.88E-02	8.28E-03	7.34E-02	0.00E+00	4.685E-01	2.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9474768	0.9815399	0.9864769	0.9987198	1.0000000	5.998E+01	1.128E+00
α_2	4.68E-04	1.39E-02	9.10E-03	4.39E-02	0.00E+00	8.512E-01	6.026E+01
α_3	2.27E-07	4.53E-03	9.72E-04	2.13E-02	0.00E+00	2.768E-01	6.083E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521027	0.9799764	0.9832554	0.9966416	1.0000000	9.268E+01	1.894E+00
α_2	1.15E-03	1.33E-02	1.01E-02	3.66E-02	0.00E+00	1.260E+00	9.331E+01
α_3	4.63E-06	4.26E-03	1.56E-03	1.76E-02	0.00E+00	4.024E-01	9.417E+01
α_4	1.70E-08	2.45E-03	3.65E-04	1.21E-02	0.00E+00	2.315E-01	9.434E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648968	0.9825131	0.9841236	0.9946232	1.0000000	1.928E+02	3.432E+00
α_2	1.67E-03	9.80E-03	8.20E-03	2.34E-02	0.00E+00	1.924E+00	1.943E+02
α_3	3.10E-04	5.34E-03	3.79E-03	1.57E-02	0.00E+00	1.049E+00	1.952E+02
α_4	1.48E-06	1.95E-03	6.71E-04	8.21E-03	0.00E+00	3.822E-01	1.959E+02
α_5	3.40E-20	3.91E-04	3.64E-07	2.27E-03	0.00E+00	7.674E-02	1.962E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676555	0.9834025	0.9847752	0.9944521	1.0000000	2.272E+02	3.835E+00
α_2	1.06E-03	7.36E-03	6.00E-03	1.83E-02	0.00E+00	1.701E+00	2.294E+02
α_3	4.12E-04	5.22E-03	3.88E-03	1.46E-02	0.00E+00	1.207E+00	2.298E+02
α_4	2.36E-05	2.58E-03	1.35E-03	9.29E-03	0.00E+00	5.960E-01	2.305E+02
α_5	3.75E-09	9.57E-04	1.28E-04	4.80E-03	0.00E+00	2.211E-01	2.308E+02
α_6	3.74E-15	4.75E-04	4.81E-06	2.74E-03	0.00E+00	1.098E-01	2.309E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733172	0.9848573	0.9856988	0.9935127	1.0000000	3.738E+02	5.747E+00
α_2	1.21E-03	5.91E-03	5.07E-03	1.35E-02	0.00E+00	2.243E+00	3.773E+02
α_3	5.76E-04	4.29E-03	3.46E-03	1.09E-02	0.00E+00	1.630E+00	3.779E+02
α_4	1.78E-04	2.85E-03	2.04E-03	8.30E-03	0.00E+00	1.083E+00	3.785E+02
α_5	1.08E-05	1.49E-03	7.51E-04	5.47E-03	0.00E+00	5.654E-01	3.790E+02
α_6	2.77E-10	5.05E-04	4.66E-05	2.63E-03	0.00E+00	1.916E-01	3.794E+02
α_7	6.28E-41	9.17E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.795E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746063	0.9856050	0.9864091	0.9938511	1.0000000	3.920E+02	5.726E+00
α_2	9.15E-04	5.07E-03	4.27E-03	1.20E-02	0.00E+00	2.018E+00	3.957E+02
α_3	3.61E-04	3.50E-03	2.71E-03	9.33E-03	0.00E+00	1.391E+00	3.964E+02
α_4	1.59E-04	2.67E-03	1.90E-03	7.82E-03	0.00E+00	1.062E+00	3.967E+02
α_5	3.12E-05	1.77E-03	1.03E-03	6.00E-03	0.00E+00	7.026E-01	3.970E+02
α_6	3.45E-07	8.79E-04	2.70E-04	3.82E-03	0.00E+00	3.497E-01	3.974E+02
α_7	1.33E-15	2.71E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.976E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.977E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.88E-02	1.39E-02	1.33E-02	9.80E-03	7.36E-03	5.91E-03	5.07E-03
α_3		4.53E-03	4.26E-03	5.34E-03	5.22E-03	4.29E-03	3.50E-03
α_4			2.45E-03	1.95E-03	2.58E-03	2.85E-03	2.67E-03
α_5				3.91E-04	9.57E-04	1.49E-03	1.77E-03
α_6					4.75E-04	5.05E-04	8.79E-04
α_7						9.17E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.88E-02	1.85E-02	2.00E-02	1.75E-02	1.66E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

2.5.1.2 CHECK VALVES FAIL TO CLOSE ALL SYSTEMS: ALL-CKV-OO

Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 29.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9282511	0.9722822	0.9779869	0.9967954	0.9667774	5.151E+01	1.469E+00
α_2	3.21E-03	2.77E-02	2.20E-02	7.18E-02	3.32E-02	1.469E+00	5.151E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9527121	0.9794902	0.9824892	0.9960195	0.9776036	1.016E+02	2.128E+00
α_2	1.29E-03	1.30E-02	1.01E-02	3.49E-02	1.12E-02	1.351E+00	1.024E+02
α_3	1.88E-04	7.49E-03	4.65E-03	2.45E-02	1.12E-02	7.768E-01	1.030E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9598731	0.9809341	0.9830039	0.9949184	0.9831081	1.489E+02	2.894E+00
α_2	1.19E-03	9.95E-03	7.89E-03	2.57E-02	4.22E-03	1.510E+00	1.503E+02
α_3	2.34E-04	5.95E-03	3.96E-03	1.84E-02	8.45E-03	9.024E-01	1.509E+02
α_4	1.02E-05	3.17E-03	1.40E-03	1.23E-02	4.22E-03	4.815E-01	1.513E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9689649	0.9834634	0.9846490	0.9939029	0.9864407	2.636E+02	4.432E+00
α_2	1.41E-03	7.65E-03	6.46E-03	1.79E-02	1.69E-03	2.049E+00	2.660E+02
α_3	5.73E-04	5.31E-03	4.14E-03	1.40E-02	5.08E-03	1.424E+00	2.666E+02
α_4	6.49E-05	2.83E-03	1.72E-03	9.33E-03	5.08E-03	7.572E-01	2.673E+02
α_5	8.69E-10	7.53E-04	8.01E-05	3.87E-03	1.69E-03	2.017E-01	2.678E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9720095	0.9847649	0.9857697	0.9940762	0.9886750	3.125E+02	4.835E+00
α_2	8.38E-04	5.56E-03	4.56E-03	1.37E-02	7.08E-04	1.764E+00	3.156E+02
α_3	5.15E-04	4.59E-03	3.60E-03	1.21E-02	2.83E-03	1.457E+00	3.159E+02
α_4	1.46E-04	3.06E-03	2.10E-03	9.25E-03	4.25E-03	9.710E-01	3.164E+02
α_5	4.23E-06	1.48E-03	6.41E-04	5.82E-03	2.83E-03	4.711E-01	3.169E+02

α_6	5.67E-11	5.43E-04	3.65E-05	2.90E-03	7.08E-04	1.723E-01	3.172E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9761391	0.9859546	0.9866215	0.9934918	0.9902771	4.737E+02	6.747E+00
α_2	9.83E-04	4.73E-03	4.07E-03	1.08E-02	3.04E-04	2.274E+00	4.781E+02
α_3	5.70E-04	3.72E-03	3.06E-03	9.13E-03	1.52E-03	1.786E+00	4.786E+02
α_4	3.02E-04	2.90E-03	2.25E-03	7.74E-03	3.04E-03	1.395E+00	4.790E+02
α_5	6.63E-05	1.83E-03	1.20E-03	5.73E-03	3.04E-03	8.779E-01	4.795E+02
α_6	2.72E-07	7.24E-04	2.21E-04	3.15E-03	1.52E-03	3.478E-01	4.800E+02
α_7	2.48E-23	1.37E-04	3.42E-08	7.85E-04	3.04E-04	6.605E-02	4.803E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9777054	0.9868935	0.9875241	0.9939321	0.9914821	5.064E+02	6.726E+00
α_2	7.21E-04	3.96E-03	3.34E-03	9.33E-03	1.33E-04	2.034E+00	5.111E+02
α_3	3.34E-04	2.89E-03	2.28E-03	7.55E-03	7.99E-04	1.484E+00	5.117E+02
α_4	2.29E-04	2.53E-03	1.92E-03	6.91E-03	2.00E-03	1.296E+00	5.118E+02
α_5	1.06E-04	1.98E-03	1.38E-03	5.89E-03	2.66E-03	1.015E+00	5.121E+02
α_6	9.53E-06	1.14E-03	5.88E-04	4.13E-03	2.00E-03	5.841E-01	5.126E+02
α_7	4.48E-10	3.93E-04	4.17E-05	2.02E-03	7.99E-04	2.016E-01	5.129E+02
α_8	1.92E-15	2.15E-04	2.23E-06	1.24E-03	1.33E-04	1.103E-01	5.130E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.72E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01
α_2	2.77E-02	1.30E-02	9.95E-03	7.65E-03	5.56E-03	4.73E-03	3.96E-03
α_3		7.49E-03	5.95E-03	5.31E-03	4.59E-03	3.72E-03	2.89E-03
α_4			3.17E-03	2.83E-03	3.06E-03	2.90E-03	2.53E-03
α_5				7.53E-04	1.48E-03	1.83E-03	1.98E-03
α_6					5.43E-04	7.24E-04	1.14E-03
α_7						1.37E-04	3.93E-04
α_8							2.15E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.72E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01
Beta	2.77E-02	2.05E-02	1.91E-02	1.65E-02	1.52E-02	1.40E-02	1.31E-02
Gamma		3.65E-01	4.78E-01	5.38E-01	6.35E-01	6.63E-01	6.98E-01
Delta			3.48E-01	4.02E-01	5.26E-01	6.01E-01	6.84E-01
Epsilon				2.10E-01	3.99E-01	4.81E-01	5.96E-01
Mu					2.68E-01	3.20E-01	4.69E-01
Omega						1.60E-01	3.48E-01
Sigma							3.54E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	29.10	43.65	58.20	72.75	87.30	101.85	116.40
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

2.5.1.3 CHECK VALVES FAIL TO REMAIN CLOSED (LEAKAGE) ALL SYSTEMS: ALL-CKV-LK

Components/Valve/Check Valve
Failure Modes/Leak (Internal)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 20.6

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9578270	0.9892246	0.9953180	0.9999673	1.0000000	4.301E+01	4.685E-01
α_2	3.02E-05	1.08E-02	4.69E-03	4.22E-02	0.00E+00	4.685E-01	4.301E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9596498	0.9858477	0.9896551	0.9990224	1.0000000	7.858E+01	1.128E+00
α_2	3.58E-04	1.07E-02	6.96E-03	3.37E-02	0.00E+00	8.512E-01	7.886E+01
α_3	1.73E-07	3.47E-03	7.43E-04	1.63E-02	0.00E+00	2.768E-01	7.943E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9599151	0.9832674	0.9860236	0.9971999	1.0000000	1.113E+02	1.894E+00
α_2	9.62E-04	1.11E-02	8.41E-03	3.06E-02	0.00E+00	1.260E+00	1.119E+02
α_3	3.86E-06	3.56E-03	1.31E-03	1.47E-02	0.00E+00	4.024E-01	1.128E+02
α_4	1.42E-08	2.05E-03	3.05E-04	1.01E-02	0.00E+00	2.315E-01	1.129E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679177	0.9840269	0.9855021	0.9950930	1.0000000	2.114E+02	3.432E+00
α_2	1.52E-03	8.96E-03	7.48E-03	2.14E-02	0.00E+00	1.924E+00	2.129E+02
α_3	2.83E-04	4.88E-03	3.46E-03	1.43E-02	0.00E+00	1.049E+00	2.138E+02
α_4	1.35E-06	1.78E-03	6.13E-04	7.50E-03	0.00E+00	3.822E-01	2.145E+02
α_5	3.10E-20	3.57E-04	3.33E-07	2.08E-03	0.00E+00	7.674E-02	2.148E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700523	0.9846391	0.9859125	0.9948728	1.0000000	2.458E+02	3.835E+00
α_2	9.77E-04	6.81E-03	5.55E-03	1.70E-02	0.00E+00	1.701E+00	2.480E+02
α_3	3.81E-04	4.83E-03	3.59E-03	1.35E-02	0.00E+00	1.207E+00	2.484E+02
α_4	2.19E-05	2.39E-03	1.25E-03	8.60E-03	0.00E+00	5.960E-01	2.491E+02

α_5	3.47E-09	8.86E-04	1.18E-04	4.44E-03	0.00E+00	2.211E-01	2.494E+02
α_6	3.46E-15	4.40E-04	4.45E-06	2.54E-03	0.00E+00	1.098E-01	2.495E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9745632	0.9855647	0.9863681	0.9938217	1.0000000	3.924E+02	5.747E+00
α_2	1.15E-03	5.63E-03	4.83E-03	1.29E-02	0.00E+00	2.243E+00	3.959E+02
α_3	5.49E-04	4.09E-03	3.30E-03	1.04E-02	0.00E+00	1.630E+00	3.965E+02
α_4	1.69E-04	2.72E-03	1.95E-03	7.91E-03	0.00E+00	1.083E+00	3.971E+02
α_5	1.03E-05	1.42E-03	7.16E-04	5.22E-03	0.00E+00	5.654E-01	3.976E+02
α_6	2.64E-10	4.81E-04	4.45E-05	2.51E-03	0.00E+00	1.916E-01	3.980E+02
α_7	5.99E-41	8.74E-05	3.25E-12	3.83E-04	0.00E+00	3.480E-02	3.981E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757359	0.9862481	0.9870174	0.9941287	1.0000000	4.106E+02	5.726E+00
α_2	8.74E-04	4.85E-03	4.08E-03	1.14E-02	0.00E+00	2.018E+00	4.143E+02
α_3	3.45E-04	3.34E-03	2.59E-03	8.91E-03	0.00E+00	1.391E+00	4.150E+02
α_4	1.52E-04	2.55E-03	1.81E-03	7.47E-03	0.00E+00	1.062E+00	4.153E+02
α_5	2.98E-05	1.69E-03	9.86E-04	5.73E-03	0.00E+00	7.026E-01	4.156E+02
α_6	3.30E-07	8.40E-04	2.58E-04	3.65E-03	0.00E+00	3.497E-01	4.160E+02
α_7	1.27E-15	2.59E-04	2.38E-06	1.50E-03	0.00E+00	1.078E-01	4.162E+02
α_8	2.65E-17	2.27E-04	9.63E-07	1.32E-03	0.00E+00	9.469E-02	4.163E+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	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.08E-02	1.07E-02	1.11E-02	8.96E-03	6.81E-03	5.63E-03	4.85E-03
α_3		3.47E-03	3.56E-03	4.88E-03	4.83E-03	4.09E-03	3.34E-03
α_4			2.05E-03	1.78E-03	2.39E-03	2.72E-03	2.55E-03
α_5				3.57E-04	8.86E-04	1.42E-03	1.69E-03
α_6					4.40E-04	4.81E-04	8.40E-04
α_7						8.74E-05	2.59E-04
α_8							2.27E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.08E-02	1.42E-02	1.67E-02	1.60E-02	1.54E-02	1.44E-02	1.38E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	20.60	20.60	20.60	20.60	20.60	20.60	20.60
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

2.5.2 Auxiliary Feedwater Check Valves

2.5.2.1 AFW CHECK VALVES FAIL TO CLOSE: AFW-CKV-OO

Systems/Clean Water/Auxiliary feedwater
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 4.6

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9334602	0.9829511	0.9925261	0.9999484	1.0000000	2.701E+01	4.685E-01
α_2	4.83E-05	1.70E-02	7.48E-03	6.65E-02	0.00E+00	4.685E-01	2.701E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9496007	0.9822933	0.9870295	0.9987778	1.0000000	6.258E+01	1.128E+00
α_2	4.49E-04	1.34E-02	8.72E-03	4.21E-02	0.00E+00	8.512E-01	6.286E+01
α_3	2.17E-07	4.35E-03	9.32E-04	2.04E-02	0.00E+00	2.768E-01	6.343E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9533730	0.9805122	0.9837065	0.9967327	1.0000000	9.528E+01	1.894E+00
α_2	1.12E-03	1.30E-02	9.81E-03	3.56E-02	0.00E+00	1.260E+00	9.591E+01
α_3	4.50E-06	4.14E-03	1.52E-03	1.71E-02	0.00E+00	4.024E-01	9.677E+01
α_4	1.65E-08	2.38E-03	3.55E-04	1.18E-02	0.00E+00	2.315E-01	9.694E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9653528	0.9827418	0.9843318	0.9946943	1.0000000	1.954E+02	3.432E+00
α_2	1.65E-03	9.68E-03	8.09E-03	2.31E-02	0.00E+00	1.924E+00	1.969E+02
α_3	3.05E-04	5.27E-03	3.74E-03	1.55E-02	0.00E+00	1.049E+00	1.978E+02
α_4	1.46E-06	1.92E-03	6.63E-04	8.11E-03	0.00E+00	3.822E-01	1.985E+02
α_5	3.35E-20	3.86E-04	3.60E-07	2.24E-03	0.00E+00	7.674E-02	1.988E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9680133	0.9835872	0.9849451	0.9945139	1.0000000	2.298E+02	3.835E+00
α_2	1.04E-03	7.28E-03	5.93E-03	1.81E-02	0.00E+00	1.701E+00	2.320E+02
α_3	4.08E-04	5.17E-03	3.84E-03	1.45E-02	0.00E+00	1.207E+00	2.324E+02

α_4	2.34E-05	2.55E-03	1.34E-03	9.19E-03	0.00E+00	5.960E-01	2.331E+02
α_5	3.71E-09	9.46E-04	1.27E-04	4.75E-03	0.00E+00	2.211E-01	2.334E+02
α_6	3.70E-15	4.70E-04	4.76E-06	2.71E-03	0.00E+00	1.098E-01	2.335E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735027	0.9849604	0.9857963	0.9935571	1.0000000	3.764E+02	5.747E+00
α_2	1.20E-03	5.87E-03	5.03E-03	1.34E-02	0.00E+00	2.243E+00	3.799E+02
α_3	5.72E-04	4.26E-03	3.44E-03	1.08E-02	0.00E+00	1.630E+00	3.805E+02
α_4	1.76E-04	2.83E-03	2.03E-03	8.24E-03	0.00E+00	1.083E+00	3.811E+02
α_5	1.07E-05	1.48E-03	7.46E-04	5.44E-03	0.00E+00	5.654E-01	3.816E+02
α_6	2.75E-10	5.01E-04	4.63E-05	2.61E-03	0.00E+00	1.916E-01	3.820E+02
α_7	6.24E-41	9.11E-05	3.39E-12	3.99E-04	0.00E+00	3.480E-02	3.821E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747703	0.9856985	0.9864976	0.9938909	1.0000000	3.946E+02	5.726E+00
α_2	9.09E-04	5.04E-03	4.24E-03	1.19E-02	0.00E+00	2.018E+00	3.983E+02
α_3	3.59E-04	3.47E-03	2.69E-03	9.27E-03	0.00E+00	1.391E+00	3.990E+02
α_4	1.58E-04	2.65E-03	1.88E-03	7.77E-03	0.00E+00	1.062E+00	3.993E+02
α_5	3.10E-05	1.75E-03	1.03E-03	5.96E-03	0.00E+00	7.026E-01	3.996E+02
α_6	3.43E-07	8.74E-04	2.68E-04	3.80E-03	0.00E+00	3.497E-01	4.000E+02
α_7	1.32E-15	2.69E-04	2.47E-06	1.56E-03	0.00E+00	1.078E-01	4.002E+02
α_8	2.75E-17	2.37E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	4.003E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.70E-02	1.34E-02	1.30E-02	9.68E-03	7.28E-03	5.87E-03	5.04E-03
α_3		4.35E-03	4.14E-03	5.27E-03	5.17E-03	4.26E-03	3.47E-03
α_4			2.38E-03	1.92E-03	2.55E-03	2.83E-03	2.65E-03
α_5				3.86E-04	9.46E-04	1.48E-03	1.75E-03
α_6					4.70E-04	5.01E-04	8.74E-04
α_7						9.11E-05	2.69E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.70E-02	1.77E-02	1.95E-02	1.73E-02	1.64E-02	1.50E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	4.60	4.60	4.60	4.60	4.60	4.60	4.60
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

2.5.3 PWR Residual Heat Removal Check Valves

2.5.3.1 PWR RHR CHECK VALVES FAIL TO CLOSE: PWR-RHR-CKV-OO

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: 2006 through 2020

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	0.9387663	0.9843204	0.9931392	0.9999526	1.0000000	2.941E+01	4.685E-01
α_2	4.43E-05	1.57E-02	6.86E-03	6.12E-02	0.00E+00	4.685E-01	2.941E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514143	0.9829362	0.9875052	0.9988234	1.0000000	6.498E+01	1.128E+00
α_2	4.32E-04	1.29E-02	8.40E-03	4.06E-02	0.00E+00	8.512E-01	6.526E+01
α_3	2.09E-07	4.19E-03	8.97E-04	1.96E-02	0.00E+00	2.768E-01	6.583E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9544871	0.9809820	0.9841019	0.9968125	1.0000000	9.768E+01	1.894E+00
α_2	1.09E-03	1.27E-02	9.57E-03	3.48E-02	0.00E+00	1.260E+00	9.831E+01
α_3	4.40E-06	4.04E-03	1.49E-03	1.67E-02	0.00E+00	4.024E-01	9.917E+01
α_4	1.61E-08	2.32E-03	3.47E-04	1.15E-02	0.00E+00	2.315E-01	9.934E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9657633	0.9829476	0.9845193	0.9947582	1.0000000	1.978E+02	3.432E+00
α_2	1.63E-03	9.56E-03	7.99E-03	2.29E-02	0.00E+00	1.924E+00	1.993E+02
α_3	3.02E-04	5.21E-03	3.69E-03	1.53E-02	0.00E+00	1.049E+00	2.002E+02
α_4	1.44E-06	1.90E-03	6.55E-04	8.01E-03	0.00E+00	3.822E-01	2.009E+02
α_5	3.31E-20	3.81E-04	3.55E-07	2.22E-03	0.00E+00	7.674E-02	2.012E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9683367	0.9837541	0.9850986	0.9945699	1.0000000	2.322E+02	3.835E+00
α_2	1.03E-03	7.21E-03	5.87E-03	1.79E-02	0.00E+00	1.701E+00	2.344E+02

α_3	4.03E-04	5.11E-03	3.80E-03	1.43E-02	0.00E+00	1.207E+00	2.348E+02
α_4	2.31E-05	2.52E-03	1.33E-03	9.10E-03	0.00E+00	5.960E-01	2.355E+02
α_5	3.67E-09	9.37E-04	1.25E-04	4.70E-03	0.00E+00	2.211E-01	2.358E+02
α_6	3.66E-15	4.65E-04	4.71E-06	2.68E-03	0.00E+00	1.098E-01	2.359E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736667	0.9850542	0.9858851	0.9935977	1.0000000	3.788E+02	5.747E+00
α_2	1.19E-03	5.83E-03	5.00E-03	1.33E-02	0.00E+00	2.243E+00	3.823E+02
α_3	5.69E-04	4.24E-03	3.42E-03	1.07E-02	0.00E+00	1.630E+00	3.829E+02
α_4	1.75E-04	2.82E-03	2.02E-03	8.19E-03	0.00E+00	1.083E+00	3.835E+02
α_5	1.06E-05	1.47E-03	7.41E-04	5.40E-03	0.00E+00	5.654E-01	3.840E+02
α_6	2.74E-10	4.98E-04	4.60E-05	2.60E-03	0.00E+00	1.916E-01	3.844E+02
α_7	6.20E-41	9.05E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.845E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749198	0.9857837	0.9865782	0.9939228	1.0000000	3.970E+02	5.726E+00
α_2	9.03E-04	5.01E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.007E+02
α_3	3.57E-04	3.45E-03	2.67E-03	9.21E-03	0.00E+00	1.391E+00	4.014E+02
α_4	1.57E-04	2.64E-03	1.87E-03	7.72E-03	0.00E+00	1.062E+00	4.017E+02
α_5	3.08E-05	1.74E-03	1.02E-03	5.92E-03	0.00E+00	7.026E-01	4.020E+02
α_6	3.41E-07	8.68E-04	2.67E-04	3.78E-03	0.00E+00	3.497E-01	4.024E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.026E+02
α_8	2.74E-17	2.35E-04	9.96E-07	1.37E-03	0.00E+00	9.469E-02	4.027E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.57E-02	1.29E-02	1.27E-02	9.56E-03	7.21E-03	5.83E-03	5.01E-03
α_3		4.19E-03	4.04E-03	5.21E-03	5.11E-03	4.24E-03	3.45E-03
α_4			2.32E-03	1.90E-03	2.52E-03	2.82E-03	2.64E-03
α_5				3.81E-04	9.37E-04	1.47E-03	1.74E-03
α_6					4.65E-04	4.98E-04	8.68E-04
α_7						9.05E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.57E-02	1.71E-02	1.90E-02	1.71E-02	1.62E-02	1.49E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	7.00	7.00	7.00	7.00	7.00	7.00	7.00
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

2.5.4 High Pressure Coolant Injection and Reactor Core Isolation Cooling Check Valves

2.5.4.1 COMBINED HPCI AND RCIC CHECK VALVES FAIL TO CLOSE: ALL-CKV-CC

Systems/Clean Water/High pressure coolant injection
Systems/Clean Water/Reactor core isolation
Components/Valve/Check Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 6.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9377318	0.9840536	0.9930199	0.9999518	1.0000000	2.891E+01	4.685E-01
α_2	4.51E-05	1.59E-02	6.98E-03	6.23E-02	0.00E+00	4.685E-01	2.891E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9510473	0.9828061	0.9874090	0.9988142	1.0000000	6.448E+01	1.128E+00
α_2	4.35E-04	1.30E-02	8.47E-03	4.09E-02	0.00E+00	8.512E-01	6.476E+01
α_3	2.11E-07	4.22E-03	9.04E-04	1.98E-02	0.00E+00	2.768E-01	6.533E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9542594	0.9808860	0.9840211	0.9967962	1.0000000	9.718E+01	1.894E+00
α_2	1.10E-03	1.27E-02	9.62E-03	3.49E-02	0.00E+00	1.260E+00	9.781E+01
α_3	4.42E-06	4.06E-03	1.49E-03	1.68E-02	0.00E+00	4.024E-01	9.867E+01
α_4	1.62E-08	2.34E-03	3.48E-04	1.16E-02	0.00E+00	2.315E-01	9.884E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9656786	0.9829051	0.9844806	0.9947450	1.0000000	1.973E+02	3.432E+00
α_2	1.63E-03	9.58E-03	8.01E-03	2.29E-02	0.00E+00	1.924E+00	1.988E+02
α_3	3.03E-04	5.22E-03	3.70E-03	1.54E-02	0.00E+00	1.049E+00	1.997E+02
α_4	1.45E-06	1.90E-03	6.56E-04	8.03E-03	0.00E+00	3.822E-01	2.004E+02
α_5	3.32E-20	3.82E-04	3.56E-07	2.22E-03	0.00E+00	7.674E-02	2.007E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b

α_1	0.9682699	0.9837196	0.9850668	0.9945583	1.0000000	2.317E+02	3.835E+00
α_2	1.04E-03	7.22E-03	5.88E-03	1.80E-02	0.00E+00	1.701E+00	2.339E+02
α_3	4.04E-04	5.12E-03	3.81E-03	1.43E-02	0.00E+00	1.207E+00	2.343E+02
α_4	2.32E-05	2.53E-03	1.33E-03	9.12E-03	0.00E+00	5.960E-01	2.350E+02
α_5	3.68E-09	9.39E-04	1.26E-04	4.71E-03	0.00E+00	2.211E-01	2.353E+02
α_6	3.67E-15	4.66E-04	4.72E-06	2.69E-03	0.00E+00	1.098E-01	2.354E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736327	0.9850348	0.9858667	0.9935893	1.0000000	3.783E+02	5.747E+00
α_2	1.19E-03	5.84E-03	5.01E-03	1.33E-02	0.00E+00	2.243E+00	3.818E+02
α_3	5.69E-04	4.24E-03	3.42E-03	1.07E-02	0.00E+00	1.630E+00	3.824E+02
α_4	1.75E-04	2.82E-03	2.02E-03	8.20E-03	0.00E+00	1.083E+00	3.830E+02
α_5	1.06E-05	1.47E-03	7.42E-04	5.41E-03	0.00E+00	5.654E-01	3.835E+02
α_6	2.74E-10	4.99E-04	4.61E-05	2.60E-03	0.00E+00	1.916E-01	3.839E+02
α_7	6.21E-41	9.06E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.840E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748888	0.9857660	0.9865615	0.9939151	1.0000000	3.965E+02	5.726E+00
α_2	9.05E-04	5.02E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.002E+02
α_3	3.57E-04	3.46E-03	2.68E-03	9.22E-03	0.00E+00	1.391E+00	4.009E+02
α_4	1.57E-04	2.64E-03	1.88E-03	7.73E-03	0.00E+00	1.062E+00	4.012E+02
α_5	3.08E-05	1.75E-03	1.02E-03	5.93E-03	0.00E+00	7.026E-01	4.015E+02
α_6	3.41E-07	8.69E-04	2.67E-04	3.78E-03	0.00E+00	3.497E-01	4.019E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.021E+02
α_8	2.74E-17	2.35E-04	9.97E-07	1.37E-03	0.00E+00	9.469E-02	4.022E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.59E-02	1.30E-02	1.27E-02	9.58E-03	7.22E-03	5.84E-03	5.02E-03
α_3		4.22E-03	4.06E-03	5.22E-03	5.12E-03	4.24E-03	3.46E-03
α_4			2.34E-03	1.90E-03	2.53E-03	2.82E-03	2.64E-03
α_5				3.82E-04	9.39E-04	1.47E-03	1.75E-03
α_6					4.66E-04	4.99E-04	8.69E-04
α_7						9.06E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.59E-02	1.72E-02	1.91E-02	1.71E-02	1.63E-02	1.50E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01

Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	6.50	6.50	6.50	6.50	6.50	6.50	6.50
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

2.6 Strainers, Trash Racks, and Filters

2.6.1 Pooled Strainers

2.6.1.1 TRAVELLING SCREENS PLUG: ALL-TSA-PG

Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 22.0

Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7554971	0.8543446	0.8601619	0.9332881	0.6940299	3.481E+01	5.935E+00
α_2	6.67E-02	1.46E-01	1.40E-01	2.45E-01	3.06E-01	5.935E+00	3.481E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8553917	0.9115046	0.9148095	0.9563119	0.7383966	7.548E+01	7.328E+00
α_2	6.76E-03	2.96E-02	2.59E-02	6.51E-02	6.75E-02	2.451E+00	8.036E+01
α_3	2.34E-02	5.89E-02	5.54E-02	1.06E-01	1.94E-01	4.877E+00	7.793E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8847987	0.9270035	0.9293329	0.9612477	0.7608200	1.129E+02	8.894E+00
α_2	7.27E-03	2.55E-02	2.30E-02	5.25E-02	6.32E-02	3.110E+00	1.187E+02
α_3	5.97E-03	2.30E-02	2.04E-02	4.88E-02	8.20E-02	2.802E+00	1.190E+02
α_4	6.72E-03	2.45E-02	2.19E-02	5.10E-02	9.40E-02	2.981E+00	1.189E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9261891	0.9515205	0.9528285	0.9723772	0.7788462	2.178E+02	1.110E+01
α_2	5.30E-03	1.62E-02	1.48E-02	3.19E-02	5.17E-02	3.716E+00	2.252E+02
α_3	4.00E-03	1.39E-02	1.25E-02	2.85E-02	6.13E-02	3.174E+00	2.258E+02
α_4	3.06E-03	1.20E-02	1.07E-02	2.58E-02	6.85E-02	2.757E+00	2.262E+02
α_5	7.08E-04	6.34E-03	4.97E-03	1.67E-02	3.97E-02	1.452E+00	2.275E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9337404	0.9560130	0.9571370	0.9744405	0.8000000	2.572E+02	1.183E+01
α_2	2.61E-03	1.03E-02	9.09E-03	2.20E-02	2.66E-02	2.764E+00	2.663E+02

α_3	4.75E-03	1.42E-02	1.31E-02	2.78E-02	6.56E-02	3.832E+00	2.652E+02
α_4	1.88E-03	8.72E-03	7.54E-03	1.96E-02	4.38E-02	2.346E+00	2.667E+02
α_5	1.47E-03	7.79E-03	6.61E-03	1.81E-02	4.69E-02	2.096E+00	2.670E+02
α_6	8.05E-05	2.96E-03	1.86E-03	9.61E-03	1.72E-02	7.973E-01	2.683E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9521749	0.9674912	0.9682232	0.9802961	0.8235294	4.091E+02	1.375E+01
α_2	2.03E-03	7.27E-03	6.51E-03	1.51E-02	1.83E-02	3.074E+00	4.198E+02
α_3	2.41E-03	7.98E-03	7.22E-03	1.61E-02	3.85E-02	3.373E+00	4.195E+02
α_4	2.03E-03	7.26E-03	6.50E-03	1.51E-02	4.38E-02	3.070E+00	4.198E+02
α_5	1.23E-03	5.62E-03	4.87E-03	1.26E-02	4.00E-02	2.378E+00	4.205E+02
α_6	3.97E-04	3.48E-03	2.74E-03	9.11E-03	2.83E-02	1.473E+00	4.214E+02
α_7	6.34E-07	8.95E-04	3.04E-04	3.79E-03	7.58E-03	3.786E-01	4.225E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9547435	0.9692536	0.9699547	0.9813806	0.8421053	4.327E+02	1.373E+01
α_2	1.47E-03	5.99E-03	5.27E-03	1.30E-02	1.29E-02	2.674E+00	4.437E+02
α_3	1.41E-03	5.86E-03	5.14E-03	1.28E-02	2.42E-02	2.618E+00	4.438E+02
α_4	1.64E-03	6.33E-03	5.61E-03	1.35E-02	3.48E-02	2.828E+00	4.436E+02
α_5	1.31E-03	5.65E-03	4.93E-03	1.24E-02	3.59E-02	2.523E+00	4.439E+02
α_6	7.07E-04	4.25E-03	3.53E-03	1.02E-02	3.05E-02	1.897E+00	4.445E+02
α_7	8.53E-05	2.06E-03	1.38E-03	6.35E-03	1.60E-02	9.203E-01	4.455E+02
α_8	2.01E-08	5.97E-04	1.18E-04	2.83E-03	3.39E-03	2.666E-01	4.461E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	8.54E-01	9.12E-01	9.27E-01	9.52E-01	9.56E-01	9.67E-01	9.69E-01
α_2	1.46E-01	2.96E-02	2.55E-02	1.62E-02	1.03E-02	7.27E-03	5.99E-03
α_3		5.89E-02	2.30E-02	1.39E-02	1.42E-02	7.98E-03	5.86E-03
α_4			2.45E-02	1.20E-02	8.72E-03	7.26E-03	6.33E-03
α_5				6.34E-03	7.79E-03	5.62E-03	5.65E-03
α_6					2.96E-03	3.48E-03	4.25E-03
α_7						8.95E-04	2.06E-03
α_8							5.97E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	8.54E-01	9.12E-01	9.27E-01	9.52E-01	9.56E-01	9.67E-01	9.69E-01
Beta	1.46E-01	8.85E-02	7.30E-02	4.85E-02	4.40E-02	3.25E-02	3.07E-02
Gamma		6.66E-01	6.50E-01	6.65E-01	7.66E-01	7.76E-01	8.05E-01
Delta			5.15E-01	5.70E-01	5.78E-01	6.84E-01	7.63E-01
Epsilon				3.45E-01	5.52E-01	5.79E-01	6.65E-01
Mu					2.76E-01	4.38E-01	5.50E-01
Omega						2.04E-01	3.85E-01

Sigma							2.25E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	10.67	16.00	21.33	26.67	32.00	37.33	42.67
N_1	1.7333	1.5000	0.9333	0.3333	0.0000	0.0000	0.0000
N_2	5.4667	1.6000	1.8500	1.7917	1.0625	0.8313	0.6556
N_3		4.6000	2.4000	2.1250	2.6250	1.7438	1.2275
N_4			2.7500	2.3750	1.7500	1.9875	1.7656
N_5				1.3750	1.8750	1.8125	1.8200
N_6					0.6875	1.2813	1.5469
N_7						0.3438	0.8125
N_8							0.1719

2.6.1.2 TRAVELLING SCREENS PLUG EXTREME ENVIRONMENTAL: ALL-TSA-PG-EE

Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 18.0

Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7438971	0.8470657	0.8530518	0.9297435	0.6567732	3.287E+01	5.935E+00
α_2	7.03E-02	1.53E-01	1.47E-01	2.56E-01	3.43E-01	5.935E+00	3.287E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8502655	0.9082825	0.9116818	0.9546742	0.7017927	7.257E+01	7.328E+00
α_2	7.01E-03	3.07E-02	2.68E-02	6.75E-02	7.70E-02	2.451E+00	7.745E+01
α_3	2.43E-02	6.10E-02	5.74E-02	1.10E-01	2.21E-01	4.877E+00	7.502E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8810816	0.9246032	0.9269958	0.9599437	0.7242779	1.091E+02	8.894E+00
α_2	7.52E-03	2.64E-02	2.37E-02	5.42E-02	7.29E-02	3.110E+00	1.148E+02
α_3	6.17E-03	2.38E-02	2.11E-02	5.04E-02	9.45E-02	2.802E+00	1.152E+02
α_4	6.95E-03	2.53E-02	2.26E-02	5.26E-02	1.08E-01	2.981E+00	1.150E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9246106	0.9504715	0.9518048	0.9717669	0.7428862	2.130E+02	1.110E+01
α_2	5.41E-03	1.66E-02	1.52E-02	3.26E-02	6.01E-02	3.716E+00	2.204E+02
α_3	4.08E-03	1.42E-02	1.27E-02	2.91E-02	7.13E-02	3.174E+00	2.209E+02
α_4	3.13E-03	1.23E-02	1.09E-02	2.63E-02	7.96E-02	2.757E+00	2.213E+02
α_5	7.23E-04	6.48E-03	5.08E-03	1.70E-02	4.61E-02	1.452E+00	2.226E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9322911	0.9550407	0.9561871	0.9738683	0.7659574	2.514E+02	1.183E+01
α_2	2.67E-03	1.05E-02	9.29E-03	2.25E-02	3.11E-02	2.764E+00	2.605E+02
α_3	4.86E-03	1.46E-02	1.33E-02	2.84E-02	7.68E-02	3.832E+00	2.594E+02

α_4	1.92E-03	8.91E-03	7.70E-03	2.00E-02	5.12E-02	2.346E+00	2.609E+02
α_5	1.51E-03	7.96E-03	6.76E-03	1.85E-02	5.49E-02	2.096E+00	2.611E+02
α_6	8.23E-05	3.03E-03	1.90E-03	9.82E-03	2.01E-02	7.973E-01	2.624E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514001	0.9669608	0.9677043	0.9799722	0.7924528	4.023E+02	1.375E+01
α_2	2.07E-03	7.39E-03	6.62E-03	1.54E-02	2.16E-02	3.074E+00	4.130E+02
α_3	2.45E-03	8.11E-03	7.33E-03	1.64E-02	4.52E-02	3.373E+00	4.127E+02
α_4	2.06E-03	7.38E-03	6.61E-03	1.53E-02	5.16E-02	3.070E+00	4.130E+02
α_5	1.25E-03	5.71E-03	4.94E-03	1.28E-02	4.70E-02	2.378E+00	4.137E+02
α_6	4.04E-04	3.54E-03	2.78E-03	9.26E-03	3.32E-02	1.473E+00	4.146E+02
α_7	6.45E-07	9.10E-04	3.09E-04	3.85E-03	8.92E-03	3.786E-01	4.157E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9539436	0.9687099	0.9694182	0.9810489	0.8135593	4.249E+02	1.373E+01
α_2	1.50E-03	6.10E-03	5.36E-03	1.32E-02	1.53E-02	2.674E+00	4.360E+02
α_3	1.44E-03	5.97E-03	5.24E-03	1.30E-02	2.86E-02	2.618E+00	4.360E+02
α_4	1.67E-03	6.45E-03	5.71E-03	1.37E-02	4.11E-02	2.828E+00	4.358E+02
α_5	1.33E-03	5.75E-03	5.02E-03	1.27E-02	4.24E-02	2.523E+00	4.361E+02
α_6	7.20E-04	4.32E-03	3.60E-03	1.04E-02	3.61E-02	1.897E+00	4.368E+02
α_7	8.69E-05	2.10E-03	1.41E-03	6.47E-03	1.89E-02	9.203E-01	4.377E+02
α_8	2.05E-08	6.08E-04	1.21E-04	2.88E-03	4.01E-03	2.666E-01	4.384E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	8.47E-01	9.08E-01	9.25E-01	9.50E-01	9.55E-01	9.67E-01	9.69E-01
α_2	1.53E-01	3.07E-02	2.64E-02	1.66E-02	1.05E-02	7.39E-03	6.10E-03
α_3		6.10E-02	2.38E-02	1.42E-02	1.46E-02	8.11E-03	5.97E-03
α_4			2.53E-02	1.23E-02	8.91E-03	7.38E-03	6.45E-03
α_5				6.48E-03	7.96E-03	5.71E-03	5.75E-03
α_6					3.03E-03	3.54E-03	4.32E-03
α_7						9.10E-04	2.10E-03
α_8							6.08E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	8.47E-01	9.08E-01	9.25E-01	9.50E-01	9.55E-01	9.67E-01	9.69E-01
Beta	1.53E-01	9.17E-02	7.54E-02	4.95E-02	4.50E-02	3.30E-02	3.13E-02
Gamma		6.66E-01	6.50E-01	6.65E-01	7.66E-01	7.76E-01	8.05E-01
Delta			5.15E-01	5.70E-01	5.78E-01	6.84E-01	7.63E-01
Epsilon				3.45E-01	5.52E-01	5.79E-01	6.65E-01
Mu					2.76E-01	4.38E-01	5.50E-01
Omega						2.04E-01	3.85E-01
Sigma							2.25E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	8.73	13.09	17.45	21.82	26.18	30.55	34.91
N_1	1.7333	1.5000	0.9333	0.3333	0.0000	0.0000	0.0000
N_2	5.4667	1.6000	1.8500	1.7917	1.0625	0.8313	0.6556
N_3		4.6000	2.4000	2.1250	2.6250	1.7438	1.2275
N_4			2.7500	2.3750	1.7500	1.9875	1.7656
N_5				1.3750	1.8750	1.8125	1.8200
N_6					0.6875	1.2813	1.5469
N_7						0.3438	0.8125
N_8							0.1719

2.6.1.3 TRAVELLING SCREENS PLUG NON ENVIRONMENTAL: ALL-TSA-PG-NE

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: 2006 through 2020

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	0.9319869	0.9825706	0.9923504	0.9999473	1.0000000	2.641E+01	4.685E-01
α_2	4.94E-05	1.74E-02	7.65E-03	6.80E-02	0.00E+00	4.685E-01	2.641E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9491259	0.9821250	0.9869099	0.9987658	1.0000000	6.198E+01	1.128E+00
α_2	4.53E-04	1.35E-02	8.81E-03	4.25E-02	0.00E+00	8.512E-01	6.226E+01
α_3	2.19E-07	4.39E-03	9.41E-04	2.06E-02	0.00E+00	2.768E-01	6.283E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9530858	0.9803911	0.9836046	0.9967121	1.0000000	9.468E+01	1.894E+00
α_2	1.13E-03	1.30E-02	9.87E-03	3.58E-02	0.00E+00	1.260E+00	9.531E+01
α_3	4.53E-06	4.17E-03	1.53E-03	1.73E-02	0.00E+00	4.024E-01	9.617E+01
α_4	1.66E-08	2.40E-03	3.58E-04	1.19E-02	0.00E+00	2.315E-01	9.634E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9652486	0.9826895	0.9842843	0.9946781	1.0000000	1.948E+02	3.432E+00
α_2	1.65E-03	9.70E-03	8.11E-03	2.32E-02	0.00E+00	1.924E+00	1.963E+02
α_3	3.06E-04	5.29E-03	3.75E-03	1.55E-02	0.00E+00	1.049E+00	1.972E+02
α_4	1.47E-06	1.93E-03	6.65E-04	8.13E-03	0.00E+00	3.822E-01	1.979E+02
α_5	3.36E-20	3.87E-04	3.61E-07	2.25E-03	0.00E+00	7.674E-02	1.982E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679315	0.9835450	0.9849062	0.9944998	1.0000000	2.292E+02	3.835E+00
α_2	1.05E-03	7.30E-03	5.95E-03	1.82E-02	0.00E+00	1.701E+00	2.314E+02
α_3	4.09E-04	5.18E-03	3.85E-03	1.45E-02	0.00E+00	1.207E+00	2.318E+02
α_4	2.34E-05	2.56E-03	1.34E-03	9.21E-03	0.00E+00	5.960E-01	2.325E+02
α_5	3.71E-09	9.49E-04	1.27E-04	4.76E-03	0.00E+00	2.211E-01	2.328E+02
α_6	3.71E-15	4.71E-04	4.77E-06	2.72E-03	0.00E+00	1.098E-01	2.329E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734614	0.9849367	0.9857739	0.9935469	1.0000000	3.758E+02	5.747E+00
α_2	1.20E-03	5.88E-03	5.04E-03	1.34E-02	0.00E+00	2.243E+00	3.793E+02
α_3	5.73E-04	4.27E-03	3.44E-03	1.08E-02	0.00E+00	1.630E+00	3.799E+02
α_4	1.77E-04	2.84E-03	2.03E-03	8.26E-03	0.00E+00	1.083E+00	3.805E+02
α_5	1.07E-05	1.48E-03	7.47E-04	5.44E-03	0.00E+00	5.654E-01	3.810E+02
α_6	2.76E-10	5.02E-04	4.64E-05	2.62E-03	0.00E+00	1.916E-01	3.814E+02
α_7	6.25E-41	9.12E-05	3.39E-12	4.00E-04	0.00E+00	3.480E-02	3.815E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747326	0.9856770	0.9864773	0.9938818	1.0000000	3.940E+02	5.726E+00
α_2	9.10E-04	5.05E-03	4.25E-03	1.19E-02	0.00E+00	2.018E+00	3.977E+02
α_3	3.59E-04	3.48E-03	2.69E-03	9.28E-03	0.00E+00	1.391E+00	3.984E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.78E-03	0.00E+00	1.062E+00	3.987E+02
α_5	3.10E-05	1.76E-03	1.03E-03	5.97E-03	0.00E+00	7.026E-01	3.990E+02
α_6	3.44E-07	8.75E-04	2.69E-04	3.80E-03	0.00E+00	3.497E-01	3.994E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.996E+02
α_8	2.76E-17	2.37E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	3.997E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.74E-02	1.35E-02	1.30E-02	9.70E-03	7.30E-03	5.88E-03	5.05E-03
α_3		4.39E-03	4.17E-03	5.29E-03	5.18E-03	4.27E-03	3.48E-03
α_4			2.40E-03	1.93E-03	2.56E-03	2.84E-03	2.66E-03
α_5				3.87E-04	9.49E-04	1.48E-03	1.76E-03
α_6					4.71E-04	5.02E-04	8.75E-04
α_7						9.12E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.74E-02	1.79E-02	1.96E-02	1.73E-02	1.65E-02	1.51E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01

Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	4.00	4.00	4.00	4.00	4.00	4.00	4.00
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

2.6.1.4 TRAVELLING SCREENS FAIL TO OPERATE NON ENVIRONMENTAL: ALL-TSA-FTOP-NE

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: 2006 through 2020

Total Number of Independent Failure Events: 36.5

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9049147	0.9611818	0.9679526	0.9942573	0.9413617	4.235E+01	1.710E+00
α_2	5.74E-03	3.88E-02	3.20E-02	9.51E-02	5.86E-02	1.710E+00	4.235E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9333465	0.9683020	0.9717075	0.9915993	0.9441748	8.715E+01	2.853E+00
α_2	4.36E-03	2.31E-02	1.96E-02	5.35E-02	3.96E-02	2.076E+00	8.793E+01
α_3	2.17E-04	8.63E-03	5.37E-03	2.82E-02	1.62E-02	7.768E-01	8.923E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9387016	0.9673296	0.9696462	0.9880292	0.9393314	1.286E+02	4.344E+00
α_2	6.07E-03	2.23E-02	1.99E-02	4.65E-02	4.21E-02	2.960E+00	1.300E+02
α_3	2.68E-04	6.79E-03	4.53E-03	2.10E-02	1.24E-02	9.024E-01	1.321E+02
α_4	1.17E-05	3.62E-03	1.60E-03	1.41E-02	6.19E-03	4.815E-01	1.325E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9567011	0.9750134	0.9763030	0.9889290	0.9464659	2.380E+02	6.099E+00
α_2	4.11E-03	1.37E-02	1.24E-02	2.77E-02	2.84E-02	3.341E+00	2.407E+02
α_3	1.14E-03	7.37E-03	6.08E-03	1.80E-02	1.51E-02	1.799E+00	2.423E+02
α_4	7.13E-05	3.10E-03	1.89E-03	1.02E-02	7.53E-03	7.572E-01	2.433E+02
α_5	9.54E-10	8.27E-04	8.79E-05	4.25E-03	2.51E-03	2.017E-01	2.439E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9602977	0.9765649	0.9776620	0.9890970	0.9506658	2.815E+02	6.755E+00
α_2	2.92E-03	1.05E-02	9.43E-03	2.19E-02	2.26E-02	3.038E+00	2.852E+02
α_3	1.22E-03	6.89E-03	5.78E-03	1.63E-02	1.31E-02	1.985E+00	2.863E+02
α_4	2.38E-04	3.78E-03	2.71E-03	1.10E-02	8.33E-03	1.089E+00	2.872E+02
α_5	4.66E-06	1.63E-03	7.05E-04	6.41E-03	4.22E-03	4.711E-01	2.878E+02
α_6	6.24E-11	5.98E-04	4.02E-05	3.20E-03	1.06E-03	1.723E-01	2.881E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682156	0.9801511	0.9808625	0.9896515	0.9546685	4.372E+02	8.854E+00
α_2	2.42E-03	7.81E-03	7.08E-03	1.57E-02	1.81E-02	3.482E+00	4.426E+02
α_3	1.19E-03	5.39E-03	4.67E-03	1.20E-02	1.13E-02	2.405E+00	4.437E+02
α_4	4.96E-04	3.67E-03	2.96E-03	9.27E-03	8.09E-03	1.637E+00	4.444E+02
α_5	8.39E-05	2.05E-03	1.37E-03	6.34E-03	5.12E-03	9.161E-01	4.452E+02
α_6	2.93E-07	7.80E-04	2.38E-04	3.40E-03	2.28E-03	3.478E-01	4.457E+02
α_7	2.67E-23	1.48E-04	3.68E-08	8.46E-04	4.56E-04	6.605E-02	4.460E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696088	0.9809506	0.9816214	0.9899994	0.9576625	4.646E+02	9.022E+00
α_2	1.97E-03	6.79E-03	6.11E-03	1.39E-02	1.54E-02	3.217E+00	4.704E+02
α_3	8.77E-04	4.53E-03	3.85E-03	1.05E-02	9.67E-03	2.143E+00	4.715E+02
α_4	4.65E-04	3.45E-03	2.78E-03	8.72E-03	7.36E-03	1.635E+00	4.720E+02
α_5	1.58E-04	2.36E-03	1.71E-03	6.79E-03	5.34E-03	1.118E+00	4.725E+02
α_6	1.16E-05	1.26E-03	6.61E-04	4.54E-03	3.17E-03	5.967E-01	4.730E+02
α_7	4.86E-10	4.26E-04	4.51E-05	2.19E-03	1.20E-03	2.016E-01	4.734E+02
α_8	2.08E-15	2.33E-04	2.42E-06	1.34E-03	2.01E-04	1.103E-01	4.735E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.61E-01	9.68E-01	9.67E-01	9.75E-01	9.77E-01	9.80E-01	9.81E-01
α_2	3.88E-02	2.31E-02	2.23E-02	1.37E-02	1.05E-02	7.81E-03	6.79E-03
α_3		8.63E-03	6.79E-03	7.37E-03	6.89E-03	5.39E-03	4.53E-03
α_4			3.62E-03	3.10E-03	3.78E-03	3.67E-03	3.45E-03
α_5				8.27E-04	1.63E-03	2.05E-03	2.36E-03
α_6					5.98E-04	7.80E-04	1.26E-03
α_7						1.48E-04	4.26E-04
α_8							2.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.61E-01	9.68E-01	9.67E-01	9.75E-01	9.77E-01	9.80E-01	9.81E-01
Beta	3.88E-02	3.17E-02	3.27E-02	2.50E-02	2.34E-02	1.98E-02	1.90E-02
Gamma		2.72E-01	3.19E-01	4.52E-01	5.50E-01	6.07E-01	6.43E-01

Delta			3.48E-01	3.48E-01	4.66E-01	5.52E-01	6.31E-01
Epsilon				2.10E-01	3.71E-01	4.48E-01	5.53E-01
Mu					2.68E-01	3.11E-01	4.48E-01
Omega						1.60E-01	3.43E-01
Sigma							3.54E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	18.25	27.38	36.50	45.63	54.75	63.88	73.00
N_1	1.6833	1.8000	1.4333	1.5208	1.5208	1.5564	1.5623
N_2	1.2417	1.2250	1.7000	1.4167	1.3368	1.2392	1.1990
N_3		0.5000	0.5000	0.7500	0.7778	0.7751	0.7528
N_4			0.2500	0.3750	0.4931	0.5544	0.5728
N_5				0.1250	0.2500	0.3507	0.4155
N_6					0.0625	0.1563	0.2469
N_7						0.0313	0.0938
N_8							0.0156

2.6.2 Service Water Strainers

2.6.2.1 SWS TRAVELLING SCREENS FAIL TO OPERATE NON ENVIRONMENTAL: SWS-TSA-FTOP-NE

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: 2006 through 2020

Total Number of Independent Failure Events: 15.0

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8806171	0.9530886	0.9622178	0.9942767	0.8868613	3.051E+01	1.502E+00
α_2	5.72E-03	4.69E-02	3.78E-02	1.19E-01	1.13E-01	1.502E+00	3.051E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9302245	0.9691651	0.9733938	0.9936399	0.9163498	7.003E+01	2.228E+00
α_2	2.26E-03	2.01E-02	1.59E-02	5.24E-02	4.56E-02	1.451E+00	7.081E+01
α_3	2.71E-04	1.08E-02	6.70E-03	3.51E-02	3.80E-02	7.768E-01	7.148E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9419669	0.9718000	0.9746223	0.9919901	0.9299611	1.066E+02	3.094E+00
α_2	2.26E-03	1.56E-02	1.28E-02	3.86E-02	2.63E-02	1.710E+00	1.080E+02
α_3	3.25E-04	8.23E-03	5.49E-03	2.55E-02	2.92E-02	9.024E-01	1.088E+02
α_4	1.42E-05	4.39E-03	1.94E-03	1.71E-02	1.46E-02	4.815E-01	1.092E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9592926	0.9778714	0.9793330	0.9914516	0.9367589	2.106E+02	4.766E+00
α_2	2.43E-03	1.11E-02	9.59E-03	2.47E-02	2.17E-02	2.383E+00	2.130E+02
α_3	7.14E-04	6.61E-03	5.16E-03	1.75E-02	1.78E-02	1.424E+00	2.139E+02

α_4	8.08E-05	3.52E-03	2.15E-03	1.16E-02	1.78E-02	7.572E-01	2.146E+02
α_5	1.08E-09	9.37E-04	9.97E-05	4.82E-03	5.93E-03	2.017E-01	2.152E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9624101	0.9790009	0.9802438	0.9913384	0.9400000	2.487E+02	5.335E+00
α_2	1.84E-03	8.91E-03	7.66E-03	2.03E-02	2.25E-02	2.264E+00	2.518E+02
α_3	6.44E-04	5.73E-03	4.50E-03	1.50E-02	1.00E-02	1.457E+00	2.526E+02
α_4	1.83E-04	3.82E-03	2.62E-03	1.15E-02	1.50E-02	9.710E-01	2.531E+02
α_5	5.28E-06	1.85E-03	8.01E-04	7.27E-03	1.00E-02	4.711E-01	2.536E+02
α_6	7.09E-11	6.78E-04	4.56E-05	3.63E-03	2.50E-03	1.723E-01	2.539E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9698925	0.9819230	0.9827055	0.9912739	0.9446367	3.991E+02	7.347E+00
α_2	1.80E-03	6.95E-03	6.16E-03	1.48E-02	2.01E-02	2.824E+00	4.036E+02
α_3	7.20E-04	4.52E-03	3.73E-03	1.10E-02	7.14E-03	1.836E+00	4.046E+02
α_4	3.57E-04	3.43E-03	2.66E-03	9.15E-03	1.08E-02	1.395E+00	4.051E+02
α_5	7.84E-05	2.16E-03	1.42E-03	6.77E-03	1.08E-02	8.779E-01	4.056E+02
α_6	3.22E-07	8.56E-04	2.61E-04	3.73E-03	5.41E-03	3.478E-01	4.061E+02
α_7	2.93E-23	1.63E-04	4.04E-08	9.28E-04	1.08E-03	6.605E-02	4.064E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9711804	0.9826604	0.9834035	0.9915906	0.9479945	4.211E+02	7.431E+00
α_2	1.49E-03	6.15E-03	5.40E-03	1.34E-02	1.88E-02	2.634E+00	4.259E+02
α_3	4.75E-04	3.70E-03	2.96E-03	9.44E-03	5.91E-03	1.584E+00	4.269E+02
α_4	2.78E-04	3.04E-03	2.31E-03	8.29E-03	7.30E-03	1.301E+00	4.272E+02
α_5	1.26E-04	2.37E-03	1.65E-03	7.05E-03	9.53E-03	1.015E+00	4.275E+02
α_6	1.14E-05	1.36E-03	7.04E-04	4.95E-03	7.15E-03	5.841E-01	4.279E+02
α_7	5.37E-10	4.70E-04	4.99E-05	2.42E-03	2.86E-03	2.016E-01	4.283E+02
α_8	2.30E-15	2.57E-04	2.67E-06	1.48E-03	4.77E-04	1.103E-01	4.284E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.53E-01	9.69E-01	9.72E-01	9.78E-01	9.79E-01	9.82E-01	9.83E-01
α_2	4.69E-02	2.01E-02	1.56E-02	1.11E-02	8.91E-03	6.95E-03	6.15E-03
α_3		1.08E-02	8.23E-03	6.61E-03	5.73E-03	4.52E-03	3.70E-03
α_4			4.39E-03	3.52E-03	3.82E-03	3.43E-03	3.04E-03
α_5				9.37E-04	1.85E-03	2.16E-03	2.37E-03
α_6					6.78E-04	8.56E-04	1.36E-03
α_7						1.63E-04	4.70E-04
α_8							2.57E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.53E-01	9.69E-01	9.72E-01	9.78E-01	9.79E-01	9.82E-01	9.83E-01
Beta	4.69E-02	3.08E-02	2.82E-02	2.21E-02	2.10E-02	1.81E-02	1.73E-02
Gamma		3.49E-01	4.47E-01	5.00E-01	5.76E-01	6.16E-01	6.46E-01
Delta			3.48E-01	4.02E-01	5.26E-01	5.94E-01	6.70E-01
Epsilon				2.10E-01	3.99E-01	4.81E-01	5.95E-01
Mu					2.68E-01	3.20E-01	4.69E-01
Omega						1.60E-01	3.48E-01
Sigma							3.54E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	7.50	11.25	15.00	18.75	22.50	26.25	30.00
N_1	0.6000	0.8000	0.9333	1.0000	1.0000	1.0500	1.0800
N_2	1.0333	0.6000	0.4500	0.4583	0.5625	0.5813	0.6156
N_3		0.5000	0.5000	0.3750	0.2500	0.2063	0.1938
N_4			0.2500	0.3750	0.3750	0.3125	0.2394
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

2.6.2.2 SWS STRAINERS PLUG POOLED CAUSES: SWS-STR-PG

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
Failure Modes/Plug
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 24.5

Total Number of Common-Cause Failure Events: 4

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8548955	0.9300208	0.9370275	0.9811462	0.8657845	3.768E+01	2.835E+00
α_2	1.89E-02	7.00E-02	6.30E-02	1.45E-01	1.34E-01	2.835E+00	3.768E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9071918	0.9508900	0.9544360	0.9824680	0.8797595	7.993E+01	4.128E+00
α_2	8.70E-03	3.33E-02	2.97E-02	7.04E-02	7.82E-02	2.801E+00	8.126E+01
α_3	1.51E-03	1.58E-02	1.21E-02	4.25E-02	4.21E-02	1.327E+00	8.273E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9200434	0.9542937	0.9567107	0.9802901	0.8812500	1.189E+02	5.694E+00
α_2	8.20E-03	2.70E-02	2.45E-02	5.43E-02	6.56E-02	3.360E+00	1.212E+02
α_3	1.69E-03	1.29E-02	1.04E-02	3.26E-02	3.75E-02	1.602E+00	1.230E+02
α_4	1.20E-04	5.87E-03	3.52E-03	1.96E-02	1.56E-02	7.315E-01	1.238E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9472619	0.9681394	0.9694677	0.9844789	0.8974359	2.258E+02	7.432E+00
α_2	4.31E-03	1.43E-02	1.30E-02	2.90E-02	3.63E-02	3.341E+00	2.299E+02
α_3	2.74E-03	1.13E-02	9.92E-03	2.45E-02	4.06E-02	2.632E+00	2.306E+02
α_4	3.34E-04	4.85E-03	3.53E-03	1.39E-02	1.92E-02	1.132E+00	2.321E+02
α_5	3.18E-07	1.40E-03	3.91E-04	6.23E-03	6.41E-03	3.267E-01	2.329E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9533312	0.9715150	0.9726485	0.9858239	0.9130435	2.672E+02	7.835E+00
α_2	1.71E-03	8.25E-03	7.10E-03	1.88E-02	1.24E-02	2.271E+00	2.728E+02
α_3	3.28E-03	1.15E-02	1.03E-02	2.36E-02	4.23E-02	3.151E+00	2.719E+02

α_4	5.94E-04	5.30E-03	4.16E-03	1.39E-02	1.87E-02	1.457E+00	2.736E+02
α_5	5.08E-05	2.62E-03	1.56E-03	8.82E-03	1.09E-02	7.211E-01	2.743E+02
α_6	7.00E-09	8.54E-04	1.31E-04	4.21E-03	2.72E-03	2.348E-01	2.748E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9644557	0.9773605	0.9780988	0.9877492	0.9245283	4.208E+02	9.747E+00
α_2	1.45E-03	6.04E-03	5.30E-03	1.32E-02	6.77E-03	2.602E+00	4.279E+02
α_3	1.89E-03	6.94E-03	6.19E-03	1.45E-02	2.56E-02	2.986E+00	4.276E+02
α_4	1.15E-03	5.41E-03	4.67E-03	1.22E-02	2.35E-02	2.330E+00	4.282E+02
α_5	2.32E-04	2.85E-03	2.13E-03	7.94E-03	1.25E-02	1.227E+00	4.293E+02
α_6	4.81E-06	1.17E-03	5.37E-04	4.48E-03	5.90E-03	5.041E-01	4.300E+02
α_7	6.00E-17	2.26E-04	1.14E-06	1.31E-03	1.18E-03	9.730E-02	4.305E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9664708	0.9786601	0.9793550	0.9884657	0.9333333	4.460E+02	9.726E+00
α_2	1.01E-03	4.93E-03	4.23E-03	1.13E-02	3.81E-03	2.247E+00	4.535E+02
α_3	1.09E-03	5.12E-03	4.42E-03	1.15E-02	1.57E-02	2.333E+00	4.534E+02
α_4	1.07E-03	5.06E-03	4.36E-03	1.15E-02	2.08E-02	2.307E+00	4.534E+02
α_5	4.48E-04	3.48E-03	2.79E-03	8.89E-03	1.47E-02	1.586E+00	4.542E+02
α_6	5.62E-05	1.82E-03	1.17E-03	5.83E-03	8.02E-03	8.308E-01	4.549E+02
α_7	6.01E-08	6.48E-04	1.54E-04	2.98E-03	3.13E-03	2.953E-01	4.555E+02
α_8	6.35E-14	2.76E-04	5.55E-06	1.57E-03	5.21E-04	1.259E-01	4.556E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.30E-01	9.51E-01	9.54E-01	9.68E-01	9.72E-01	9.77E-01	9.79E-01
α_2	7.00E-02	3.33E-02	2.70E-02	1.43E-02	8.25E-03	6.04E-03	4.93E-03
α_3		1.58E-02	1.29E-02	1.13E-02	1.15E-02	6.94E-03	5.12E-03
α_4			5.87E-03	4.85E-03	5.30E-03	5.41E-03	5.06E-03
α_5				1.40E-03	2.62E-03	2.85E-03	3.48E-03
α_6					8.54E-04	1.17E-03	1.82E-03
α_7						2.26E-04	6.48E-04
α_8							2.76E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.30E-01	9.51E-01	9.54E-01	9.68E-01	9.72E-01	9.77E-01	9.79E-01
Beta	7.00E-02	4.91E-02	4.57E-02	3.19E-02	2.85E-02	2.26E-02	2.13E-02
Gamma		3.21E-01	4.10E-01	5.50E-01	7.10E-01	7.33E-01	7.69E-01
Delta			3.13E-01	3.57E-01	4.34E-01	5.82E-01	6.88E-01
Epsilon				2.24E-01	3.96E-01	4.40E-01	5.52E-01
Mu					2.46E-01	3.29E-01	4.41E-01
Omega						1.62E-01	3.36E-01
Sigma							2.99E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	14.00	21.00	28.00	35.00	42.00	49.00	56.00
N_1	1.2667	0.9500	0.2000	0.0000	0.0000	0.0000	0.0000
N_2	2.3667	1.9500	2.1000	1.4167	0.5694	0.3588	0.2288
N_3		1.0500	1.2000	1.5833	1.9444	1.3569	0.9426
N_4			0.5000	0.7500	0.8611	1.2472	1.2450
N_5				0.2500	0.5000	0.6620	0.8838
N_6					0.1250	0.3125	0.4811
N_7						0.0625	0.1875
N_8							0.0313

2.6.2.3 SWS STRAINERS PLUG ENVIRONMENTAL: SWS-STR-PG-EE

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 7.0

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8210245	0.9148972	0.9237615	0.9783873	0.7319588	2.833E+01	2.635E+00
α_2	2.16E-02	8.51E-02	7.62E-02	1.79E-01	2.68E-01	2.635E+00	2.833E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8987790	0.9481576	0.9523811	0.9830764	0.7701149	6.635E+01	3.628E+00
α_2	7.36E-03	3.36E-02	2.92E-02	7.47E-02	1.38E-01	2.351E+00	6.763E+01
α_3	1.63E-03	1.82E-02	1.39E-02	4.97E-02	9.20E-02	1.277E+00	6.871E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9163444	0.9538641	0.9566928	0.9817083	0.7777778	1.012E+02	4.894E+00
α_2	6.67E-03	2.60E-02	2.31E-02	5.54E-02	1.11E-01	2.760E+00	1.033E+02
α_3	1.40E-03	1.32E-02	1.03E-02	3.50E-02	7.41E-02	1.402E+00	1.047E+02
α_4	1.41E-04	6.90E-03	4.14E-03	2.30E-02	3.70E-02	7.315E-01	1.053E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9477499	0.9694284	0.9709029	0.9860617	0.8139535	2.040E+02	6.432E+00
α_2	3.53E-03	1.35E-02	1.20E-02	2.86E-02	5.68E-02	2.841E+00	2.076E+02
α_3	1.96E-03	1.01E-02	8.63E-03	2.35E-02	6.72E-02	2.132E+00	2.083E+02
α_4	3.71E-04	5.38E-03	3.92E-03	1.54E-02	4.65E-02	1.132E+00	2.093E+02
α_5	3.53E-07	1.55E-03	4.34E-04	6.91E-03	1.55E-02	3.267E-01	2.101E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9534483	0.9724181	0.9736821	0.9870779	0.8400000	2.410E+02	6.835E+00
α_2	1.90E-03	9.16E-03	7.88E-03	2.08E-02	3.04E-02	2.271E+00	2.455E+02

α_3	1.70E-03	8.68E-03	7.40E-03	2.01E-02	5.04E-02	2.151E+00	2.457E+02
α_4	6.60E-04	5.88E-03	4.62E-03	1.54E-02	4.59E-02	1.457E+00	2.463E+02
α_5	5.65E-05	2.91E-03	1.73E-03	9.79E-03	2.67E-02	7.211E-01	2.471E+02
α_6	7.77E-09	9.47E-04	1.45E-04	4.67E-03	6.67E-03	2.348E-01	2.476E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9648181	0.9780725	0.9788702	0.9886099	0.8596491	3.902E+02	8.747E+00
α_2	1.56E-03	6.52E-03	5.72E-03	1.42E-02	1.68E-02	2.602E+00	3.963E+02
α_3	1.31E-03	5.98E-03	5.18E-03	1.34E-02	3.54E-02	2.386E+00	3.965E+02
α_4	8.24E-04	4.84E-03	4.04E-03	1.16E-02	3.96E-02	1.930E+00	3.970E+02
α_5	2.51E-04	3.08E-03	2.30E-03	8.57E-03	3.10E-02	1.227E+00	3.977E+02
α_6	5.20E-06	1.26E-03	5.80E-04	4.84E-03	1.46E-02	5.041E-01	3.984E+02
α_7	6.47E-17	2.44E-04	1.23E-06	1.42E-03	2.92E-03	9.730E-02	3.988E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9666259	0.9792123	0.9799671	0.9892198	0.8750000	4.110E+02	8.726E+00
α_2	1.10E-03	5.35E-03	4.59E-03	1.22E-02	9.53E-03	2.247E+00	4.175E+02
α_3	8.24E-04	4.70E-03	3.94E-03	1.12E-02	2.43E-02	1.973E+00	4.178E+02
α_4	6.89E-04	4.35E-03	3.60E-03	1.06E-02	3.19E-02	1.827E+00	4.179E+02
α_5	3.67E-04	3.40E-03	2.65E-03	8.99E-03	3.02E-02	1.426E+00	4.183E+02
α_6	6.11E-05	1.98E-03	1.27E-03	6.33E-03	2.00E-02	8.308E-01	4.189E+02
α_7	6.53E-08	7.04E-04	1.67E-04	3.23E-03	7.81E-03	2.953E-01	4.195E+02
α_8	6.90E-14	3.00E-04	6.03E-06	1.70E-03	1.30E-03	1.259E-01	4.196E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.15E-01	9.48E-01	9.54E-01	9.69E-01	9.72E-01	9.78E-01	9.79E-01
α_2	8.51E-02	3.36E-02	2.60E-02	1.35E-02	9.16E-03	6.52E-03	5.35E-03
α_3		1.82E-02	1.32E-02	1.01E-02	8.68E-03	5.98E-03	4.70E-03
α_4			6.90E-03	5.38E-03	5.88E-03	4.84E-03	4.35E-03
α_5				1.55E-03	2.91E-03	3.08E-03	3.40E-03
α_6					9.47E-04	1.26E-03	1.98E-03
α_7						2.44E-04	7.04E-04
α_8							3.00E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.15E-01	9.48E-01	9.54E-01	9.69E-01	9.72E-01	9.78E-01	9.79E-01
Beta	8.51E-02	5.18E-02	4.61E-02	3.06E-02	2.76E-02	2.19E-02	2.08E-02
Gamma		3.52E-01	4.36E-01	5.58E-01	6.68E-01	7.03E-01	7.42E-01
Delta			3.43E-01	4.06E-01	5.29E-01	6.12E-01	6.95E-01
Epsilon				2.24E-01	3.96E-01	4.87E-01	5.94E-01
Mu					2.46E-01	3.29E-01	4.67E-01
Omega						1.62E-01	3.36E-01

Sigma							2.99E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	5.25	7.88	10.50	13.13	15.75	18.38	21.00
N_1	0.6667	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000
N_2	2.1667	1.5000	1.5000	0.9167	0.5694	0.3588	0.2288
N_3		1.0000	1.0000	1.0833	0.9444	0.7569	0.5826
N_4			0.5000	0.7500	0.8611	0.8472	0.7650
N_5				0.2500	0.5000	0.6620	0.7238
N_6					0.1250	0.3125	0.4811
N_7						0.0625	0.1875
N_8							0.0313

2.6.2.4 SWS STRAINERS PLUG NON ENVIRONMENTAL: SWS-STR-PG-NE

Systems/Raw Water/Normally operating service water
Systems/Raw Water/Standby service water
Components/Filter/Strainer/Self-Cleaning strainer
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: 2006 through 2020

Total Number of Independent Failure Events: 17.5

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9225083	0.9773494	0.9868947	0.9996574	0.9698492	2.885E+01	6.685E-01
α_2	3.41E-04	2.27E-02	1.31E-02	7.75E-02	3.02E-02	6.685E-01	2.885E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9406845	0.9763390	0.9807866	0.9967860	0.9484536	6.718E+01	1.628E+00
α_2	1.75E-03	1.89E-02	1.45E-02	5.12E-02	4.64E-02	1.301E+00	6.751E+01
α_3	1.09E-06	4.75E-03	1.33E-03	2.11E-02	5.15E-03	3.268E-01	6.848E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9451397	0.9744041	0.9773525	0.9935885	0.9368421	1.025E+02	2.694E+00
α_2	2.89E-03	1.77E-02	1.47E-02	4.26E-02	4.74E-02	1.860E+00	1.034E+02
α_3	5.52E-05	5.72E-03	3.04E-03	2.05E-02	1.58E-02	6.024E-01	1.046E+02
α_4	1.53E-08	2.20E-03	3.28E-04	1.09E-02	0.00E+00	2.315E-01	1.050E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9604236	0.9788798	0.9803813	0.9922040	0.9358289	2.054E+02	4.432E+00
α_2	2.58E-03	1.16E-02	1.00E-02	2.57E-02	3.21E-02	2.424E+00	2.074E+02
α_3	9.17E-04	7.38E-03	5.89E-03	1.90E-02	3.21E-02	1.549E+00	2.083E+02
α_4	1.38E-06	1.82E-03	6.28E-04	7.68E-03	0.00E+00	3.822E-01	2.095E+02
α_5	3.18E-20	3.66E-04	3.41E-07	2.12E-03	0.00E+00	7.674E-02	2.098E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9641732	0.9804693	0.9817470	0.9923973	0.9459459	2.427E+02	4.835E+00
α_2	9.85E-04	6.87E-03	5.60E-03	1.71E-02	0.00E+00	1.701E+00	2.459E+02
α_3	1.79E-03	8.92E-03	7.63E-03	2.04E-02	5.41E-02	2.207E+00	2.453E+02
α_4	2.21E-05	2.41E-03	1.26E-03	8.67E-03	0.00E+00	5.960E-01	2.470E+02
α_5	3.50E-09	8.93E-04	1.19E-04	4.48E-03	0.00E+00	2.211E-01	2.473E+02
α_6	3.49E-15	4.43E-04	4.49E-06	2.56E-03	0.00E+00	1.098E-01	2.474E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712869	0.9830878	0.9838863	0.9921488	0.9533074	3.922E+02	6.747E+00
α_2	1.15E-03	5.62E-03	4.82E-03	1.28E-02	0.00E+00	2.243E+00	3.967E+02
α_3	1.13E-03	5.59E-03	4.79E-03	1.28E-02	2.80E-02	2.230E+00	3.967E+02
α_4	4.29E-04	3.72E-03	2.93E-03	9.70E-03	1.87E-02	1.483E+00	3.975E+02
α_5	1.02E-05	1.42E-03	7.15E-04	5.21E-03	0.00E+00	5.654E-01	3.984E+02
α_6	2.64E-10	4.80E-04	4.44E-05	2.50E-03	0.00E+00	1.916E-01	3.988E+02
α_7	5.97E-41	8.72E-05	3.24E-12	3.83E-04	0.00E+00	3.480E-02	3.989E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9727910	0.9839898	0.9847494	0.9925863	0.9589041	4.134E+02	6.726E+00
α_2	8.66E-04	4.80E-03	4.04E-03	1.13E-02	0.00E+00	2.018E+00	4.181E+02
α_3	6.21E-04	4.17E-03	3.41E-03	1.03E-02	1.48E-02	1.751E+00	4.183E+02
α_4	4.52E-04	3.67E-03	2.92E-03	9.46E-03	1.97E-02	1.542E+00	4.185E+02
α_5	7.08E-05	2.05E-03	1.34E-03	6.48E-03	6.58E-03	8.626E-01	4.192E+02
α_6	3.27E-07	8.33E-04	2.56E-04	3.62E-03	0.00E+00	3.497E-01	4.197E+02
α_7	1.26E-15	2.57E-04	2.36E-06	1.48E-03	0.00E+00	1.078E-01	4.200E+02
α_8	2.62E-17	2.25E-04	9.55E-07	1.31E-03	0.00E+00	9.469E-02	4.200E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.77E-01	9.76E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
α_2	2.27E-02	1.89E-02	1.77E-02	1.16E-02	6.87E-03	5.62E-03	4.80E-03
α_3		4.75E-03	5.72E-03	7.38E-03	8.92E-03	5.59E-03	4.17E-03
α_4			2.20E-03	1.82E-03	2.41E-03	3.72E-03	3.67E-03
α_5				3.66E-04	8.93E-04	1.42E-03	2.05E-03
α_6					4.43E-04	4.80E-04	8.33E-04
α_7						8.72E-05	2.57E-04
α_8							2.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.77E-01	9.76E-01	9.74E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01

Beta	2.27E-02	2.37E-02	2.56E-02	2.11E-02	1.95E-02	1.69E-02	1.60E-02
Gamma		2.01E-01	3.10E-01	4.53E-01	6.48E-01	6.68E-01	7.00E-01
Delta			2.78E-01	2.29E-01	2.96E-01	5.05E-01	6.28E-01
Epsilon				1.67E-01	3.57E-01	3.48E-01	4.78E-01
Mu					3.32E-01	2.86E-01	3.90E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	5.83	8.75	11.67	14.58	17.50	20.42	23.33
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

2.6.3 Circulating Water Strainers

2.6.3.1 CWS TRAVELLING SCREENS PLUG EXTREME ENVIRONMENTAL: CWS-TSA-PG-EE

Systems/Raw Water/Circulating water system
Components/Filter/Strainer/Traveling Screen
Failure Modes/Plug
CCF Categories/Cause/Environment/Extreme environmental stress
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 18.0

Total Number of Common-Cause Failure Events: 8

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.7438971	0.8470657	0.8530518	0.9297435	0.6567732	3.287E+01	5.935E+00
α_2	7.03E-02	1.53E-01	1.47E-01	2.56E-01	3.43E-01	5.935E+00	3.287E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8502655	0.9082825	0.9116818	0.9546742	0.7017927	7.257E+01	7.328E+00
α_2	7.01E-03	3.07E-02	2.68E-02	6.75E-02	7.70E-02	2.451E+00	7.745E+01
α_3	2.43E-02	6.10E-02	5.74E-02	1.10E-01	2.21E-01	4.877E+00	7.502E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.8810816	0.9246032	0.9269958	0.9599437	0.7242779	1.091E+02	8.894E+00
α_2	7.52E-03	2.64E-02	2.37E-02	5.42E-02	7.29E-02	3.110E+00	1.148E+02
α_3	6.17E-03	2.38E-02	2.11E-02	5.04E-02	9.45E-02	2.802E+00	1.152E+02
α_4	6.95E-03	2.53E-02	2.26E-02	5.26E-02	1.08E-01	2.981E+00	1.150E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9246106	0.9504715	0.9518048	0.9717669	0.7428862	2.130E+02	1.110E+01
α_2	5.41E-03	1.66E-02	1.52E-02	3.26E-02	6.01E-02	3.716E+00	2.204E+02
α_3	4.08E-03	1.42E-02	1.27E-02	2.91E-02	7.13E-02	3.174E+00	2.209E+02
α_4	3.13E-03	1.23E-02	1.09E-02	2.63E-02	7.96E-02	2.757E+00	2.213E+02
α_5	7.23E-04	6.48E-03	5.08E-03	1.70E-02	4.61E-02	1.452E+00	2.226E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9322911	0.9550407	0.9561871	0.9738683	0.7659574	2.514E+02	1.183E+01

α_2	2.67E-03	1.05E-02	9.29E-03	2.25E-02	3.11E-02	2.764E+00	2.605E+02
α_3	4.86E-03	1.46E-02	1.33E-02	2.84E-02	7.68E-02	3.832E+00	2.594E+02
α_4	1.92E-03	8.91E-03	7.70E-03	2.00E-02	5.12E-02	2.346E+00	2.609E+02
α_5	1.51E-03	7.96E-03	6.76E-03	1.85E-02	5.49E-02	2.096E+00	2.611E+02
α_6	8.23E-05	3.03E-03	1.90E-03	9.82E-03	2.01E-02	7.973E-01	2.624E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514001	0.9669608	0.9677043	0.9799722	0.7924528	4.023E+02	1.375E+01
α_2	2.07E-03	7.39E-03	6.62E-03	1.54E-02	2.16E-02	3.074E+00	4.130E+02
α_3	2.45E-03	8.11E-03	7.33E-03	1.64E-02	4.52E-02	3.373E+00	4.127E+02
α_4	2.06E-03	7.38E-03	6.61E-03	1.53E-02	5.16E-02	3.070E+00	4.130E+02
α_5	1.25E-03	5.71E-03	4.94E-03	1.28E-02	4.70E-02	2.378E+00	4.137E+02
α_6	4.04E-04	3.54E-03	2.78E-03	9.26E-03	3.32E-02	1.473E+00	4.146E+02
α_7	6.45E-07	9.10E-04	3.09E-04	3.85E-03	8.92E-03	3.786E-01	4.157E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9539436	0.9687099	0.9694182	0.9810489	0.8135593	4.249E+02	1.373E+01
α_2	1.50E-03	6.10E-03	5.36E-03	1.32E-02	1.53E-02	2.674E+00	4.360E+02
α_3	1.44E-03	5.97E-03	5.24E-03	1.30E-02	2.86E-02	2.618E+00	4.360E+02
α_4	1.67E-03	6.45E-03	5.71E-03	1.37E-02	4.11E-02	2.828E+00	4.358E+02
α_5	1.33E-03	5.75E-03	5.02E-03	1.27E-02	4.24E-02	2.523E+00	4.361E+02
α_6	7.20E-04	4.32E-03	3.60E-03	1.04E-02	3.61E-02	1.897E+00	4.368E+02
α_7	8.69E-05	2.10E-03	1.41E-03	6.47E-03	1.89E-02	9.203E-01	4.377E+02
α_8	2.05E-08	6.08E-04	1.21E-04	2.88E-03	4.01E-03	2.666E-01	4.384E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	8.47E-01	9.08E-01	9.25E-01	9.50E-01	9.55E-01	9.67E-01	9.69E-01
α_2	1.53E-01	3.07E-02	2.64E-02	1.66E-02	1.05E-02	7.39E-03	6.10E-03
α_3		6.10E-02	2.38E-02	1.42E-02	1.46E-02	8.11E-03	5.97E-03
α_4			2.53E-02	1.23E-02	8.91E-03	7.38E-03	6.45E-03
α_5				6.48E-03	7.96E-03	5.71E-03	5.75E-03
α_6					3.03E-03	3.54E-03	4.32E-03
α_7						9.10E-04	2.10E-03
α_8							6.08E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	8.47E-01	9.08E-01	9.25E-01	9.50E-01	9.55E-01	9.67E-01	9.69E-01
Beta	1.53E-01	9.17E-02	7.54E-02	4.95E-02	4.50E-02	3.30E-02	3.13E-02
Gamma		6.66E-01	6.50E-01	6.65E-01	7.66E-01	7.76E-01	8.05E-01
Delta			5.15E-01	5.70E-01	5.78E-01	6.84E-01	7.63E-01
Epsilon				3.45E-01	5.52E-01	5.79E-01	6.65E-01
Mu					2.76E-01	4.38E-01	5.50E-01

Omega						2.04E-01	3.85E-01
Sigma							2.25E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	8.73	13.09	17.45	21.82	26.18	30.55	34.91
N_1	1.7333	1.5000	0.9333	0.3333	0.0000	0.0000	0.0000
N_2	5.4667	1.6000	1.8500	1.7917	1.0625	0.8313	0.6556
N_3		4.6000	2.4000	2.1250	2.6250	1.7438	1.2275
N_4			2.7500	2.3750	1.7500	1.9875	1.7656
N_5				1.3750	1.8750	1.8125	1.8200
N_6					0.6875	1.2813	1.5469
N_7						0.3438	0.8125
N_8							0.1719

2.6.3.2 CWS TRAVELLING SCREENS PLUG NON ENVIRONMENTAL: CWS-TSA-PG-NE

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: 2006 through 2020

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	0.9319869	0.9825706	0.9923504	0.9999473	1.0000000	2.641E+01	4.685E-01
α_2	4.94E-05	1.74E-02	7.65E-03	6.80E-02	0.00E+00	4.685E-01	2.641E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9491259	0.9821250	0.9869099	0.9987658	1.0000000	6.198E+01	1.128E+00
α_2	4.53E-04	1.35E-02	8.81E-03	4.25E-02	0.00E+00	8.512E-01	6.226E+01
α_3	2.19E-07	4.39E-03	9.41E-04	2.06E-02	0.00E+00	2.768E-01	6.283E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9530858	0.9803911	0.9836046	0.9967121	1.0000000	9.468E+01	1.894E+00
α_2	1.13E-03	1.30E-02	9.87E-03	3.58E-02	0.00E+00	1.260E+00	9.531E+01
α_3	4.53E-06	4.17E-03	1.53E-03	1.73E-02	0.00E+00	4.024E-01	9.617E+01
α_4	1.66E-08	2.40E-03	3.58E-04	1.19E-02	0.00E+00	2.315E-01	9.634E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9652486	0.9826895	0.9842843	0.9946781	1.0000000	1.948E+02	3.432E+00
α_2	1.65E-03	9.70E-03	8.11E-03	2.32E-02	0.00E+00	1.924E+00	1.963E+02
α_3	3.06E-04	5.29E-03	3.75E-03	1.55E-02	0.00E+00	1.049E+00	1.972E+02
α_4	1.47E-06	1.93E-03	6.65E-04	8.13E-03	0.00E+00	3.822E-01	1.979E+02
α_5	3.36E-20	3.87E-04	3.61E-07	2.25E-03	0.00E+00	7.674E-02	1.982E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679315	0.9835450	0.9849062	0.9944998	1.0000000	2.292E+02	3.835E+00
α_2	1.05E-03	7.30E-03	5.95E-03	1.82E-02	0.00E+00	1.701E+00	2.314E+02
α_3	4.09E-04	5.18E-03	3.85E-03	1.45E-02	0.00E+00	1.207E+00	2.318E+02
α_4	2.34E-05	2.56E-03	1.34E-03	9.21E-03	0.00E+00	5.960E-01	2.325E+02
α_5	3.71E-09	9.49E-04	1.27E-04	4.76E-03	0.00E+00	2.211E-01	2.328E+02
α_6	3.71E-15	4.71E-04	4.77E-06	2.72E-03	0.00E+00	1.098E-01	2.329E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9734614	0.9849367	0.9857739	0.9935469	1.0000000	3.758E+02	5.747E+00
α_2	1.20E-03	5.88E-03	5.04E-03	1.34E-02	0.00E+00	2.243E+00	3.793E+02
α_3	5.73E-04	4.27E-03	3.44E-03	1.08E-02	0.00E+00	1.630E+00	3.799E+02
α_4	1.77E-04	2.84E-03	2.03E-03	8.26E-03	0.00E+00	1.083E+00	3.805E+02
α_5	1.07E-05	1.48E-03	7.47E-04	5.44E-03	0.00E+00	5.654E-01	3.810E+02
α_6	2.76E-10	5.02E-04	4.64E-05	2.62E-03	0.00E+00	1.916E-01	3.814E+02
α_7	6.25E-41	9.12E-05	3.39E-12	4.00E-04	0.00E+00	3.480E-02	3.815E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747326	0.9856770	0.9864773	0.9938818	1.0000000	3.940E+02	5.726E+00
α_2	9.10E-04	5.05E-03	4.25E-03	1.19E-02	0.00E+00	2.018E+00	3.977E+02
α_3	3.59E-04	3.48E-03	2.69E-03	9.28E-03	0.00E+00	1.391E+00	3.984E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.78E-03	0.00E+00	1.062E+00	3.987E+02
α_5	3.10E-05	1.76E-03	1.03E-03	5.97E-03	0.00E+00	7.026E-01	3.990E+02
α_6	3.44E-07	8.75E-04	2.69E-04	3.80E-03	0.00E+00	3.497E-01	3.994E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.996E+02
α_8	2.76E-17	2.37E-04	1.00E-06	1.38E-03	0.00E+00	9.469E-02	3.997E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.74E-02	1.35E-02	1.30E-02	9.70E-03	7.30E-03	5.88E-03	5.05E-03
α_3		4.39E-03	4.17E-03	5.29E-03	5.18E-03	4.27E-03	3.48E-03
α_4			2.40E-03	1.93E-03	2.56E-03	2.84E-03	2.66E-03
α_5				3.87E-04	9.49E-04	1.48E-03	1.76E-03
α_6					4.71E-04	5.02E-04	8.75E-04
α_7						9.12E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.83E-01	9.82E-01	9.80E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01

Beta	1.74E-02	1.79E-02	1.96E-02	1.73E-02	1.65E-02	1.51E-02	1.43E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	4.00	4.00	4.00	4.00	4.00	4.00	4.00
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

2.7 Heat Exchangers

2.7.1 Pooled Heat Exchangers

2.7.1.1 HEAT EXCHANGERS LOSS OF HEAT TRANSFER ALL SYSTEMS: ALL-HTX-HT

Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 15.0

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9378731	0.9814004	0.9888171	0.9996349	0.9841270	3.791E+01	7.185E-01
α_2	3.63E-04	1.86E-02	1.12E-02	6.21E-02	1.59E-02	7.185E-01	3.791E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9504217	0.9802619	0.9839980	0.9973268	0.9786096	8.085E+01	1.628E+00
α_2	1.22E-03	1.49E-02	1.12E-02	4.12E-02	1.60E-02	1.226E+00	8.126E+01
α_3	5.25E-06	4.87E-03	1.79E-03	2.02E-02	5.35E-03	4.018E-01	8.208E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9545557	0.9791014	0.9816342	0.9949968	0.9777778	1.209E+02	2.581E+00
α_2	1.80E-03	1.32E-02	1.07E-02	3.33E-02	1.21E-02	1.635E+00	1.219E+02
α_3	7.07E-05	5.28E-03	2.96E-03	1.84E-02	8.08E-03	6.524E-01	1.229E+02
α_4	2.12E-07	2.38E-03	5.64E-04	1.10E-02	2.02E-03	2.940E-01	1.232E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9654058	0.9817622	0.9831226	0.9934582	0.9788790	2.285E+02	4.245E+00
α_2	1.96E-03	9.61E-03	8.25E-03	2.19E-02	8.12E-03	2.237E+00	2.305E+02
α_3	5.83E-04	5.85E-03	4.51E-03	1.57E-02	8.12E-03	1.362E+00	2.314E+02
α_4	1.33E-05	2.31E-03	1.12E-03	8.65E-03	4.06E-03	5.385E-01	2.322E+02
α_5	2.36E-15	4.64E-04	4.30E-06	2.68E-03	8.12E-04	1.080E-01	2.326E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682743	0.9828186	0.9839734	0.9934058	0.9806320	2.703E+02	4.726E+00

α_2	1.20E-03	7.04E-03	5.88E-03	1.68E-02	5.10E-03	1.935E+00	2.731E+02
α_3	6.65E-04	5.52E-03	4.38E-03	1.43E-02	6.80E-03	1.520E+00	2.735E+02
α_4	9.30E-05	3.02E-03	1.93E-03	9.65E-03	5.10E-03	8.303E-01	2.742E+02
α_5	1.89E-07	1.14E-03	3.02E-04	5.15E-03	2.04E-03	3.148E-01	2.747E+02
α_6	9.52E-14	4.56E-04	8.99E-06	2.59E-03	3.40E-04	1.254E-01	2.749E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736049	0.9844913	0.9852323	0.9928394	0.9824741	4.244E+02	6.685E+00
α_2	1.23E-03	5.58E-03	4.84E-03	1.25E-02	3.07E-03	2.407E+00	4.286E+02
α_3	7.38E-04	4.41E-03	3.68E-03	1.06E-02	5.11E-03	1.903E+00	4.291E+02
α_4	3.11E-04	3.15E-03	2.42E-03	8.47E-03	5.11E-03	1.356E+00	4.297E+02
α_5	3.41E-05	1.69E-03	1.01E-03	5.67E-03	3.07E-03	7.294E-01	4.303E+02
α_6	8.16E-09	5.71E-04	9.69E-05	2.78E-03	1.02E-03	2.463E-01	4.308E+02
α_7	3.97E-34	9.89E-05	1.16E-10	4.91E-04	1.46E-04	4.261E-02	4.310E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750681	0.9853519	0.9860524	0.9932378	0.9841819	4.501E+02	6.690E+00
α_2	8.95E-04	4.66E-03	3.96E-03	1.08E-02	1.79E-03	2.127E+00	4.546E+02
α_3	4.64E-04	3.52E-03	2.83E-03	8.95E-03	3.59E-03	1.609E+00	4.551E+02
α_4	2.81E-04	2.92E-03	2.24E-03	7.91E-03	4.48E-03	1.336E+00	4.554E+02
α_5	8.38E-05	2.02E-03	1.35E-03	6.21E-03	3.59E-03	9.213E-01	4.558E+02
α_6	2.47E-06	1.01E-03	4.23E-04	3.98E-03	1.79E-03	4.591E-01	4.563E+02
α_7	6.07E-13	3.05E-04	9.42E-06	1.70E-03	5.12E-04	1.391E-01	4.566E+02
α_8	8.47E-17	2.16E-04	1.18E-06	1.25E-03	6.40E-05	9.860E-02	4.566E+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	9.80E-01	9.79E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
α_2	1.86E-02	1.49E-02	1.32E-02	9.61E-03	7.04E-03	5.58E-03	4.66E-03
α_3		4.87E-03	5.28E-03	5.85E-03	5.52E-03	4.41E-03	3.52E-03
α_4			2.38E-03	2.31E-03	3.02E-03	3.15E-03	2.92E-03
α_5				4.64E-04	1.14E-03	1.69E-03	2.02E-03
α_6					4.56E-04	5.71E-04	1.01E-03
α_7						9.89E-05	3.05E-04
α_8							2.16E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.80E-01	9.79E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
Beta	1.86E-02	1.97E-02	2.09E-02	1.82E-02	1.72E-02	1.55E-02	1.46E-02
Gamma		2.47E-01	3.67E-01	4.73E-01	5.90E-01	6.40E-01	6.82E-01
Delta			3.11E-01	3.22E-01	4.55E-01	5.55E-01	6.47E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01

Omega						1.48E-01	3.41E-01
Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	15.00	22.50	30.00	37.50	45.00	52.50	60.00
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	0.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		0.1250	0.2500	0.3125	0.3125	0.2734	0.2188
N_4			0.0625	0.1563	0.2344	0.2734	0.2734
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.7.2 Component Cooling Heat Exchangers

2.7.2.1 CCW HEAT EXCHANGERS LOSS OF HEAT TRANSFER: CCW-HTX-HT

Systems/Clean Water/Component cooling water
Components/Other/Heat Exchanger
Failure Modes/Loss of Heat Transfer
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 11.5

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9317504	0.9795474	0.9876821	0.9995977	0.9795918	3.441E+01	7.185E-01
α_2	4.00E-04	2.05E-02	1.23E-02	6.82E-02	2.04E-02	7.185E-01	3.441E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9470854	0.9789201	0.9829008	0.9971422	0.9724138	7.560E+01	1.628E+00
α_2	1.31E-03	1.59E-02	1.19E-02	4.39E-02	2.07E-02	1.226E+00	7.601E+01
α_3	5.61E-06	5.20E-03	1.91E-03	2.15E-02	6.90E-03	4.018E-01	7.683E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9518503	0.9778458	0.9805242	0.9946917	0.9712794	1.139E+02	2.581E+00
α_2	1.91E-03	1.40E-02	1.14E-02	3.53E-02	1.57E-02	1.635E+00	1.149E+02
α_3	7.50E-05	5.60E-03	3.14E-03	1.95E-02	1.04E-02	6.524E-01	1.159E+02
α_4	2.25E-07	2.52E-03	5.98E-04	1.16E-02	2.61E-03	2.940E-01	1.162E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9640684	0.9810498	0.9824614	0.9931999	0.9726604	2.197E+02	4.245E+00
α_2	2.04E-03	9.99E-03	8.57E-03	2.28E-02	1.05E-02	2.237E+00	2.218E+02
α_3	6.06E-04	6.08E-03	4.69E-03	1.63E-02	1.05E-02	1.362E+00	2.226E+02
α_4	1.38E-05	2.40E-03	1.17E-03	8.98E-03	5.26E-03	5.385E-01	2.235E+02
α_5	2.45E-15	4.82E-04	4.46E-06	2.79E-03	1.05E-03	1.080E-01	2.239E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670226	0.9821367	0.9833358	0.9931416	0.9749009	2.598E+02	4.726E+00
α_2	1.25E-03	7.32E-03	6.12E-03	1.75E-02	6.61E-03	1.935E+00	2.626E+02
α_3	6.91E-04	5.74E-03	4.56E-03	1.49E-02	8.81E-03	1.520E+00	2.630E+02

α_4	9.68E-05	3.14E-03	2.01E-03	1.00E-02	6.61E-03	8.303E-01	2.637E+02
α_5	1.97E-07	1.19E-03	3.14E-04	5.36E-03	2.64E-03	3.148E-01	2.642E+02
α_6	9.89E-14	4.74E-04	9.34E-06	2.69E-03	4.40E-04	1.254E-01	2.644E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728353	0.9840377	0.9847997	0.9926295	0.9772684	4.121E+02	6.685E+00
α_2	1.27E-03	5.75E-03	4.98E-03	1.28E-02	3.98E-03	2.407E+00	4.164E+02
α_3	7.60E-04	4.54E-03	3.78E-03	1.09E-02	6.63E-03	1.903E+00	4.169E+02
α_4	3.20E-04	3.24E-03	2.49E-03	8.71E-03	6.63E-03	1.356E+00	4.174E+02
α_5	3.51E-05	1.74E-03	1.04E-03	5.84E-03	3.98E-03	7.294E-01	4.181E+02
α_6	8.40E-09	5.88E-04	9.98E-05	2.86E-03	1.33E-03	2.463E-01	4.185E+02
α_7	4.09E-34	1.02E-04	1.20E-10	5.06E-04	1.89E-04	4.261E-02	4.187E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9742834	0.9848887	0.9856107	0.9930220	0.9794697	4.361E+02	6.690E+00
α_2	9.24E-04	4.81E-03	4.08E-03	1.12E-02	2.33E-03	2.127E+00	4.406E+02
α_3	4.78E-04	3.63E-03	2.92E-03	9.23E-03	4.65E-03	1.609E+00	4.411E+02
α_4	2.89E-04	3.02E-03	2.31E-03	8.16E-03	5.82E-03	1.336E+00	4.414E+02
α_5	8.64E-05	2.08E-03	1.40E-03	6.41E-03	4.65E-03	9.213E-01	4.418E+02
α_6	2.55E-06	1.04E-03	4.36E-04	4.10E-03	2.33E-03	4.591E-01	4.423E+02
α_7	6.26E-13	3.14E-04	9.72E-06	1.75E-03	6.65E-04	1.391E-01	4.426E+02
α_8	8.74E-17	2.23E-04	1.21E-06	1.29E-03	8.31E-05	9.860E-02	4.426E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
α_2	2.05E-02	1.59E-02	1.40E-02	9.99E-03	7.32E-03	5.75E-03	4.81E-03
α_3		5.20E-03	5.60E-03	6.08E-03	5.74E-03	4.54E-03	3.63E-03
α_4			2.52E-03	2.40E-03	3.14E-03	3.24E-03	3.02E-03
α_5				4.82E-04	1.19E-03	1.74E-03	2.08E-03
α_6					4.74E-04	5.88E-04	1.04E-03
α_7						1.02E-04	3.14E-04
α_8							2.23E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.79E-01	9.78E-01	9.81E-01	9.82E-01	9.84E-01	9.85E-01
Beta	2.05E-02	2.11E-02	2.22E-02	1.90E-02	1.79E-02	1.60E-02	1.51E-02
Gamma		2.47E-01	3.67E-01	4.73E-01	5.90E-01	6.40E-01	6.82E-01
Delta			3.11E-01	3.22E-01	4.55E-01	5.55E-01	6.47E-01
Epsilon				1.67E-01	3.46E-01	4.29E-01	5.48E-01
Mu					2.85E-01	2.84E-01	4.31E-01
Omega						1.48E-01	3.41E-01
Sigma							4.15E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	11.50	17.25	23.00	28.75	34.50	40.25	46.00
N_1	0.5000	0.3750	0.2500	0.1563	0.0938	0.0547	0.0313
N_2	0.2500	0.3750	0.3750	0.3125	0.2344	0.1641	0.1094
N_3		0.1250	0.2500	0.3125	0.3125	0.2734	0.2188
N_4			0.0625	0.1563	0.2344	0.2734	0.2734
N_5				0.0313	0.0938	0.1641	0.2188
N_6					0.0156	0.0547	0.1094
N_7						0.0078	0.0313
N_8							0.0039

2.8 Safety and Relief Valves

2.8.1 Pooled Safety Valves

2.8.1.1 SAFETY VALVES (DIRECT ACTING) FAIL TO OPEN ALL SYSTEMS: ALL-SVV-CC

Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 2.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9175046	0.9780228	0.9893927	0.9998954	0.9298246	2.308E+01	5.185E-01
α_2	1.08E-04	2.20E-02	1.06E-02	8.25E-02	7.02E-02	5.185E-01	2.308E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9425571	0.9789752	0.9840158	0.9981539	0.8644068	5.884E+01	1.264E+00
α_2	8.07E-04	1.63E-02	1.13E-02	4.88E-02	1.28E-01	9.798E-01	5.913E+01
α_3	3.04E-07	4.72E-03	1.06E-03	2.20E-02	7.14E-03	2.840E-01	5.982E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9475865	0.9772110	0.9805140	0.9955455	0.8048673	9.168E+01	2.138E+00
α_2	1.82E-03	1.57E-02	1.25E-02	4.09E-02	1.74E-01	1.477E+00	9.235E+01
α_3	7.49E-06	4.57E-03	1.80E-03	1.85E-02	2.10E-02	4.288E-01	9.339E+01
α_4	1.77E-08	2.47E-03	3.71E-04	1.22E-02	4.39E-04	2.320E-01	9.359E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9621326	0.9805996	0.9822112	0.9935531	0.7522701	1.919E+02	3.798E+00
α_2	2.31E-03	1.14E-02	9.76E-03	2.60E-02	2.05E-01	2.226E+00	1.935E+02
α_3	3.74E-04	5.67E-03	4.10E-03	1.63E-02	4.10E-02	1.109E+00	1.946E+02
α_4	1.57E-06	1.97E-03	6.84E-04	8.27E-03	1.86E-03	3.850E-01	1.954E+02
α_5	3.41E-20	3.92E-04	3.65E-07	2.28E-03	0.00E+00	7.674E-02	1.957E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9646321	0.9812595	0.9826308	0.9931936	0.7075495	2.264E+02	4.324E+00

α_2	1.68E-03	8.98E-03	7.61E-03	2.10E-02	2.22E-01	2.072E+00	2.287E+02
α_3	5.35E-04	5.71E-03	4.36E-03	1.55E-02	6.57E-02	1.317E+00	2.294E+02
α_4	2.55E-05	2.62E-03	1.39E-03	9.39E-03	4.93E-03	6.042E-01	2.301E+02
α_5	3.75E-09	9.58E-04	1.28E-04	4.81E-03	0.00E+00	2.211E-01	2.305E+02
α_6	3.74E-15	4.76E-04	4.82E-06	2.74E-03	0.00E+00	1.098E-01	2.306E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9711746	0.9832496	0.9840893	0.9924440	0.6714323	3.730E+02	6.355E+00
α_2	1.71E-03	7.01E-03	6.16E-03	1.52E-02	2.25E-01	2.659E+00	3.767E+02
α_3	7.38E-04	4.75E-03	3.91E-03	1.16E-02	9.36E-02	1.803E+00	3.776E+02
α_4	1.88E-04	2.90E-03	2.09E-03	8.40E-03	1.04E-02	1.102E+00	3.783E+02
α_5	1.08E-05	1.49E-03	7.52E-04	5.47E-03	0.00E+00	5.654E-01	3.788E+02
α_6	2.77E-10	5.05E-04	4.67E-05	2.63E-03	0.00E+00	1.916E-01	3.792E+02
α_7	6.28E-41	9.17E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.794E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9722130	0.9838068	0.9846087	0.9926533	0.6443595	3.913E+02	6.441E+00
α_2	1.39E-03	6.16E-03	5.35E-03	1.37E-02	2.14E-01	2.449E+00	3.953E+02
α_3	5.56E-04	4.11E-03	3.32E-03	1.04E-02	1.22E-01	1.637E+00	3.961E+02
α_4	1.79E-04	2.77E-03	1.99E-03	8.00E-03	1.91E-02	1.101E+00	3.967E+02
α_5	3.12E-05	1.77E-03	1.03E-03	6.00E-03	0.00E+00	7.026E-01	3.971E+02
α_6	3.45E-07	8.79E-04	2.70E-04	3.82E-03	0.00E+00	3.497E-01	3.974E+02
α_7	1.33E-15	2.71E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.976E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.977E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.78E-01	9.79E-01	9.77E-01	9.81E-01	9.81E-01	9.83E-01	9.84E-01
α_2	2.20E-02	1.63E-02	1.57E-02	1.14E-02	8.98E-03	7.01E-03	6.16E-03
α_3		4.72E-03	4.57E-03	5.67E-03	5.71E-03	4.75E-03	4.11E-03
α_4			2.47E-03	1.97E-03	2.62E-03	2.90E-03	2.77E-03
α_5				3.92E-04	9.58E-04	1.49E-03	1.77E-03
α_6					4.76E-04	5.05E-04	8.79E-04
α_7						9.17E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.78E-01	9.79E-01	9.77E-01	9.81E-01	9.81E-01	9.83E-01	9.84E-01
Beta	2.20E-02	2.10E-02	2.28E-02	1.94E-02	1.87E-02	1.68E-02	1.62E-02
Gamma		2.25E-01	3.09E-01	4.14E-01	5.21E-01	5.82E-01	6.20E-01
Delta			3.51E-01	2.94E-01	4.15E-01	5.12E-01	5.90E-01
Epsilon				1.66E-01	3.54E-01	4.18E-01	5.33E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	0.26	0.39	0.52	0.66	0.79	0.92	1.05
N_1	0.4000	0.4714	0.4835	0.4533	0.3956	0.3231	0.2462
N_2	0.0500	0.1286	0.2176	0.3022	0.3709	0.4154	0.4308
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 SYSTEMS: ALL-SVV-OO

Components/Valve/Safety Valve (Single Acting)
Failure Modes/Fail to Close
Date Range: 2006 through 2020

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	0.9235240	0.9803811	0.9913633	0.9999407	1.0000000	2.341E+01	4.685E-01
α_2	5.58E-05	1.96E-02	8.63E-03	7.65E-02	0.00E+00	4.685E-01	2.341E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9466116	0.9812328	0.9862494	0.9986987	1.0000000	5.898E+01	1.128E+00
α_2	4.76E-04	1.42E-02	9.25E-03	4.46E-02	0.00E+00	8.512E-01	5.926E+01
α_3	2.31E-07	4.61E-03	9.88E-04	2.16E-02	0.00E+00	2.768E-01	5.983E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9515956	0.9797624	0.9830751	0.9966052	1.0000000	9.168E+01	1.894E+00
α_2	1.17E-03	1.35E-02	1.02E-02	3.70E-02	0.00E+00	1.260E+00	9.231E+01
α_3	4.68E-06	4.30E-03	1.58E-03	1.78E-02	0.00E+00	4.024E-01	9.317E+01
α_4	1.72E-08	2.47E-03	3.69E-04	1.23E-02	0.00E+00	2.315E-01	9.334E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9647181	0.9824236	0.9840420	0.9945954	1.0000000	1.918E+02	3.432E+00
α_2	1.68E-03	9.85E-03	8.24E-03	2.36E-02	0.00E+00	1.924E+00	1.933E+02
α_3	3.11E-04	5.37E-03	3.81E-03	1.58E-02	0.00E+00	1.049E+00	1.942E+02
α_4	1.49E-06	1.96E-03	6.75E-04	8.26E-03	0.00E+00	3.822E-01	1.949E+02
α_5	3.41E-20	3.93E-04	3.66E-07	2.28E-03	0.00E+00	7.674E-02	1.952E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9675157	0.9833304	0.9847088	0.9944279	1.0000000	2.262E+02	3.835E+00
α_2	1.06E-03	7.39E-03	6.02E-03	1.84E-02	0.00E+00	1.701E+00	2.284E+02
α_3	4.14E-04	5.25E-03	3.90E-03	1.47E-02	0.00E+00	1.207E+00	2.288E+02
α_4	2.37E-05	2.59E-03	1.36E-03	9.33E-03	0.00E+00	5.960E-01	2.295E+02
α_5	3.76E-09	9.61E-04	1.29E-04	4.82E-03	0.00E+00	2.211E-01	2.298E+02
α_6	3.75E-15	4.77E-04	4.83E-06	2.75E-03	0.00E+00	1.098E-01	2.299E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9732470	0.9848173	0.9856609	0.9934954	1.0000000	3.728E+02	5.747E+00
α_2	1.21E-03	5.93E-03	5.08E-03	1.35E-02	0.00E+00	2.243E+00	3.763E+02
α_3	5.78E-04	4.30E-03	3.47E-03	1.09E-02	0.00E+00	1.630E+00	3.769E+02
α_4	1.78E-04	2.86E-03	2.05E-03	8.32E-03	0.00E+00	1.083E+00	3.775E+02
α_5	1.08E-05	1.49E-03	7.53E-04	5.49E-03	0.00E+00	5.654E-01	3.780E+02
α_6	2.78E-10	5.06E-04	4.68E-05	2.64E-03	0.00E+00	1.916E-01	3.784E+02
α_7	6.30E-41	9.19E-05	3.42E-12	4.03E-04	0.00E+00	3.480E-02	3.785E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9745473	0.9855687	0.9863748	0.9938356	1.0000000	3.910E+02	5.726E+00
α_2	9.17E-04	5.09E-03	4.28E-03	1.20E-02	0.00E+00	2.018E+00	3.947E+02
α_3	3.62E-04	3.50E-03	2.71E-03	9.35E-03	0.00E+00	1.391E+00	3.954E+02
α_4	1.59E-04	2.68E-03	1.90E-03	7.84E-03	0.00E+00	1.062E+00	3.957E+02
α_5	3.13E-05	1.77E-03	1.03E-03	6.01E-03	0.00E+00	7.026E-01	3.960E+02
α_6	3.46E-07	8.82E-04	2.71E-04	3.83E-03	0.00E+00	3.497E-01	3.964E+02
α_7	1.33E-15	2.72E-04	2.49E-06	1.57E-03	0.00E+00	1.078E-01	3.966E+02
α_8	2.78E-17	2.39E-04	1.01E-06	1.39E-03	0.00E+00	9.469E-02	3.967E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.96E-02	1.42E-02	1.35E-02	9.85E-03	7.39E-03	5.93E-03	5.09E-03
α_3		4.61E-03	4.30E-03	5.37E-03	5.25E-03	4.30E-03	3.50E-03
α_4			2.47E-03	1.96E-03	2.59E-03	2.86E-03	2.68E-03
α_5				3.93E-04	9.61E-04	1.49E-03	1.77E-03
α_6					4.77E-04	5.06E-04	8.82E-04
α_7						9.19E-05	2.72E-04
α_8							2.39E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01

Beta	1.96E-02	1.88E-02	2.02E-02	1.76E-02	1.67E-02	1.52E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	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

2.8.2 BWR Safety Relief Valves

2.8.2.1 BWR SAFETY RELIEF VALVES FAIL TO OPEN: BWR-MSS-SRV-CC

Plants/BWR
Systems/Steam
Components/Valve/Safety Relief Valve (Dual Actuation)
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 23.4

Total Number of Common-Cause Failure Events: 6

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9067552	0.9680089	0.9770949	0.9981705	0.9398566	3.121E+01	1.031E+00
α_2	1.83E-03	3.20E-02	2.29E-02	9.32E-02	6.01E-02	1.031E+00	3.121E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9238601	0.9649446	0.9691444	0.9916715	0.8941429	6.990E+01	2.539E+00
α_2	5.71E-03	2.93E-02	2.51E-02	6.74E-02	9.55E-02	2.124E+00	7.032E+01
α_3	7.71E-06	5.74E-03	2.19E-03	2.35E-02	1.04E-02	4.155E-01	7.202E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9256636	0.9602642	0.9630363	0.9853765	0.8550182	1.052E+02	4.352E+00
α_2	9.31E-03	3.06E-02	2.78E-02	6.16E-02	1.24E-01	3.354E+00	1.062E+02
α_3	1.14E-04	6.42E-03	3.77E-03	2.17E-02	1.77E-02	7.032E-01	1.088E+02
α_4	2.48E-07	2.69E-03	6.42E-04	1.24E-02	3.74E-03	2.949E-01	1.092E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9492088	0.9703604	0.9718074	0.9865646	0.8566978	2.084E+02	6.365E+00
α_2	6.04E-03	1.80E-02	1.65E-02	3.49E-02	9.46E-02	3.859E+00	2.109E+02
α_3	1.40E-03	8.64E-03	7.17E-03	2.09E-02	3.94E-02	1.855E+00	2.129E+02
α_4	1.51E-05	2.53E-03	1.24E-03	9.42E-03	7.85E-03	5.429E-01	2.142E+02
α_5	2.60E-15	5.03E-04	4.68E-06	2.91E-03	1.53E-03	1.081E-01	2.146E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9524670	0.9714971	0.9727290	0.9863108	0.8586992	2.457E+02	7.209E+00
α_2	4.40E-03	1.40E-02	1.27E-02	2.79E-02	7.70E-02	3.541E+00	2.494E+02

α_3	1.86E-03	8.96E-03	7.71E-03	2.04E-02	4.44E-02	2.267E+00	2.507E+02
α_4	1.76E-04	3.80E-03	2.60E-03	1.15E-02	1.53E-02	9.606E-01	2.520E+02
α_5	2.08E-07	1.25E-03	3.29E-04	5.61E-03	3.94E-03	3.152E-01	2.526E+02
α_6	1.03E-13	4.96E-04	9.77E-06	2.81E-03	6.54E-04	1.254E-01	2.528E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9628963	0.9764650	0.9772482	0.9873717	0.8612254	3.953E+02	9.526E+00
α_2	3.41E-03	9.92E-03	9.12E-03	1.91E-02	6.50E-02	4.014E+00	4.008E+02
α_3	1.82E-03	6.99E-03	6.20E-03	1.49E-02	4.41E-02	2.831E+00	4.019E+02
α_4	5.36E-04	4.01E-03	3.23E-03	1.02E-02	1.99E-02	1.624E+00	4.032E+02
α_5	4.59E-05	1.90E-03	1.17E-03	6.25E-03	7.48E-03	7.690E-01	4.040E+02
α_6	8.69E-09	6.08E-04	1.03E-04	2.96E-03	2.01E-03	2.463E-01	4.045E+02
α_7	4.23E-34	1.05E-04	1.24E-10	5.23E-04	2.87E-04	4.261E-02	4.047E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9637586	0.9768567	0.9776013	0.9874203	0.8644028	4.164E+02	9.865E+00
α_2	2.82E-03	8.70E-03	7.94E-03	1.72E-02	5.53E-02	3.707E+00	4.226E+02
α_3	1.58E-03	6.34E-03	5.59E-03	1.37E-02	4.30E-02	2.705E+00	4.236E+02
α_4	5.83E-04	4.03E-03	3.28E-03	1.00E-02	2.14E-02	1.716E+00	4.246E+02
α_5	1.33E-04	2.41E-03	1.69E-03	7.15E-03	1.07E-02	1.028E+00	4.252E+02
α_6	3.17E-06	1.11E-03	4.78E-04	4.34E-03	3.99E-03	4.717E-01	4.258E+02
α_7	6.50E-13	3.26E-04	1.01E-05	1.82E-03	1.02E-03	1.391E-01	4.261E+02
α_8	9.08E-17	2.31E-04	1.26E-06	1.34E-03	1.28E-04	9.860E-02	4.262E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.68E-01	9.65E-01	9.60E-01	9.70E-01	9.71E-01	9.76E-01	9.77E-01
α_2	3.20E-02	2.93E-02	3.06E-02	1.80E-02	1.40E-02	9.92E-03	8.70E-03
α_3		5.74E-03	6.42E-03	8.64E-03	8.96E-03	6.99E-03	6.34E-03
α_4			2.69E-03	2.53E-03	3.80E-03	4.01E-03	4.03E-03
α_5				5.03E-04	1.25E-03	1.90E-03	2.41E-03
α_6					4.96E-04	6.08E-04	1.11E-03
α_7						1.05E-04	3.26E-04
α_8							2.31E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.68E-01	9.65E-01	9.60E-01	9.70E-01	9.71E-01	9.76E-01	9.77E-01
Beta	3.20E-02	3.51E-02	3.97E-02	2.96E-02	2.85E-02	2.35E-02	2.31E-02
Gamma		1.64E-01	2.29E-01	3.94E-01	5.09E-01	5.79E-01	6.24E-01
Delta			2.95E-01	2.60E-01	3.82E-01	4.87E-01	5.61E-01
Epsilon				1.66E-01	3.14E-01	3.94E-01	5.03E-01
Mu					2.85E-01	2.73E-01	4.08E-01
Omega						1.48E-01	3.35E-01

Sigma							4.15E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	6.24	9.36	12.48	15.60	18.72	21.84	24.96
N_1	2.5561	2.5614	2.0189	1.9312	1.7871	1.6129	1.4309
N_2	0.5629	1.2727	2.0943	1.9349	1.8398	1.7703	1.6889
N_3		0.1386	0.3008	0.8056	1.0602	1.2012	1.3141
N_4			0.0634	0.1606	0.3646	0.5414	0.6542
N_5				0.0313	0.0942	0.2037	0.3255
N_6					0.0156	0.0547	0.1219
N_7						0.0078	0.0313
N_8							0.0039

2.8.2.2 BWR SAFETY RELIEF VALVES FAIL TO CLOSE: BWR-MSS-SRV-OO

Plants/BWR
Systems/Steam
Components/Valve/Safety Relief Valve (Dual Actuation)
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 2.6

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9282864	0.9816130	0.9919194	0.9999444	1.0000000	2.501E+01	4.685E-01
α_2	5.22E-05	1.84E-02	8.08E-03	7.17E-02	0.00E+00	4.685E-01	2.501E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9479827	0.9817194	0.9866098	0.9987321	1.0000000	6.058E+01	1.128E+00
α_2	4.63E-04	1.38E-02	9.01E-03	4.35E-02	0.00E+00	8.512E-01	6.086E+01
α_3	2.24E-07	4.49E-03	9.62E-04	2.10E-02	0.00E+00	2.768E-01	6.143E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9524020	0.9801027	0.9833617	0.9966630	1.0000000	9.328E+01	1.894E+00
α_2	1.15E-03	1.32E-02	1.00E-02	3.63E-02	0.00E+00	1.260E+00	9.391E+01
α_3	4.60E-06	4.23E-03	1.55E-03	1.75E-02	0.00E+00	4.024E-01	9.477E+01
α_4	1.69E-08	2.43E-03	3.63E-04	1.20E-02	0.00E+00	2.315E-01	9.494E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650030	0.9825664	0.9841721	0.9946398	1.0000000	1.934E+02	3.432E+00
α_2	1.66E-03	9.77E-03	8.17E-03	2.34E-02	0.00E+00	1.924E+00	1.949E+02
α_3	3.09E-04	5.33E-03	3.77E-03	1.57E-02	0.00E+00	1.049E+00	1.958E+02
α_4	1.48E-06	1.94E-03	6.69E-04	8.19E-03	0.00E+00	3.822E-01	1.965E+02
α_5	3.39E-20	3.90E-04	3.63E-07	2.27E-03	0.00E+00	7.674E-02	1.968E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677388	0.9834455	0.9848147	0.9944665	1.0000000	2.278E+02	3.835E+00
α_2	1.05E-03	7.34E-03	5.98E-03	1.83E-02	0.00E+00	1.701E+00	2.300E+02
α_3	4.11E-04	5.21E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.304E+02

α_4	2.36E-05	2.57E-03	1.35E-03	9.27E-03	0.00E+00	5.960E-01	2.311E+02
α_5	3.74E-09	9.54E-04	1.28E-04	4.79E-03	0.00E+00	2.211E-01	2.314E+02
α_6	3.73E-15	4.74E-04	4.80E-06	2.73E-03	0.00E+00	1.098E-01	2.315E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733593	0.9848812	0.9857214	0.9935230	1.0000000	3.744E+02	5.747E+00
α_2	1.21E-03	5.90E-03	5.06E-03	1.35E-02	0.00E+00	2.243E+00	3.779E+02
α_3	5.75E-04	4.29E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.785E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.29E-03	0.00E+00	1.083E+00	3.791E+02
α_5	1.08E-05	1.49E-03	7.50E-04	5.46E-03	0.00E+00	5.654E-01	3.796E+02
α_6	2.77E-10	5.04E-04	4.66E-05	2.63E-03	0.00E+00	1.916E-01	3.800E+02
α_7	6.27E-41	9.15E-05	3.41E-12	4.02E-04	0.00E+00	3.480E-02	3.801E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746444	0.9856267	0.9864296	0.9938603	1.0000000	3.926E+02	5.726E+00
α_2	9.13E-04	5.07E-03	4.27E-03	1.20E-02	0.00E+00	2.018E+00	3.963E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.31E-03	0.00E+00	1.391E+00	3.970E+02
α_4	1.59E-04	2.67E-03	1.89E-03	7.81E-03	0.00E+00	1.062E+00	3.973E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.99E-03	0.00E+00	7.026E-01	3.976E+02
α_6	3.45E-07	8.78E-04	2.69E-04	3.82E-03	0.00E+00	3.497E-01	3.980E+02
α_7	1.32E-15	2.71E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.982E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.983E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.84E-02	1.38E-02	1.32E-02	9.77E-03	7.34E-03	5.90E-03	5.07E-03
α_3		4.49E-03	4.23E-03	5.33E-03	5.21E-03	4.29E-03	3.49E-03
α_4			2.43E-03	1.94E-03	2.57E-03	2.85E-03	2.67E-03
α_5				3.90E-04	9.54E-04	1.49E-03	1.76E-03
α_6					4.74E-04	5.04E-04	8.78E-04
α_7						9.15E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.84E-02	1.83E-02	1.99E-02	1.74E-02	1.66E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	2.60	2.60	2.60	2.60	2.60	2.60	2.60
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

2.9 Power-Operated Relief Valves

2.9.1 Pooled Power-Operated Relief Valves

2.9.1.1 POWER-OPERATED RELIEF VALVES FAIL TO OPEN ALL SYSTEMS: ALL-PORV-CC

Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 74.3

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9208476	0.9691580	0.9753434	0.9962960	0.9599522	4.715E+01	1.500E+00
α_2	3.71E-03	3.08E-02	2.47E-02	7.92E-02	4.00E-02	1.500E+00	4.715E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9480222	0.9771260	0.9803176	0.9953216	0.9712474	9.498E+01	2.223E+00
α_2	4.38E-04	9.74E-03	6.65E-03	2.96E-02	2.51E-03	9.467E-01	9.626E+01
α_3	1.17E-03	1.31E-02	9.98E-03	3.59E-02	2.62E-02	1.277E+00	9.593E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9554504	0.9784256	0.9806154	0.9939094	0.9763718	1.399E+02	3.085E+00
α_2	1.13E-03	1.01E-02	7.97E-03	2.66E-02	3.79E-03	1.451E+00	1.415E+02
α_3	2.49E-04	6.31E-03	4.21E-03	1.95E-02	9.92E-03	9.024E-01	1.421E+02
α_4	1.05E-04	5.12E-03	3.07E-03	1.71E-02	9.92E-03	7.315E-01	1.422E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9659567	0.9815382	0.9827714	0.9928985	0.9790743	2.522E+02	4.744E+00
α_2	1.77E-03	8.69E-03	7.45E-03	1.98E-02	4.92E-03	2.232E+00	2.547E+02
α_3	4.65E-04	5.07E-03	3.86E-03	1.38E-02	4.04E-03	1.302E+00	2.556E+02
α_4	1.27E-04	3.43E-03	2.26E-03	1.07E-02	7.98E-03	8.822E-01	2.561E+02
α_5	2.89E-07	1.27E-03	3.55E-04	5.66E-03	3.99E-03	3.267E-01	2.566E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9687244	0.9825816	0.9836271	0.9928554	0.9805150	2.987E+02	5.295E+00

α_2	1.38E-03	7.08E-03	6.03E-03	1.64E-02	6.02E-03	2.152E+00	3.018E+02
α_3	4.26E-04	4.41E-03	3.38E-03	1.19E-02	1.78E-03	1.340E+00	3.026E+02
α_4	1.53E-04	3.19E-03	2.19E-03	9.65E-03	5.01E-03	9.711E-01	3.030E+02
α_5	1.80E-05	1.96E-03	1.03E-03	7.07E-03	5.01E-03	5.961E-01	3.034E+02
α_6	6.33E-09	7.72E-04	1.18E-04	3.81E-03	1.67E-03	2.348E-01	3.037E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9735469	0.9841135	0.9848005	0.9923258	0.9812378	4.573E+02	7.382E+00
α_2	1.61E-03	6.16E-03	5.47E-03	1.31E-02	7.10E-03	2.862E+00	4.618E+02
α_3	5.29E-04	3.67E-03	2.99E-03	9.16E-03	8.97E-04	1.708E+00	4.630E+02
α_4	2.74E-04	2.87E-03	2.20E-03	7.77E-03	2.87E-03	1.333E+00	4.633E+02
α_5	8.88E-05	2.02E-03	1.37E-03	6.19E-03	4.30E-03	9.404E-01	4.637E+02
α_6	1.85E-06	9.50E-04	3.84E-04	3.81E-03	2.87E-03	4.416E-01	4.642E+02
α_7	5.56E-17	2.09E-04	1.05E-06	1.22E-03	7.17E-04	9.730E-02	4.646E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746943	0.9847267	0.9853724	0.9925456	0.9815168	4.875E+02	7.561E+00
α_2	1.48E-03	5.71E-03	5.06E-03	1.22E-02	8.15E-03	2.828E+00	4.922E+02
α_3	3.23E-04	2.92E-03	2.29E-03	7.70E-03	5.68E-04	1.447E+00	4.936E+02
α_4	1.98E-04	2.46E-03	1.83E-03	6.88E-03	1.58E-03	1.219E+00	4.938E+02
α_5	1.09E-04	2.05E-03	1.43E-03	6.10E-03	3.15E-03	1.015E+00	4.940E+02
α_6	1.89E-05	1.34E-03	7.53E-04	4.64E-03	3.15E-03	6.622E-01	4.944E+02
α_7	1.63E-08	5.33E-04	1.04E-04	2.54E-03	1.57E-03	2.641E-01	4.948E+02
α_8	5.85E-14	2.54E-04	5.11E-06	1.44E-03	3.15E-04	1.259E-01	4.949E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.69E-01	9.77E-01	9.78E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
α_2	3.08E-02	9.74E-03	1.01E-02	8.69E-03	7.08E-03	6.16E-03	5.71E-03
α_3		1.31E-02	6.31E-03	5.07E-03	4.41E-03	3.67E-03	2.92E-03
α_4			5.12E-03	3.43E-03	3.19E-03	2.87E-03	2.46E-03
α_5				1.27E-03	1.96E-03	2.02E-03	2.05E-03
α_6					7.72E-04	9.50E-04	1.34E-03
α_7						2.09E-04	5.33E-04
α_8							2.54E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.69E-01	9.77E-01	9.78E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01
Beta	3.08E-02	2.29E-02	2.16E-02	1.85E-02	1.74E-02	1.59E-02	1.53E-02
Gamma		5.74E-01	5.30E-01	5.29E-01	5.93E-01	6.12E-01	6.26E-01
Delta			4.48E-01	4.81E-01	5.73E-01	6.22E-01	6.94E-01
Epsilon				2.70E-01	4.61E-01	5.26E-01	6.29E-01
Mu					2.83E-01	3.64E-01	5.09E-01

Omega						1.81E-01	3.71E-01
Sigma							3.23E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	23.46	35.19	46.93	58.66	70.39	82.12	93.85
N_1	1.2697	1.8091	2.2848	2.7053	3.0685	3.3757	3.6283
N_2	1.0318	0.0955	0.1909	0.3082	0.4512	0.6188	0.8096
N_3		1.0000	0.5000	0.2533	0.1334	0.0781	0.0564
N_4			0.5000	0.5000	0.3751	0.2504	0.1571
N_5				0.2500	0.3750	0.3750	0.3125
N_6					0.1250	0.2500	0.3125
N_7						0.0625	0.1563
N_8							0.0313

2.9.1.2 POWER-OPERATED RELIEF VALVES FAIL TO CLOSE ALL SYSTEMS: ALL-PORV-OO

Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 24.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9609552	0.9900274	0.9956666	0.9999697	1.0000000	4.651E+01	4.685E-01
α_2	2.79E-05	9.97E-03	4.33E-03	3.90E-02	0.00E+00	4.685E-01	4.651E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9613298	0.9864430	0.9900939	0.9990638	1.0000000	8.208E+01	1.128E+00
α_2	3.42E-04	1.02E-02	6.66E-03	3.23E-02	0.00E+00	8.512E-01	8.236E+01
α_3	1.66E-07	3.33E-03	7.12E-04	1.56E-02	0.00E+00	2.768E-01	8.293E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9611134	0.9837694	0.9864453	0.9972849	1.0000000	1.148E+02	1.894E+00
α_2	9.33E-04	1.08E-02	8.16E-03	2.97E-02	0.00E+00	1.260E+00	1.154E+02
α_3	3.75E-06	3.45E-03	1.27E-03	1.43E-02	0.00E+00	4.024E-01	1.163E+02
α_4	1.38E-08	1.98E-03	2.96E-04	9.83E-03	0.00E+00	2.315E-01	1.164E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9684290	0.9842829	0.9857400	0.9951723	1.0000000	2.149E+02	3.432E+00
α_2	1.50E-03	8.81E-03	7.36E-03	2.11E-02	0.00E+00	1.924E+00	2.164E+02
α_3	2.78E-04	4.80E-03	3.40E-03	1.41E-02	0.00E+00	1.049E+00	2.173E+02
α_4	1.33E-06	1.75E-03	6.03E-04	7.38E-03	0.00E+00	3.822E-01	2.180E+02
α_5	3.05E-20	3.51E-04	3.27E-07	2.04E-03	0.00E+00	7.674E-02	2.183E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9704641	0.9848515	0.9861078	0.9949443	1.0000000	2.493E+02	3.835E+00
α_2	9.63E-04	6.72E-03	5.47E-03	1.67E-02	0.00E+00	1.701E+00	2.515E+02
α_3	3.76E-04	4.77E-03	3.54E-03	1.33E-02	0.00E+00	1.207E+00	2.519E+02
α_4	2.16E-05	2.35E-03	1.24E-03	8.48E-03	0.00E+00	5.960E-01	2.526E+02

α_5	3.42E-09	8.73E-04	1.17E-04	4.38E-03	0.00E+00	2.211E-01	2.529E+02
α_6	3.41E-15	4.34E-04	4.39E-06	2.50E-03	0.00E+00	1.098E-01	2.530E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747789	0.9856905	0.9864871	0.9938754	1.0000000	3.959E+02	5.747E+00
α_2	1.14E-03	5.58E-03	4.79E-03	1.28E-02	0.00E+00	2.243E+00	3.994E+02
α_3	5.44E-04	4.06E-03	3.27E-03	1.03E-02	0.00E+00	1.630E+00	4.000E+02
α_4	1.68E-04	2.70E-03	1.93E-03	7.84E-03	0.00E+00	1.083E+00	4.006E+02
α_5	1.02E-05	1.41E-03	7.10E-04	5.17E-03	0.00E+00	5.654E-01	4.011E+02
α_6	2.62E-10	4.77E-04	4.41E-05	2.49E-03	0.00E+00	1.916E-01	4.015E+02
α_7	5.93E-41	8.66E-05	3.22E-12	3.80E-04	0.00E+00	3.480E-02	4.016E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9759419	0.9863627	0.9871258	0.9941762	1.0000000	4.141E+02	5.726E+00
α_2	8.67E-04	4.81E-03	4.05E-03	1.13E-02	0.00E+00	2.018E+00	4.178E+02
α_3	3.42E-04	3.31E-03	2.56E-03	8.84E-03	0.00E+00	1.391E+00	4.185E+02
α_4	1.50E-04	2.53E-03	1.80E-03	7.41E-03	0.00E+00	1.062E+00	4.188E+02
α_5	2.95E-05	1.67E-03	9.78E-04	5.68E-03	0.00E+00	7.026E-01	4.191E+02
α_6	3.27E-07	8.33E-04	2.56E-04	3.62E-03	0.00E+00	3.497E-01	4.195E+02
α_7	1.26E-15	2.57E-04	2.36E-06	1.48E-03	0.00E+00	1.078E-01	4.197E+02
α_8	2.62E-17	2.26E-04	9.55E-07	1.31E-03	0.00E+00	9.469E-02	4.198E+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	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	9.97E-03	1.02E-02	1.08E-02	8.81E-03	6.72E-03	5.58E-03	4.81E-03
α_3		3.33E-03	3.45E-03	4.80E-03	4.77E-03	4.06E-03	3.31E-03
α_4			1.98E-03	1.75E-03	2.35E-03	2.70E-03	2.53E-03
α_5				3.51E-04	8.73E-04	1.41E-03	1.67E-03
α_6					4.34E-04	4.77E-04	8.33E-04
α_7						8.66E-05	2.57E-04
α_8							2.26E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	9.97E-03	1.36E-02	1.62E-02	1.57E-02	1.51E-02	1.43E-02	1.36E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	24.10	24.10	24.10	24.10	24.10	24.10	24.10
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

2.9.2 PWR Main Steam PORV

2.9.2.1 PWR MSS POWER-OPERATED RELIEF VALVES FAIL TO OPEN: PWR-MSS-PRV-CC

Plants/PWR
Systems/Steam
Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 58.2

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9117666	0.9655583	0.9724164	0.9958464	0.9501066	4.206E+01	1.500E+00
α_2	4.15E-03	3.44E-02	2.76E-02	8.82E-02	4.99E-02	1.500E+00	4.206E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9436451	0.9751787	0.9786292	0.9949165	0.9640516	8.736E+01	2.223E+00
α_2	4.76E-04	1.06E-02	7.22E-03	3.21E-02	3.13E-03	9.467E-01	8.863E+01
α_3	1.27E-03	1.43E-02	1.08E-02	3.89E-02	3.28E-02	1.277E+00	8.830E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9520700	0.9767737	0.9791286	0.9934326	0.9704002	1.297E+02	3.085E+00
α_2	1.22E-03	1.09E-02	8.58E-03	2.86E-02	4.75E-03	1.451E+00	1.314E+02
α_3	2.68E-04	6.80E-03	4.53E-03	2.10E-02	1.24E-02	9.024E-01	1.319E+02
α_4	1.13E-04	5.51E-03	3.31E-03	1.84E-02	1.24E-02	7.315E-01	1.321E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9642014	0.9805774	0.9818726	0.9925261	0.9737509	2.395E+02	4.744E+00
α_2	1.86E-03	9.14E-03	7.84E-03	2.09E-02	6.17E-03	2.232E+00	2.420E+02
α_3	4.89E-04	5.33E-03	4.06E-03	1.45E-02	5.07E-03	1.302E+00	2.429E+02
α_4	1.33E-04	3.61E-03	2.38E-03	1.13E-02	1.00E-02	8.822E-01	2.434E+02
α_5	3.04E-07	1.34E-03	3.73E-04	5.95E-03	5.00E-03	3.267E-01	2.439E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9670812	0.9816615	0.9827603	0.9924752	0.9755339	2.834E+02	5.295E+00

α_2	1.46E-03	7.45E-03	6.35E-03	1.72E-02	7.56E-03	2.152E+00	2.866E+02
α_3	4.49E-04	4.64E-03	3.56E-03	1.25E-02	2.24E-03	1.340E+00	2.874E+02
α_4	1.61E-04	3.36E-03	2.31E-03	1.02E-02	6.29E-03	9.711E-01	2.877E+02
α_5	1.89E-05	2.06E-03	1.08E-03	7.44E-03	6.29E-03	5.961E-01	2.881E+02
α_6	6.67E-09	8.13E-04	1.25E-04	4.01E-03	2.10E-03	2.348E-01	2.885E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9724978	0.9834809	0.9841945	0.9920141	0.9764226	4.395E+02	7.382E+00
α_2	1.68E-03	6.40E-03	5.68E-03	1.36E-02	8.92E-03	2.862E+00	4.440E+02
α_3	5.50E-04	3.82E-03	3.11E-03	9.52E-03	1.13E-03	1.708E+00	4.452E+02
α_4	2.85E-04	2.98E-03	2.28E-03	8.08E-03	3.61E-03	1.333E+00	4.456E+02
α_5	9.23E-05	2.10E-03	1.42E-03	6.44E-03	5.41E-03	9.404E-01	4.459E+02
α_6	1.93E-06	9.88E-04	4.00E-04	3.97E-03	3.61E-03	4.416E-01	4.464E+02
α_7	5.78E-17	2.18E-04	1.09E-06	1.27E-03	9.01E-04	9.730E-02	4.468E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736152	0.9840724	0.9847449	0.9922209	0.9767575	4.672E+02	7.561E+00
α_2	1.54E-03	5.96E-03	5.28E-03	1.27E-02	1.03E-02	2.828E+00	4.719E+02
α_3	3.37E-04	3.05E-03	2.38E-03	8.02E-03	7.14E-04	1.447E+00	4.733E+02
α_4	2.06E-04	2.57E-03	1.91E-03	7.17E-03	1.99E-03	1.219E+00	4.735E+02
α_5	1.14E-04	2.14E-03	1.49E-03	6.37E-03	3.96E-03	1.015E+00	4.737E+02
α_6	1.97E-05	1.39E-03	7.86E-04	4.84E-03	3.96E-03	6.622E-01	4.741E+02
α_7	1.70E-08	5.56E-04	1.08E-04	2.65E-03	1.98E-03	2.641E-01	4.745E+02
α_8	6.10E-14	2.65E-04	5.33E-06	1.50E-03	3.96E-04	1.259E-01	4.746E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.66E-01	9.75E-01	9.77E-01	9.81E-01	9.82E-01	9.83E-01	9.84E-01
α_2	3.44E-02	1.06E-02	1.09E-02	9.14E-03	7.45E-03	6.40E-03	5.96E-03
α_3		1.43E-02	6.80E-03	5.33E-03	4.64E-03	3.82E-03	3.05E-03
α_4			5.51E-03	3.61E-03	3.36E-03	2.98E-03	2.57E-03
α_5				1.34E-03	2.06E-03	2.10E-03	2.14E-03
α_6					8.13E-04	9.88E-04	1.39E-03
α_7						2.18E-04	5.56E-04
α_8							2.65E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.66E-01	9.75E-01	9.77E-01	9.81E-01	9.82E-01	9.83E-01	9.84E-01
Beta	3.44E-02	2.48E-02	2.32E-02	1.94E-02	1.83E-02	1.65E-02	1.59E-02
Gamma		5.74E-01	5.30E-01	5.29E-01	5.93E-01	6.12E-01	6.26E-01
Delta			4.48E-01	4.81E-01	5.73E-01	6.22E-01	6.94E-01
Epsilon				2.70E-01	4.61E-01	5.26E-01	6.29E-01
Mu					2.83E-01	3.64E-01	5.09E-01

Omega						1.81E-01	3.71E-01
Sigma							3.23E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	18.38	27.57	36.76	45.95	55.14	64.33	73.52
N_1	1.2697	1.8091	2.2848	2.7053	3.0685	3.3757	3.6283
N_2	1.0318	0.0955	0.1909	0.3082	0.4512	0.6188	0.8096
N_3		1.0000	0.5000	0.2533	0.1334	0.0781	0.0564
N_4			0.5000	0.5000	0.3751	0.2504	0.1571
N_5				0.2500	0.3750	0.3750	0.3125
N_6					0.1250	0.2500	0.3125
N_7						0.0625	0.1563
N_8							0.0313

2.9.2.2 PWR MSS POWER-OPERATED RELIEF VALVES FAIL TO CLOSE: PWR-MSS-PRV-OO

Plants/PWR
Systems/Steam
Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 19.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9563275	0.9888396	0.9951428	0.9999661	1.0000000	4.151E+01	4.685E-01
α_2	3.13E-05	1.12E-02	4.86E-03	4.37E-02	0.00E+00	4.685E-01	4.151E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9588768	0.9855762	0.9894550	0.9990035	1.0000000	7.708E+01	1.128E+00
α_2	3.64E-04	1.09E-02	7.09E-03	3.43E-02	0.00E+00	8.512E-01	7.736E+01
α_3	1.77E-07	3.54E-03	7.58E-04	1.66E-02	0.00E+00	2.768E-01	7.793E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9593807	0.9830427	0.9858348	0.9971619	1.0000000	1.098E+02	1.894E+00
α_2	9.75E-04	1.13E-02	8.53E-03	3.10E-02	0.00E+00	1.260E+00	1.104E+02
α_3	3.92E-06	3.60E-03	1.32E-03	1.49E-02	0.00E+00	4.024E-01	1.113E+02
α_4	1.44E-08	2.07E-03	3.09E-04	1.03E-02	0.00E+00	2.315E-01	1.114E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9676935	0.9839146	0.9853999	0.9950582	1.0000000	2.099E+02	3.432E+00
α_2	1.53E-03	9.02E-03	7.54E-03	2.16E-02	0.00E+00	1.924E+00	2.114E+02
α_3	2.85E-04	4.92E-03	3.48E-03	1.44E-02	0.00E+00	1.049E+00	2.123E+02
α_4	1.36E-06	1.79E-03	6.17E-04	7.56E-03	0.00E+00	3.822E-01	2.130E+02
α_5	3.12E-20	3.60E-04	3.35E-07	2.09E-03	0.00E+00	7.674E-02	2.133E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9698723	0.9845462	0.9858271	0.9948416	1.0000000	2.443E+02	3.835E+00
α_2	9.83E-04	6.85E-03	5.58E-03	1.71E-02	0.00E+00	1.701E+00	2.465E+02

α_3	3.84E-04	4.86E-03	3.62E-03	1.36E-02	0.00E+00	1.207E+00	2.469E+02
α_4	2.20E-05	2.40E-03	1.26E-03	8.65E-03	0.00E+00	5.960E-01	2.476E+02
α_5	3.49E-09	8.91E-04	1.19E-04	4.47E-03	0.00E+00	2.211E-01	2.479E+02
α_6	3.48E-15	4.42E-04	4.48E-06	2.55E-03	0.00E+00	1.098E-01	2.480E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744669	0.9855101	0.9863164	0.9937983	1.0000000	3.909E+02	5.747E+00
α_2	1.16E-03	5.66E-03	4.85E-03	1.29E-02	0.00E+00	2.243E+00	3.944E+02
α_3	5.51E-04	4.11E-03	3.31E-03	1.04E-02	0.00E+00	1.630E+00	3.950E+02
α_4	1.70E-04	2.73E-03	1.95E-03	7.94E-03	0.00E+00	1.083E+00	3.956E+02
α_5	1.03E-05	1.43E-03	7.19E-04	5.24E-03	0.00E+00	5.654E-01	3.961E+02
α_6	2.65E-10	4.83E-04	4.46E-05	2.52E-03	0.00E+00	1.916E-01	3.965E+02
α_7	6.01E-41	8.77E-05	3.26E-12	3.85E-04	0.00E+00	3.480E-02	3.966E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9756484	0.9861983	0.9869703	0.9941057	1.0000000	4.091E+02	5.726E+00
α_2	8.77E-04	4.86E-03	4.10E-03	1.15E-02	0.00E+00	2.018E+00	4.128E+02
α_3	3.46E-04	3.35E-03	2.60E-03	8.94E-03	0.00E+00	1.391E+00	4.135E+02
α_4	1.52E-04	2.56E-03	1.82E-03	7.50E-03	0.00E+00	1.062E+00	4.138E+02
α_5	2.99E-05	1.69E-03	9.89E-04	5.75E-03	0.00E+00	7.026E-01	4.141E+02
α_6	3.31E-07	8.43E-04	2.59E-04	3.67E-03	0.00E+00	3.497E-01	4.145E+02
α_7	1.27E-15	2.60E-04	2.39E-06	1.50E-03	0.00E+00	1.078E-01	4.147E+02
α_8	2.66E-17	2.28E-04	9.67E-07	1.33E-03	0.00E+00	9.469E-02	4.148E+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	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.12E-02	1.09E-02	1.13E-02	9.02E-03	6.85E-03	5.66E-03	4.86E-03
α_3		3.54E-03	3.60E-03	4.92E-03	4.86E-03	4.11E-03	3.35E-03
α_4			2.07E-03	1.79E-03	2.40E-03	2.73E-03	2.56E-03
α_5				3.60E-04	8.91E-04	1.43E-03	1.69E-03
α_6					4.42E-04	4.83E-04	8.43E-04
α_7						8.77E-05	2.60E-04
α_8							2.28E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.12E-02	1.44E-02	1.70E-02	1.61E-02	1.55E-02	1.45E-02	1.38E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	19.10	19.10	19.10	19.10	19.10	19.10	19.10
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

2.9.3 PWR Pressurizer Power-Operated Relief Valves

2.9.3.1 PRESSURIZER POWER-OPERATED RELIEF VALVES FAIL TO OPEN: PWR-RCS-PORV-CC

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

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	0.9489457	0.9869423	0.9943066	0.9999604	1.0000000	3.541E+01	4.685E-01
α_2	3.67E-05	1.31E-02	5.70E-03	5.11E-02	0.00E+00	4.685E-01	3.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9554249	0.9843560	0.9885545	0.9989185	1.0000000	7.098E+01	1.128E+00
α_2	3.96E-04	1.18E-02	7.70E-03	3.72E-02	0.00E+00	8.512E-01	7.126E+01
α_3	1.92E-07	3.84E-03	8.22E-04	1.80E-02	0.00E+00	2.768E-01	7.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9570527	0.9820628	0.9850112	0.9969959	1.0000000	1.037E+02	1.894E+00
α_2	1.03E-03	1.19E-02	9.02E-03	3.28E-02	0.00E+00	1.260E+00	1.043E+02
α_3	4.14E-06	3.81E-03	1.40E-03	1.58E-02	0.00E+00	4.024E-01	1.052E+02
α_4	1.52E-08	2.19E-03	3.27E-04	1.09E-02	0.00E+00	2.315E-01	1.053E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9667484	0.9834412	0.9849688	0.9949115	1.0000000	2.038E+02	3.432E+00
α_2	1.58E-03	9.28E-03	7.76E-03	2.22E-02	0.00E+00	1.924E+00	2.053E+02
α_3	2.93E-04	5.06E-03	3.58E-03	1.49E-02	0.00E+00	1.049E+00	2.062E+02
α_4	1.40E-06	1.84E-03	6.36E-04	7.78E-03	0.00E+00	3.822E-01	2.069E+02
α_5	3.22E-20	3.70E-04	3.45E-07	2.15E-03	0.00E+00	7.674E-02	2.072E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9691173	0.9841568	0.9854689	0.9947104	1.0000000	2.382E+02	3.835E+00

α_2	1.01E-03	7.03E-03	5.72E-03	1.75E-02	0.00E+00	1.701E+00	2.404E+02
α_3	3.93E-04	4.99E-03	3.71E-03	1.40E-02	0.00E+00	1.207E+00	2.408E+02
α_4	2.26E-05	2.46E-03	1.29E-03	8.87E-03	0.00E+00	5.960E-01	2.415E+02
α_5	3.58E-09	9.13E-04	1.22E-04	4.58E-03	0.00E+00	2.211E-01	2.418E+02
α_6	3.57E-15	4.54E-04	4.59E-06	2.62E-03	0.00E+00	1.098E-01	2.419E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9740651	0.9852838	0.9861023	0.9937016	1.0000000	3.848E+02	5.747E+00
α_2	1.17E-03	5.74E-03	4.92E-03	1.31E-02	0.00E+00	2.243E+00	3.883E+02
α_3	5.60E-04	4.17E-03	3.36E-03	1.06E-02	0.00E+00	1.630E+00	3.889E+02
α_4	1.73E-04	2.77E-03	1.98E-03	8.07E-03	0.00E+00	1.083E+00	3.895E+02
α_5	1.05E-05	1.45E-03	7.30E-04	5.32E-03	0.00E+00	5.654E-01	3.900E+02
α_6	2.69E-10	4.91E-04	4.53E-05	2.56E-03	0.00E+00	1.916E-01	3.904E+02
α_7	6.10E-41	8.91E-05	3.31E-12	3.91E-04	0.00E+00	3.480E-02	3.905E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9752863	0.9859924	0.9867755	0.9940179	1.0000000	4.030E+02	5.726E+00
α_2	8.90E-04	4.94E-03	4.16E-03	1.17E-02	0.00E+00	2.018E+00	4.067E+02
α_3	3.51E-04	3.40E-03	2.63E-03	9.08E-03	0.00E+00	1.391E+00	4.074E+02
α_4	1.55E-04	2.60E-03	1.85E-03	7.61E-03	0.00E+00	1.062E+00	4.077E+02
α_5	3.03E-05	1.72E-03	1.00E-03	5.84E-03	0.00E+00	7.026E-01	4.080E+02
α_6	3.36E-07	8.56E-04	2.63E-04	3.72E-03	0.00E+00	3.497E-01	4.084E+02
α_7	1.29E-15	2.64E-04	2.42E-06	1.52E-03	0.00E+00	1.078E-01	4.086E+02
α_8	2.70E-17	2.32E-04	9.81E-07	1.35E-03	0.00E+00	9.469E-02	4.087E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.31E-02	1.18E-02	1.19E-02	9.28E-03	7.03E-03	5.74E-03	4.94E-03
α_3		3.84E-03	3.81E-03	5.06E-03	4.99E-03	4.17E-03	3.40E-03
α_4			2.19E-03	1.84E-03	2.46E-03	2.77E-03	2.60E-03
α_5				3.70E-04	9.13E-04	1.45E-03	1.72E-03
α_6					4.54E-04	4.91E-04	8.56E-04
α_7						8.91E-05	2.64E-04
α_8							2.32E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.31E-02	1.56E-02	1.79E-02	1.66E-02	1.58E-02	1.47E-02	1.40E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	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

2.9.3.2 PWR PRESSURIZER POWER-OPERATED RELIEF VALVES FAIL TO CLOSE: PWR-RCS-PORV-OO

Plants/PWR
Systems/Clean Water/Reactor coolant
Components/Valve/Power-Operated Relief Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

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	0.9293809	0.9818971	0.9920474	0.9999453	1.0000000	2.541E+01	4.685E-01
α_2	5.13E-05	1.81E-02	7.95E-03	7.06E-02	0.00E+00	4.685E-01	2.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9483145	0.9818372	0.9866969	0.9987453	1.0000000	6.098E+01	1.128E+00
α_2	4.60E-04	1.37E-02	8.95E-03	4.32E-02	0.00E+00	8.512E-01	6.126E+01
α_3	2.23E-07	4.46E-03	9.56E-04	2.09E-02	0.00E+00	2.768E-01	6.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525994	0.9801860	0.9834318	0.9966772	1.0000000	9.368E+01	1.894E+00
α_2	1.14E-03	1.32E-02	9.97E-03	3.62E-02	0.00E+00	1.260E+00	9.431E+01
α_3	4.58E-06	4.21E-03	1.55E-03	1.74E-02	0.00E+00	4.024E-01	9.517E+01
α_4	1.68E-08	2.42E-03	3.61E-04	1.20E-02	0.00E+00	2.315E-01	9.534E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650736	0.9826018	0.9842043	0.9946508	1.0000000	1.938E+02	3.432E+00
α_2	1.66E-03	9.75E-03	8.15E-03	2.33E-02	0.00E+00	1.924E+00	1.953E+02
α_3	3.08E-04	5.32E-03	3.77E-03	1.56E-02	0.00E+00	1.049E+00	1.962E+02
α_4	1.47E-06	1.94E-03	6.68E-04	8.17E-03	0.00E+00	3.822E-01	1.969E+02
α_5	3.38E-20	3.89E-04	3.63E-07	2.26E-03	0.00E+00	7.674E-02	1.972E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677940	0.9834740	0.9848410	0.9944760	1.0000000	2.282E+02	3.835E+00
α_2	1.05E-03	7.33E-03	5.97E-03	1.83E-02	0.00E+00	1.701E+00	2.304E+02

α_3	4.10E-04	5.20E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.308E+02
α_4	2.35E-05	2.57E-03	1.35E-03	9.25E-03	0.00E+00	5.960E-01	2.315E+02
α_5	3.73E-09	9.53E-04	1.27E-04	4.78E-03	0.00E+00	2.211E-01	2.318E+02
α_6	3.72E-15	4.73E-04	4.79E-06	2.73E-03	0.00E+00	1.098E-01	2.319E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733872	0.9848971	0.9857364	0.9935299	1.0000000	3.748E+02	5.747E+00
α_2	1.21E-03	5.89E-03	5.05E-03	1.35E-02	0.00E+00	2.243E+00	3.783E+02
α_3	5.75E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.789E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.28E-03	0.00E+00	1.083E+00	3.795E+02
α_5	1.07E-05	1.49E-03	7.49E-04	5.46E-03	0.00E+00	5.654E-01	3.800E+02
α_6	2.76E-10	5.03E-04	4.65E-05	2.62E-03	0.00E+00	1.916E-01	3.804E+02
α_7	6.26E-41	9.14E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.805E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746696	0.9856411	0.9864433	0.9938665	1.0000000	3.930E+02	5.726E+00
α_2	9.13E-04	5.06E-03	4.26E-03	1.19E-02	0.00E+00	2.018E+00	3.967E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.30E-03	0.00E+00	1.391E+00	3.974E+02
α_4	1.58E-04	2.66E-03	1.89E-03	7.80E-03	0.00E+00	1.062E+00	3.977E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.98E-03	0.00E+00	7.026E-01	3.980E+02
α_6	3.44E-07	8.77E-04	2.69E-04	3.81E-03	0.00E+00	3.497E-01	3.984E+02
α_7	1.32E-15	2.70E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.986E+02
α_8	2.76E-17	2.37E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.987E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.81E-02	1.37E-02	1.32E-02	9.75E-03	7.33E-03	5.89E-03	5.06E-03
α_3		4.46E-03	4.21E-03	5.32E-03	5.20E-03	4.28E-03	3.49E-03
α_4			2.42E-03	1.94E-03	2.57E-03	2.85E-03	2.66E-03
α_5				3.89E-04	9.53E-04	1.49E-03	1.76E-03
α_6					4.73E-04	5.03E-04	8.77E-04
α_7						9.14E-05	2.70E-04
α_8							2.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.81E-02	1.82E-02	1.98E-02	1.74E-02	1.65E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	3.00	3.00	3.00	3.00	3.00	3.00	3.00
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

2.10 Main Steam Isolation Valves

2.10.1 PWR Main Steam Isolation Valves

2.10.1.1 PWR MAIN STEAM ISOLATION VALVES FAIL TO OPEN: PWR-MSS-MSV-CC

Plants/PWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 11.1

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9243133	0.9782949	0.9878504	0.9997357	0.9738903	2.863E+01	6.352E-01
α_2	2.67E-04	2.17E-02	1.21E-02	7.57E-02	2.61E-02	6.352E-01	2.863E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9403631	0.9762094	0.9806803	0.9967681	0.9463807	6.680E+01	1.628E+00
α_2	1.96E-03	1.97E-02	1.53E-02	5.28E-02	5.36E-02	1.351E+00	6.708E+01
α_3	2.02E-07	4.05E-03	8.67E-04	1.90E-02	0.00E+00	2.768E-01	6.816E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9420081	0.9723547	0.9753119	0.9925952	0.9173554	1.018E+02	2.894E+00
α_2	4.50E-03	2.16E-02	1.86E-02	4.88E-02	8.26E-02	2.260E+00	1.024E+02
α_3	4.18E-06	3.84E-03	1.41E-03	1.59E-02	0.00E+00	4.024E-01	1.043E+02
α_4	1.54E-08	2.21E-03	3.30E-04	1.10E-02	0.00E+00	2.315E-01	1.044E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9602905	0.9788083	0.9803147	0.9921773	0.9327731	2.047E+02	4.432E+00
α_2	2.96E-03	1.24E-02	1.09E-02	2.70E-02	4.48E-02	2.591E+00	2.066E+02
α_3	6.77E-04	6.61E-03	5.12E-03	1.76E-02	2.24E-02	1.382E+00	2.078E+02
α_4	1.39E-06	1.83E-03	6.30E-04	7.71E-03	0.00E+00	3.822E-01	2.088E+02
α_5	3.19E-20	3.67E-04	3.42E-07	2.13E-03	0.00E+00	7.674E-02	2.091E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9640505	0.9804020	0.9816840	0.9923709	0.9433428	2.419E+02	4.835E+00
α_2	1.69E-03	8.70E-03	7.41E-03	2.01E-02	2.52E-02	2.146E+00	2.446E+02
α_3	9.18E-04	6.69E-03	5.42E-03	1.68E-02	2.52E-02	1.651E+00	2.451E+02
α_4	5.18E-05	2.87E-03	1.68E-03	9.71E-03	6.30E-03	7.071E-01	2.460E+02
α_5	3.51E-09	8.96E-04	1.20E-04	4.50E-03	0.00E+00	2.211E-01	2.465E+02
α_6	3.50E-15	4.45E-04	4.50E-06	2.57E-03	0.00E+00	1.098E-01	2.466E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9712158	0.9830457	0.9838461	0.9921291	0.9510404	3.912E+02	6.747E+00
α_2	1.49E-03	6.38E-03	5.58E-03	1.40E-02	1.45E-02	2.539E+00	3.954E+02
α_3	9.72E-04	5.21E-03	4.41E-03	1.22E-02	2.18E-02	2.074E+00	3.959E+02
α_4	3.01E-04	3.28E-03	2.49E-03	8.94E-03	1.09E-02	1.305E+00	3.967E+02
α_5	1.45E-05	1.51E-03	8.00E-04	5.44E-03	1.81E-03	6.024E-01	3.974E+02
α_6	2.64E-10	4.81E-04	4.45E-05	2.51E-03	0.00E+00	1.916E-01	3.978E+02
α_7	5.99E-41	8.74E-05	3.25E-12	3.84E-04	0.00E+00	3.480E-02	3.979E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9727177	0.9839465	0.9847081	0.9925629	0.9568966	4.122E+02	6.726E+00
α_2	1.07E-03	5.29E-03	4.52E-03	1.21E-02	8.51E-03	2.216E+00	4.167E+02
α_3	6.53E-04	4.26E-03	3.50E-03	1.05E-02	1.70E-02	1.786E+00	4.172E+02
α_4	3.21E-04	3.24E-03	2.49E-03	8.72E-03	1.28E-02	1.358E+00	4.176E+02
α_5	5.27E-05	1.91E-03	1.20E-03	6.20E-03	4.26E-03	8.014E-01	4.181E+02
α_6	4.42E-07	8.64E-04	2.78E-04	3.71E-03	5.32E-04	3.621E-01	4.186E+02
α_7	1.26E-15	2.57E-04	2.36E-06	1.49E-03	0.00E+00	1.078E-01	4.188E+02
α_8	2.63E-17	2.26E-04	9.57E-07	1.32E-03	0.00E+00	9.469E-02	4.189E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.78E-01	9.76E-01	9.72E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
α_2	2.17E-02	1.97E-02	2.16E-02	1.24E-02	8.70E-03	6.38E-03	5.29E-03
α_3		4.05E-03	3.84E-03	6.61E-03	6.69E-03	5.21E-03	4.26E-03
α_4			2.21E-03	1.83E-03	2.87E-03	3.28E-03	3.24E-03
α_5				3.67E-04	8.96E-04	1.51E-03	1.91E-03
α_6					4.45E-04	4.81E-04	8.64E-04
α_7						8.74E-05	2.57E-04
α_8							2.26E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.78E-01	9.76E-01	9.72E-01	9.79E-01	9.80E-01	9.83E-01	9.84E-01
Beta	2.17E-02	2.38E-02	2.76E-02	2.12E-02	1.96E-02	1.70E-02	1.61E-02
Gamma		1.70E-01	2.19E-01	4.15E-01	5.56E-01	6.24E-01	6.71E-01

Delta			3.65E-01	2.49E-01	3.86E-01	5.07E-01	6.04E-01
Epsilon				1.67E-01	3.19E-01	3.88E-01	5.01E-01
Mu					3.32E-01	2.73E-01	4.13E-01
Omega						1.54E-01	3.59E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	5.55	8.33	11.10	13.88	16.65	19.43	22.20
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

2.10.1.2 PWR MAIN STEAM ISOLATION VALVES FAIL TO CLOSE: PWR-MSS-MSV-OO

Plants/PWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 20.7

Total Number of Common-Cause Failure Events: 5

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9143454	0.9702493	0.9784363	0.9981472	0.9541075	3.496E+01	1.072E+00
α_2	1.86E-03	2.98E-02	2.16E-02	8.57E-02	4.59E-02	1.072E+00	3.496E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9238196	0.9638194	0.9677157	0.9904799	0.9102791	7.516E+01	2.821E+00
α_2	7.40E-03	3.19E-02	2.80E-02	6.98E-02	8.66E-02	2.486E+00	7.549E+01
α_3	1.21E-06	4.30E-03	1.25E-03	1.89E-02	3.09E-03	3.352E-01	7.765E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9339268	0.9653881	0.9680116	0.9878825	0.9117838	1.130E+02	4.050E+00
α_2	5.73E-03	2.30E-02	2.03E-02	4.93E-02	5.84E-02	2.687E+00	1.143E+02
α_3	6.67E-04	9.66E-03	7.05E-03	2.76E-02	2.98E-02	1.131E+00	1.159E+02
α_4	1.48E-08	1.99E-03	3.01E-04	9.84E-03	5.68E-05	2.329E-01	1.168E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9535819	0.9733153	0.9747136	0.9882844	0.9147609	2.182E+02	5.982E+00
α_2	4.05E-03	1.41E-02	1.27E-02	2.90E-02	4.13E-02	3.159E+00	2.210E+02
α_3	1.79E-03	9.40E-03	7.99E-03	2.18E-02	3.54E-02	2.108E+00	2.221E+02
α_4	3.48E-05	2.85E-03	1.57E-03	1.00E-02	8.55E-03	6.381E-01	2.236E+02
α_5	3.34E-20	3.43E-04	3.28E-07	2.00E-03	7.74E-06	7.697E-02	2.241E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9574978	0.9750283	0.9762197	0.9884987	0.9217051	2.578E+02	6.603E+00
α_2	2.14E-03	9.38E-03	8.17E-03	2.07E-02	2.20E-02	2.479E+00	2.619E+02

α_3	2.51E-03	1.01E-02	8.93E-03	2.19E-02	4.17E-02	2.681E+00	2.617E+02
α_4	1.85E-04	3.73E-03	2.57E-03	1.12E-02	1.10E-02	9.855E-01	2.634E+02
α_5	4.88E-07	1.31E-03	4.00E-04	5.72E-03	3.57E-03	3.472E-01	2.641E+02
α_6	3.27E-15	4.15E-04	4.20E-06	2.39E-03	0.00E+00	1.098E-01	2.643E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9665853	0.9791987	0.9799562	0.9892245	0.9275142	4.096E+02	8.701E+00
α_2	2.03E-03	7.31E-03	6.54E-03	1.52E-02	2.00E-02	3.057E+00	4.152E+02
α_3	1.54E-03	6.33E-03	5.57E-03	1.37E-02	2.50E-02	2.650E+00	4.156E+02
α_4	7.45E-04	4.51E-03	3.75E-03	1.09E-02	1.97E-02	1.886E+00	4.164E+02
α_5	5.77E-05	1.96E-03	1.24E-03	6.29E-03	6.22E-03	8.188E-01	4.175E+02
α_6	1.24E-08	6.08E-04	1.10E-04	2.93E-03	1.54E-03	2.543E-01	4.180E+02
α_7	5.70E-41	8.32E-05	3.09E-12	3.65E-04	0.00E+00	3.480E-02	4.183E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9678796	0.9799349	0.9806528	0.9895326	0.9319073	4.330E+02	8.866E+00
α_2	1.73E-03	6.53E-03	5.81E-03	1.38E-02	1.88E-02	2.887E+00	4.390E+02
α_3	9.48E-04	4.87E-03	4.15E-03	1.13E-02	1.65E-02	2.151E+00	4.397E+02
α_4	7.21E-04	4.31E-03	3.59E-03	1.04E-02	1.83E-02	1.904E+00	4.400E+02
α_5	2.02E-04	2.68E-03	1.97E-03	7.55E-03	1.04E-02	1.183E+00	4.407E+02
α_6	4.85E-06	1.15E-03	5.29E-04	4.38E-03	3.40E-03	5.067E-01	4.414E+02
α_7	6.31E-13	3.15E-04	9.75E-06	1.76E-03	6.78E-04	1.391E-01	4.417E+02
α_8	2.49E-17	2.14E-04	9.08E-07	1.25E-03	0.00E+00	9.469E-02	4.418E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.70E-01	9.64E-01	9.65E-01	9.73E-01	9.75E-01	9.79E-01	9.80E-01
α_2	2.98E-02	3.19E-02	2.30E-02	1.41E-02	9.38E-03	7.31E-03	6.53E-03
α_3		4.30E-03	9.66E-03	9.40E-03	1.01E-02	6.33E-03	4.87E-03
α_4			1.99E-03	2.85E-03	3.73E-03	4.51E-03	4.31E-03
α_5				3.43E-04	1.31E-03	1.96E-03	2.68E-03
α_6					4.15E-04	6.08E-04	1.15E-03
α_7						8.32E-05	3.15E-04
α_8							2.14E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.70E-01	9.64E-01	9.65E-01	9.73E-01	9.75E-01	9.79E-01	9.80E-01
Beta	2.98E-02	3.62E-02	3.46E-02	2.67E-02	2.50E-02	2.08E-02	2.01E-02
Gamma		1.19E-01	3.37E-01	4.72E-01	6.25E-01	6.49E-01	6.74E-01
Delta			1.71E-01	2.53E-01	3.50E-01	5.30E-01	6.40E-01
Epsilon				1.08E-01	3.17E-01	3.70E-01	5.02E-01
Mu					2.40E-01	2.61E-01	3.85E-01
Omega						1.20E-01	3.16E-01

Sigma							4.05E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	10.35	15.53	20.70	25.88	31.05	36.23	41.40
N_1	2.1933	1.6550	1.5891	1.4941	1.5320	1.5704	1.5812
N_2	0.6033	1.6350	1.4268	1.2350	0.7778	0.8139	0.8689
N_3		0.0583	0.7283	1.0593	1.4742	1.0204	0.7610
N_4			0.0014	0.2558	0.3896	0.8034	0.8423
N_5				0.0002	0.1262	0.2534	0.4800
N_6					0.0000	0.0627	0.1570
N_7						0.0000	0.0313
N_8							0.0000

2.10.2 BWR Main Steam Isolation Valves

2.10.2.1 BWR MAIN STEAM ISOLATION VALVES FAIL TO OPEN: BWR-MSS-MSV-CC

Plants/BWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 2.8

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9288356	0.9817561	0.9919839	0.9999449	1.0000000	2.521E+01	4.685E-01
α_2	5.17E-05	1.82E-02	8.01E-03	7.12E-02	0.00E+00	4.685E-01	2.521E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9481491	0.9817785	0.9866535	0.9987411	1.0000000	6.078E+01	1.128E+00
α_2	4.62E-04	1.37E-02	8.98E-03	4.33E-02	0.00E+00	8.512E-01	6.106E+01
α_3	2.24E-07	4.47E-03	9.59E-04	2.10E-02	0.00E+00	2.768E-01	6.163E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9525009	0.9801444	0.9833968	0.9966701	1.0000000	9.348E+01	1.894E+00
α_2	1.14E-03	1.32E-02	9.99E-03	3.63E-02	0.00E+00	1.260E+00	9.411E+01
α_3	4.59E-06	4.22E-03	1.55E-03	1.75E-02	0.00E+00	4.024E-01	9.497E+01
α_4	1.69E-08	2.43E-03	3.62E-04	1.20E-02	0.00E+00	2.315E-01	9.514E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9650383	0.9825841	0.9841882	0.9946453	1.0000000	1.936E+02	3.432E+00
α_2	1.66E-03	9.76E-03	8.16E-03	2.33E-02	0.00E+00	1.924E+00	1.951E+02
α_3	3.08E-04	5.32E-03	3.77E-03	1.56E-02	0.00E+00	1.049E+00	1.960E+02
α_4	1.48E-06	1.94E-03	6.69E-04	8.18E-03	0.00E+00	3.822E-01	1.967E+02
α_5	3.38E-20	3.89E-04	3.63E-07	2.26E-03	0.00E+00	7.674E-02	1.970E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9677664	0.9834598	0.9848279	0.9944712	1.0000000	2.280E+02	3.835E+00

α_2	1.05E-03	7.34E-03	5.98E-03	1.83E-02	0.00E+00	1.701E+00	2.302E+02
α_3	4.11E-04	5.21E-03	3.87E-03	1.46E-02	0.00E+00	1.207E+00	2.306E+02
α_4	2.36E-05	2.57E-03	1.35E-03	9.26E-03	0.00E+00	5.960E-01	2.313E+02
α_5	3.73E-09	9.54E-04	1.28E-04	4.78E-03	0.00E+00	2.211E-01	2.316E+02
α_6	3.73E-15	4.73E-04	4.79E-06	2.73E-03	0.00E+00	1.098E-01	2.317E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733732	0.9848892	0.9857289	0.9935264	1.0000000	3.746E+02	5.747E+00
α_2	1.21E-03	5.90E-03	5.06E-03	1.35E-02	0.00E+00	2.243E+00	3.781E+02
α_3	5.75E-04	4.28E-03	3.45E-03	1.08E-02	0.00E+00	1.630E+00	3.787E+02
α_4	1.77E-04	2.85E-03	2.04E-03	8.28E-03	0.00E+00	1.083E+00	3.793E+02
α_5	1.07E-05	1.49E-03	7.50E-04	5.46E-03	0.00E+00	5.654E-01	3.798E+02
α_6	2.77E-10	5.04E-04	4.65E-05	2.62E-03	0.00E+00	1.916E-01	3.802E+02
α_7	6.27E-41	9.15E-05	3.40E-12	4.01E-04	0.00E+00	3.480E-02	3.803E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9746570	0.9856339	0.9864365	0.9938634	1.0000000	3.928E+02	5.726E+00
α_2	9.13E-04	5.06E-03	4.26E-03	1.20E-02	0.00E+00	2.018E+00	3.965E+02
α_3	3.60E-04	3.49E-03	2.70E-03	9.31E-03	0.00E+00	1.391E+00	3.972E+02
α_4	1.59E-04	2.66E-03	1.89E-03	7.81E-03	0.00E+00	1.062E+00	3.975E+02
α_5	3.11E-05	1.76E-03	1.03E-03	5.99E-03	0.00E+00	7.026E-01	3.978E+02
α_6	3.45E-07	8.78E-04	2.69E-04	3.82E-03	0.00E+00	3.497E-01	3.982E+02
α_7	1.32E-15	2.71E-04	2.48E-06	1.56E-03	0.00E+00	1.078E-01	3.984E+02
α_8	2.77E-17	2.38E-04	1.01E-06	1.38E-03	0.00E+00	9.469E-02	3.985E+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	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.82E-02	1.37E-02	1.32E-02	9.76E-03	7.34E-03	5.90E-03	5.06E-03
α_3		4.47E-03	4.22E-03	5.32E-03	5.21E-03	4.28E-03	3.49E-03
α_4			2.43E-03	1.94E-03	2.57E-03	2.85E-03	2.66E-03
α_5				3.89E-04	9.54E-04	1.49E-03	1.76E-03
α_6					4.73E-04	5.04E-04	8.78E-04
α_7						9.15E-05	2.71E-04
α_8							2.38E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.82E-01	9.82E-01	9.80E-01	9.83E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.82E-02	1.82E-02	1.99E-02	1.74E-02	1.65E-02	1.51E-02	1.44E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	2.80	2.80	2.80	2.80	2.80	2.80	2.80
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

2.10.2.2 BWR MAIN STEAM ISOLATION VALVES FAIL TO CLOSE: BWR-MSS-MSV-OO

Plants/BWR
Systems/Steam
Components/Valve/Main Steam Stop Valve
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 9.2

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9274723	0.9812541	0.9915898	0.9999365	0.9961131	2.507E+01	4.789E-01
α_2	6.01E-05	1.87E-02	8.41E-03	7.25E-02	3.89E-03	4.789E-01	2.507E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9482193	0.9816281	0.9864210	0.9986564	0.9922094	6.193E+01	1.159E+00
α_2	5.21E-04	1.40E-02	9.28E-03	4.35E-02	7.79E-03	8.822E-01	6.221E+01
α_3	2.20E-07	4.39E-03	9.41E-04	2.06E-02	0.00E+00	2.768E-01	6.281E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9526804	0.9800156	0.9831887	0.9965053	0.9882752	9.590E+01	1.956E+00
α_2	1.28E-03	1.35E-02	1.04E-02	3.65E-02	1.17E-02	1.322E+00	9.654E+01
α_3	4.48E-06	4.11E-03	1.51E-03	1.70E-02	1.35E-05	4.025E-01	9.746E+01
α_4	1.64E-08	2.37E-03	3.53E-04	1.17E-02	0.00E+00	2.315E-01	9.763E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9649526	0.9823984	0.9839725	0.9944575	0.9843237	1.973E+02	3.535E+00
α_2	1.84E-03	1.01E-02	8.52E-03	2.37E-02	1.56E-02	2.027E+00	1.988E+02
α_3	3.03E-04	5.22E-03	3.70E-03	1.53E-02	2.71E-05	1.049E+00	1.998E+02
α_4	1.45E-06	1.90E-03	6.56E-04	8.03E-03	0.00E+00	3.822E-01	2.005E+02
α_5	3.32E-20	3.82E-04	3.56E-07	2.22E-03	0.00E+00	7.674E-02	2.008E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9675286	0.9831610	0.9844998	0.9942165	0.9803503	2.329E+02	3.990E+00
α_2	1.27E-03	7.83E-03	6.50E-03	1.90E-02	1.96E-02	1.855E+00	2.351E+02

α_3	4.02E-04	5.10E-03	3.79E-03	1.43E-02	4.54E-05	1.207E+00	2.357E+02
α_4	2.31E-05	2.52E-03	1.32E-03	9.06E-03	0.00E+00	5.960E-01	2.363E+02
α_5	3.65E-09	9.33E-04	1.25E-04	4.68E-03	0.00E+00	2.211E-01	2.367E+02
α_6	3.65E-15	4.63E-04	4.69E-06	2.67E-03	0.00E+00	1.098E-01	2.368E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9730599	0.9845779	0.9854036	0.9932643	0.9763548	3.807E+02	5.964E+00
α_2	1.44E-03	6.36E-03	5.53E-03	1.41E-02	2.36E-02	2.459E+00	3.842E+02
α_3	5.66E-04	4.22E-03	3.40E-03	1.07E-02	6.83E-05	1.630E+00	3.851E+02
α_4	1.74E-04	2.80E-03	2.00E-03	8.15E-03	0.00E+00	1.083E+00	3.856E+02
α_5	1.06E-05	1.46E-03	7.37E-04	5.37E-03	0.00E+00	5.654E-01	3.861E+02
α_6	2.72E-10	4.95E-04	4.58E-05	2.58E-03	0.00E+00	1.916E-01	3.865E+02
α_7	6.16E-41	9.00E-05	3.35E-12	3.95E-04	0.00E+00	3.480E-02	3.867E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741868	0.9851940	0.9859811	0.9935074	0.9723370	4.001E+02	6.014E+00
α_2	1.20E-03	5.68E-03	4.89E-03	1.28E-02	2.76E-02	2.305E+00	4.039E+02
α_3	3.54E-04	3.43E-03	2.65E-03	9.14E-03	9.61E-05	1.392E+00	4.048E+02
α_4	1.56E-04	2.62E-03	1.86E-03	7.66E-03	0.00E+00	1.062E+00	4.051E+02
α_5	3.05E-05	1.73E-03	1.01E-03	5.88E-03	0.00E+00	7.026E-01	4.055E+02
α_6	3.38E-07	8.61E-04	2.64E-04	3.74E-03	0.00E+00	3.497E-01	4.058E+02
α_7	1.30E-15	2.66E-04	2.44E-06	1.53E-03	0.00E+00	1.078E-01	4.060E+02
α_8	2.71E-17	2.33E-04	9.88E-07	1.36E-03	0.00E+00	9.469E-02	4.061E+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	9.82E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.85E-01
α_2	1.87E-02	1.40E-02	1.35E-02	1.01E-02	7.83E-03	6.36E-03	5.68E-03
α_3		4.39E-03	4.11E-03	5.22E-03	5.10E-03	4.22E-03	3.43E-03
α_4			2.37E-03	1.90E-03	2.52E-03	2.80E-03	2.62E-03
α_5				3.82E-04	9.33E-04	1.46E-03	1.73E-03
α_6					4.63E-04	4.95E-04	8.61E-04
α_7						9.00E-05	2.66E-04
α_8							2.33E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.81E-01	9.82E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.85E-01
Beta	1.87E-02	1.84E-02	2.00E-02	1.76E-02	1.68E-02	1.54E-02	1.48E-02
Gamma		2.39E-01	3.24E-01	4.27E-01	5.35E-01	5.88E-01	6.17E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	2.30	3.45	4.60	5.75	6.90	8.05	9.20
N_1	0.3543	0.5004	0.6259	0.7309	0.8154	0.8794	0.9230
N_2	0.0104	0.0310	0.0619	0.1030	0.1543	0.2156	0.2870
N_3		0.0000	0.0001	0.0002	0.0004	0.0006	0.0010
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 GENERATORS FAIL TO START: EPS-EDG-FS

Systems/Electrical/Emergency power supply
Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 153.4

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783559	0.9917164	0.9934749	0.9990540	0.9935233	1.758E+02	1.469E+00
α_2	9.44E-04	8.28E-03	6.52E-03	2.16E-02	6.48E-03	1.469E+00	1.758E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9829993	0.9926672	0.9937659	0.9985853	0.9956729	2.881E+02	2.128E+00
α_2	4.57E-04	4.66E-03	3.58E-03	1.25E-02	2.16E-03	1.351E+00	2.889E+02
α_3	6.69E-05	2.68E-03	1.66E-03	8.76E-03	2.16E-03	7.768E-01	2.894E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9847153	0.9927726	0.9935785	0.9980879	0.9967511	3.975E+02	2.894E+00
α_2	4.48E-04	3.77E-03	2.98E-03	9.78E-03	8.12E-04	1.510E+00	3.989E+02
α_3	8.84E-05	2.25E-03	1.50E-03	7.00E-03	1.62E-03	9.024E-01	3.995E+02
α_4	3.87E-06	1.20E-03	5.30E-04	4.68E-03	8.12E-04	4.815E-01	3.999E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9855869	0.9923421	0.9928990	0.9971860	0.9973992	5.743E+02	4.432E+00
α_2	6.50E-04	3.54E-03	2.99E-03	8.32E-03	3.25E-04	2.049E+00	5.767E+02
α_3	2.65E-04	2.46E-03	1.92E-03	6.51E-03	9.75E-04	1.424E+00	5.773E+02
α_4	3.00E-05	1.31E-03	7.97E-04	4.33E-03	9.75E-04	7.572E-01	5.780E+02
α_5	4.02E-10	3.49E-04	3.70E-05	1.79E-03	3.25E-04	2.017E-01	5.786E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9870951	0.9929954	0.9934630	0.9972884	0.9978317	6.854E+02	4.835E+00

α_2	3.85E-04	2.55E-03	2.09E-03	6.30E-03	1.36E-04	1.764E+00	6.885E+02
α_3	2.36E-04	2.11E-03	1.65E-03	5.55E-03	5.42E-04	1.457E+00	6.888E+02
α_4	6.71E-05	1.41E-03	9.64E-04	4.26E-03	8.13E-04	9.710E-01	6.893E+02
α_5	1.94E-06	6.82E-04	2.94E-04	2.68E-03	5.42E-04	4.711E-01	6.898E+02
α_6	2.60E-11	2.50E-04	1.68E-05	1.33E-03	1.36E-04	1.723E-01	6.901E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9874557	0.9926294	0.9929868	0.9965935	0.9981409	9.087E+02	6.747E+00
α_2	5.15E-04	2.48E-03	2.13E-03	5.66E-03	5.81E-05	2.274E+00	9.132E+02
α_3	2.99E-04	1.95E-03	1.60E-03	4.79E-03	2.90E-04	1.786E+00	9.137E+02
α_4	1.58E-04	1.52E-03	1.18E-03	4.07E-03	5.81E-04	1.395E+00	9.141E+02
α_5	3.48E-05	9.59E-04	6.29E-04	3.01E-03	5.81E-04	8.779E-01	9.146E+02
α_6	1.43E-07	3.80E-04	1.16E-04	1.66E-03	2.90E-04	3.478E-01	9.151E+02
α_7	1.30E-23	7.22E-05	1.79E-08	4.12E-04	5.81E-05	6.605E-02	9.154E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9886568	0.9933433	0.9936628	0.9969288	0.9983729	1.004E+03	6.726E+00
α_2	3.66E-04	2.01E-03	1.70E-03	4.75E-03	2.54E-05	2.034E+00	1.008E+03
α_3	1.69E-04	1.47E-03	1.16E-03	3.84E-03	1.53E-04	1.484E+00	1.009E+03
α_4	1.16E-04	1.28E-03	9.73E-04	3.51E-03	3.81E-04	1.296E+00	1.009E+03
α_5	5.35E-05	1.00E-03	7.01E-04	2.99E-03	5.08E-04	1.015E+00	1.009E+03
α_6	4.84E-06	5.78E-04	2.99E-04	2.10E-03	3.81E-04	5.841E-01	1.010E+03
α_7	2.28E-10	2.00E-04	2.11E-05	1.03E-03	1.53E-04	2.016E-01	1.010E+03
α_8	9.74E-16	1.09E-04	1.13E-06	6.29E-04	2.54E-05	1.103E-01	1.010E+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	9.93E-01	9.93E-01	9.92E-01	9.93E-01	9.93E-01	9.93E-01
α_2	8.28E-03	4.66E-03	3.77E-03	3.54E-03	2.55E-03	2.48E-03	2.01E-03
α_3		2.68E-03	2.25E-03	2.46E-03	2.11E-03	1.95E-03	1.47E-03
α_4			1.20E-03	1.31E-03	1.41E-03	1.52E-03	1.28E-03
α_5				3.49E-04	6.82E-04	9.59E-04	1.00E-03
α_6					2.50E-04	3.80E-04	5.78E-04
α_7						7.22E-05	2.00E-04
α_8							1.09E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.93E-01	9.93E-01	9.92E-01	9.93E-01	9.93E-01	9.93E-01
Beta	8.28E-03	7.33E-03	7.23E-03	7.66E-03	7.00E-03	7.37E-03	6.66E-03
Gamma		3.65E-01	4.78E-01	5.38E-01	6.35E-01	6.63E-01	6.98E-01
Delta			3.48E-01	4.02E-01	5.26E-01	6.01E-01	6.84E-01
Epsilon				2.10E-01	3.99E-01	4.81E-01	5.96E-01
Mu					2.68E-01	3.20E-01	4.69E-01

Omega						1.60E-01	3.48E-01
Sigma							3.54E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	153.40	230.10	306.80	383.50	460.20	536.90	613.60
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

2.11.1.2 EMERGENCY DIESEL GENERATORS FAIL TO LOAD RUN: EPS-EDG-LR

Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Load and-or Run
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 181.6

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9804798	0.9944434	0.9969387	0.9999293	0.9981649	1.140E+02	6.369E-01
α_2	6.76E-05	5.56E-03	3.06E-03	1.95E-02	1.84E-03	6.369E-01	1.140E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9790312	0.9916873	0.9932894	0.9988802	0.9963231	1.948E+02	1.633E+00
α_2	6.84E-04	6.90E-03	5.32E-03	1.85E-02	3.68E-03	1.356E+00	1.951E+02
α_3	7.00E-08	1.41E-03	3.00E-04	6.61E-03	0.00E+00	2.768E-01	1.962E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9777499	0.9894552	0.9906135	0.9971904	0.9944745	2.725E+02	2.904E+00
α_2	1.71E-03	8.24E-03	7.09E-03	1.87E-02	5.53E-03	2.270E+00	2.731E+02
α_3	1.58E-06	1.46E-03	5.35E-04	6.06E-03	0.00E+00	4.024E-01	2.750E+02
α_4	5.81E-09	8.41E-04	1.25E-04	4.16E-03	0.00E+00	2.315E-01	2.751E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9802166	0.9894719	0.9902363	0.9961192	0.9955484	4.181E+02	4.448E+00
α_2	1.48E-03	6.17E-03	5.41E-03	1.35E-02	2.99E-03	2.607E+00	4.199E+02
α_3	3.35E-04	3.27E-03	2.53E-03	8.75E-03	1.46E-03	1.383E+00	4.211E+02
α_4	6.87E-07	9.05E-04	3.11E-04	3.82E-03	0.00E+00	3.822E-01	4.221E+02
α_5	1.58E-20	1.82E-04	1.69E-07	1.05E-03	0.00E+00	7.674E-02	4.224E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9822395	0.9903364	0.9909817	0.9962437	0.9962611	4.979E+02	4.858E+00
α_2	8.47E-04	4.31E-03	3.68E-03	9.95E-03	1.71E-03	2.168E+00	5.006E+02
α_3	4.50E-04	3.29E-03	2.66E-03	8.28E-03	1.63E-03	1.652E+00	5.011E+02
α_4	2.54E-05	1.41E-03	8.25E-04	4.77E-03	4.06E-04	7.071E-01	5.020E+02
α_5	1.72E-09	4.40E-04	5.87E-05	2.21E-03	0.00E+00	2.211E-01	5.025E+02

α_6	1.72E-15	2.18E-04	2.21E-06	1.26E-03	0.00E+00	1.098E-01	5.026E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9834630	0.9902693	0.9907378	0.9954878	0.9967671	6.899E+02	6.779E+00
α_2	8.71E-04	3.69E-03	3.23E-03	8.09E-03	1.02E-03	2.570E+00	6.941E+02
α_3	5.55E-04	2.98E-03	2.52E-03	6.98E-03	1.40E-03	2.076E+00	6.946E+02
α_4	1.72E-04	1.87E-03	1.42E-03	5.11E-03	6.96E-04	1.305E+00	6.954E+02
α_5	8.29E-06	8.65E-04	4.57E-04	3.11E-03	1.16E-04	6.024E-01	6.961E+02
α_6	1.51E-10	2.75E-04	2.54E-05	1.43E-03	0.00E+00	1.916E-01	6.965E+02
α_7	3.42E-41	5.00E-05	1.86E-12	2.19E-04	0.00E+00	3.480E-02	6.966E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9848649	0.9911000	0.9915243	0.9958784	0.9971441	7.535E+02	6.767E+00
α_2	6.09E-04	2.96E-03	2.54E-03	6.77E-03	6.48E-04	2.254E+00	7.580E+02
α_3	3.61E-04	2.35E-03	1.93E-03	5.78E-03	1.09E-03	1.788E+00	7.585E+02
α_4	1.77E-04	1.79E-03	1.37E-03	4.81E-03	8.13E-04	1.358E+00	7.589E+02
α_5	2.90E-05	1.05E-03	6.62E-04	3.42E-03	2.71E-04	8.014E-01	7.595E+02
α_6	2.44E-07	4.76E-04	1.53E-04	2.05E-03	3.39E-05	3.621E-01	7.599E+02
α_7	6.93E-16	1.42E-04	1.30E-06	8.19E-04	0.00E+00	1.078E-01	7.602E+02
α_8	1.45E-17	1.25E-04	5.27E-07	7.25E-04	0.00E+00	9.469E-02	7.602E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.92E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.91E-01
α_2	5.56E-03	6.90E-03	8.24E-03	6.17E-03	4.31E-03	3.69E-03	2.96E-03
α_3		1.41E-03	1.46E-03	3.27E-03	3.29E-03	2.98E-03	2.35E-03
α_4			8.41E-04	9.05E-04	1.41E-03	1.87E-03	1.79E-03
α_5				1.82E-04	4.40E-04	8.65E-04	1.05E-03
α_6					2.18E-04	2.75E-04	4.76E-04
α_7						5.00E-05	1.42E-04
α_8							1.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.92E-01	9.89E-01	9.89E-01	9.90E-01	9.90E-01	9.91E-01
Beta	5.56E-03	8.31E-03	1.05E-02	1.05E-02	9.66E-03	9.73E-03	8.90E-03
Gamma		1.70E-01	2.18E-01	4.14E-01	5.54E-01	6.21E-01	6.67E-01
Delta			3.65E-01	2.49E-01	3.86E-01	5.07E-01	6.04E-01
Epsilon				1.67E-01	3.19E-01	3.88E-01	5.01E-01
Mu					3.32E-01	2.73E-01	4.13E-01
Omega						1.54E-01	3.59E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	90.80	136.20	181.60	227.00	272.40	317.80	363.20
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

2.11.1.3 EMERGENCY DIESEL GENERATORS FAIL TO RUN: EPS-EDG-FR

Systems/Electrical/Emergency power supply
Components/Emergency Power/Generator/Emergency Diesel Generator
Failure Modes/Fail to Run
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 181.6

Total Number of Common-Cause Failure Events: 3

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9667472	0.9862465	0.9885732	0.9977766	0.9876264	1.325E+02	1.848E+00
α_2	2.23E-03	1.38E-02	1.14E-02	3.32E-02	1.24E-02	1.848E+00	1.325E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9705371	0.9855576	0.9869717	0.9957530	0.9872090	2.220E+02	3.253E+00
α_2	2.50E-03	1.10E-02	9.55E-03	2.43E-02	9.74E-03	2.470E+00	2.228E+02
α_3	8.93E-05	3.48E-03	2.16E-03	1.13E-02	3.05E-03	7.832E-01	2.245E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748188	0.9868493	0.9878732	0.9953857	0.9899123	3.092E+02	4.121E+00
α_2	1.42E-03	7.06E-03	6.05E-03	1.62E-02	4.32E-03	2.214E+00	3.111E+02
α_3	4.90E-04	4.55E-03	3.55E-03	1.20E-02	4.63E-03	1.425E+00	3.119E+02
α_4	5.00E-06	1.54E-03	6.79E-04	5.99E-03	1.14E-03	4.823E-01	3.129E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783404	0.9877019	0.9883897	0.9947283	0.9914891	4.639E+02	5.776E+00
α_2	1.31E-03	5.52E-03	4.83E-03	1.21E-02	2.42E-03	2.591E+00	4.671E+02
α_3	7.35E-04	4.20E-03	3.52E-03	9.99E-03	3.35E-03	1.973E+00	4.677E+02
α_4	1.14E-04	2.15E-03	1.50E-03	6.42E-03	2.28E-03	1.011E+00	4.687E+02
α_5	4.99E-10	4.30E-04	4.57E-05	2.21E-03	4.54E-04	2.018E-01	4.695E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9805690	0.9887547	0.9893304	0.9949677	0.9925704	5.528E+02	6.287E+00
α_2	8.17E-04	4.01E-03	3.43E-03	9.16E-03	1.63E-03	2.240E+00	5.568E+02
α_3	5.81E-04	3.44E-03	2.86E-03	8.24E-03	2.16E-03	1.921E+00	5.571E+02
α_4	2.40E-04	2.43E-03	1.87E-03	6.53E-03	2.31E-03	1.357E+00	5.577E+02

α_5	9.82E-06	1.07E-03	5.60E-04	3.85E-03	1.14E-03	5.968E-01	5.584E+02
α_6	3.22E-11	3.08E-04	2.07E-05	1.65E-03	1.89E-04	1.723E-01	5.589E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9822788	0.9890998	0.9895269	0.9944697	0.9933436	7.538E+02	8.307E+00
α_2	9.03E-04	3.59E-03	3.17E-03	7.73E-03	1.29E-03	2.739E+00	7.594E+02
α_3	5.58E-04	2.84E-03	2.42E-03	6.57E-03	1.40E-03	2.167E+00	7.599E+02
α_4	3.63E-04	2.35E-03	1.94E-03	5.78E-03	1.85E-03	1.794E+00	7.603E+02
α_5	1.01E-04	1.48E-03	1.08E-03	4.25E-03	1.47E-03	1.130E+00	7.610E+02
α_6	6.63E-07	5.39E-04	2.01E-04	2.22E-03	5.69E-04	4.105E-01	7.617E+02
α_7	1.56E-23	8.67E-05	2.15E-08	4.95E-04	8.13E-05	6.605E-02	7.620E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9836866	0.9899496	0.9903405	0.9948815	0.9939306	8.265E+02	8.391E+00
α_2	6.91E-04	3.00E-03	2.62E-03	6.63E-03	1.11E-03	2.506E+00	8.324E+02
α_3	3.41E-04	2.18E-03	1.79E-03	5.32E-03	9.70E-04	1.817E+00	8.330E+02
α_4	2.70E-04	1.98E-03	1.60E-03	4.98E-03	1.34E-03	1.650E+00	8.332E+02
α_5	1.53E-04	1.60E-03	1.22E-03	4.33E-03	1.44E-03	1.333E+00	8.335E+02
α_6	1.89E-05	8.87E-04	5.34E-04	2.96E-03	8.91E-04	7.409E-01	8.341E+02
α_7	2.07E-09	2.79E-04	4.19E-05	1.38E-03	2.85E-04	2.329E-01	8.346E+02
α_8	1.18E-15	1.32E-04	1.37E-06	7.61E-04	3.56E-05	1.103E-01	8.348E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.86E-01	9.86E-01	9.87E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01
α_2	1.38E-02	1.10E-02	7.06E-03	5.52E-03	4.01E-03	3.59E-03	3.00E-03
α_3		3.48E-03	4.55E-03	4.20E-03	3.44E-03	2.84E-03	2.18E-03
α_4			1.54E-03	2.15E-03	2.43E-03	2.35E-03	1.98E-03
α_5				4.30E-04	1.07E-03	1.48E-03	1.60E-03
α_6					3.08E-04	5.39E-04	8.87E-04
α_7						8.67E-05	2.79E-04
α_8							1.32E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.86E-01	9.87E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01
Beta	1.38E-02	1.44E-02	1.32E-02	1.23E-02	1.12E-02	1.09E-02	1.01E-02
Gamma		2.41E-01	4.63E-01	5.51E-01	6.44E-01	6.70E-01	7.01E-01
Delta			2.53E-01	3.81E-01	5.25E-01	6.11E-01	6.91E-01
Epsilon				1.66E-01	3.62E-01	4.72E-01	5.94E-01
Mu					2.24E-01	2.97E-01	4.48E-01
Omega						1.39E-01	3.17E-01
Sigma							3.21E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	108.96	163.44	217.92	272.40	326.88	381.36	435.84
N_1	1.1347	0.5832	0.6415	0.6561	0.6580	0.6415	0.6127
N_2	1.3793	1.6188	0.9541	0.6666	0.5390	0.4956	0.4881
N_3		0.5064	1.0223	0.9236	0.7135	0.5380	0.4261
N_4			0.2508	0.6286	0.7610	0.7112	0.5883
N_5				0.1251	0.3757	0.5649	0.6309
N_6					0.0625	0.2189	0.3911
N_7						0.0313	0.1250
N_8							0.0156

2.12 Vacuum Breakers

2.12.1 BWR Pressure Suppression Vacuum Breakers

2.12.1.1 CONTAINMENT VACUUM BREAKERS FAIL TO OPEN: CVR-VAC-CC

Systems/Atmosphere/Vapor suppression
Components/Valve/Vacuum Breaker
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 6.2

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9370942	0.9838891	0.9929464	0.9999513	1.0000000	2.861E+01	4.685E-01
α_2	4.55E-05	1.61E-02	7.06E-03	6.29E-02	0.00E+00	4.685E-01	2.861E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9508244	0.9827271	0.9873505	0.9988086	1.0000000	6.418E+01	1.128E+00
α_2	4.37E-04	1.30E-02	8.51E-03	4.11E-02	0.00E+00	8.512E-01	6.446E+01
α_3	2.12E-07	4.24E-03	9.09E-04	1.99E-02	0.00E+00	2.768E-01	6.503E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9541217	0.9808279	0.9839723	0.9967863	1.0000000	9.688E+01	1.894E+00
α_2	1.10E-03	1.28E-02	9.65E-03	3.50E-02	0.00E+00	1.260E+00	9.751E+01
α_3	4.43E-06	4.07E-03	1.50E-03	1.69E-02	0.00E+00	4.024E-01	9.837E+01
α_4	1.63E-08	2.34E-03	3.50E-04	1.16E-02	0.00E+00	2.315E-01	9.854E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9656276	0.9828795	0.9844573	0.9947371	1.0000000	1.970E+02	3.432E+00
α_2	1.63E-03	9.60E-03	8.02E-03	2.29E-02	0.00E+00	1.924E+00	1.985E+02
α_3	3.03E-04	5.23E-03	3.71E-03	1.54E-02	0.00E+00	1.049E+00	1.994E+02
α_4	1.45E-06	1.91E-03	6.57E-04	8.04E-03	0.00E+00	3.822E-01	2.001E+02
α_5	3.32E-20	3.83E-04	3.57E-07	2.22E-03	0.00E+00	7.674E-02	2.004E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682297	0.9836988	0.9850477	0.9945513	1.0000000	2.314E+02	3.835E+00

α_2	1.04E-03	7.23E-03	5.89E-03	1.80E-02	0.00E+00	1.701E+00	2.336E+02
α_3	4.05E-04	5.13E-03	3.81E-03	1.44E-02	0.00E+00	1.207E+00	2.340E+02
α_4	2.32E-05	2.53E-03	1.33E-03	9.13E-03	0.00E+00	5.960E-01	2.347E+02
α_5	3.68E-09	9.40E-04	1.26E-04	4.71E-03	0.00E+00	2.211E-01	2.350E+02
α_6	3.67E-15	4.67E-04	4.72E-06	2.69E-03	0.00E+00	1.098E-01	2.351E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736123	0.9850231	0.9858556	0.9935842	1.0000000	3.780E+02	5.747E+00
α_2	1.20E-03	5.85E-03	5.01E-03	1.33E-02	0.00E+00	2.243E+00	3.815E+02
α_3	5.70E-04	4.25E-03	3.42E-03	1.07E-02	0.00E+00	1.630E+00	3.821E+02
α_4	1.76E-04	2.82E-03	2.02E-03	8.21E-03	0.00E+00	1.083E+00	3.827E+02
α_5	1.06E-05	1.47E-03	7.43E-04	5.41E-03	0.00E+00	5.654E-01	3.832E+02
α_6	2.74E-10	4.99E-04	4.61E-05	2.60E-03	0.00E+00	1.916E-01	3.836E+02
α_7	6.21E-41	9.07E-05	3.37E-12	3.98E-04	0.00E+00	3.480E-02	3.837E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748702	0.9857554	0.9865514	0.9939105	1.0000000	3.962E+02	5.726E+00
α_2	9.05E-04	5.02E-03	4.23E-03	1.18E-02	0.00E+00	2.018E+00	3.999E+02
α_3	3.57E-04	3.46E-03	2.68E-03	9.23E-03	0.00E+00	1.391E+00	4.006E+02
α_4	1.57E-04	2.64E-03	1.88E-03	7.74E-03	0.00E+00	1.062E+00	4.009E+02
α_5	3.08E-05	1.75E-03	1.02E-03	5.94E-03	0.00E+00	7.026E-01	4.012E+02
α_6	3.42E-07	8.70E-04	2.67E-04	3.78E-03	0.00E+00	3.497E-01	4.016E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.018E+02
α_8	2.74E-17	2.36E-04	9.98E-07	1.37E-03	0.00E+00	9.469E-02	4.019E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.61E-02	1.30E-02	1.28E-02	9.60E-03	7.23E-03	5.85E-03	5.02E-03
α_3		4.24E-03	4.07E-03	5.23E-03	5.13E-03	4.25E-03	3.46E-03
α_4			2.34E-03	1.91E-03	2.53E-03	2.82E-03	2.64E-03
α_5				3.83E-04	9.40E-04	1.47E-03	1.75E-03
α_6					4.67E-04	4.99E-04	8.70E-04
α_7						9.07E-05	2.68E-04
α_8							2.36E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.61E-02	1.73E-02	1.92E-02	1.71E-02	1.63E-02	1.50E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	6.20	6.20	6.20	6.20	6.20	6.20	6.20
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 AC Power Distribution Breakers

2.13.1 480 V Circuit Breakers

2.13.1.1 480 V CIRCUIT BREAKERS FAIL TO OPEN: ACP-CRB-480-CC

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Fail to Open
Date Range: 2006 through 2020

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	0.9504557	0.9873307	0.9944788	0.9999616	1.0000000	3.651E+01	4.685E-01
α_2	3.56E-05	1.27E-02	5.52E-03	4.95E-02	0.00E+00	4.685E-01	3.651E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9560895	0.9845911	0.9887281	0.9989349	1.0000000	7.208E+01	1.128E+00
α_2	3.90E-04	1.16E-02	7.58E-03	3.67E-02	0.00E+00	8.512E-01	7.236E+01
α_3	1.89E-07	3.78E-03	8.10E-04	1.77E-02	0.00E+00	2.768E-01	7.293E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9574921	0.9822478	0.9851667	0.9970272	1.0000000	1.048E+02	1.894E+00
α_2	1.02E-03	1.18E-02	8.93E-03	3.25E-02	0.00E+00	1.260E+00	1.054E+02
α_3	4.10E-06	3.77E-03	1.39E-03	1.56E-02	0.00E+00	4.024E-01	1.063E+02
α_4	1.51E-08	2.17E-03	3.24E-04	1.07E-02	0.00E+00	2.315E-01	1.064E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9669229	0.9835286	0.9850484	0.9949386	1.0000000	2.049E+02	3.432E+00
α_2	1.57E-03	9.23E-03	7.72E-03	2.21E-02	0.00E+00	1.924E+00	2.064E+02
α_3	2.91E-04	5.03E-03	3.57E-03	1.48E-02	0.00E+00	1.049E+00	2.073E+02
α_4	1.39E-06	1.83E-03	6.32E-04	7.74E-03	0.00E+00	3.822E-01	2.080E+02
α_5	3.20E-20	3.68E-04	3.43E-07	2.14E-03	0.00E+00	7.674E-02	2.083E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9692563	0.9842285	0.9855349	0.9947346	1.0000000	2.393E+02	3.835E+00

α_2	1.00E-03	7.00E-03	5.70E-03	1.74E-02	0.00E+00	1.701E+00	2.415E+02
α_3	3.92E-04	4.96E-03	3.69E-03	1.39E-02	0.00E+00	1.207E+00	2.419E+02
α_4	2.25E-05	2.45E-03	1.29E-03	8.83E-03	0.00E+00	5.960E-01	2.426E+02
α_5	3.56E-09	9.09E-04	1.22E-04	4.56E-03	0.00E+00	2.211E-01	2.429E+02
α_6	3.55E-15	4.51E-04	4.57E-06	2.60E-03	0.00E+00	1.098E-01	2.430E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9741382	0.9853252	0.9861414	0.9937192	1.0000000	3.859E+02	5.747E+00
α_2	1.17E-03	5.73E-03	4.91E-03	1.31E-02	0.00E+00	2.243E+00	3.894E+02
α_3	5.58E-04	4.16E-03	3.35E-03	1.05E-02	0.00E+00	1.630E+00	3.900E+02
α_4	1.72E-04	2.76E-03	1.98E-03	8.04E-03	0.00E+00	1.083E+00	3.906E+02
α_5	1.04E-05	1.44E-03	7.28E-04	5.30E-03	0.00E+00	5.654E-01	3.911E+02
α_6	2.69E-10	4.89E-04	4.52E-05	2.55E-03	0.00E+00	1.916E-01	3.915E+02
α_7	6.09E-41	8.89E-05	3.31E-12	3.90E-04	0.00E+00	3.480E-02	3.916E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753524	0.9860300	0.9868111	0.9940334	1.0000000	4.041E+02	5.726E+00
α_2	8.88E-04	4.92E-03	4.15E-03	1.16E-02	0.00E+00	2.018E+00	4.078E+02
α_3	3.50E-04	3.39E-03	2.63E-03	9.05E-03	0.00E+00	1.391E+00	4.085E+02
α_4	1.54E-04	2.59E-03	1.84E-03	7.59E-03	0.00E+00	1.062E+00	4.088E+02
α_5	3.03E-05	1.71E-03	1.00E-03	5.82E-03	0.00E+00	7.026E-01	4.091E+02
α_6	3.35E-07	8.53E-04	2.62E-04	3.71E-03	0.00E+00	3.497E-01	4.095E+02
α_7	1.29E-15	2.63E-04	2.41E-06	1.52E-03	0.00E+00	1.078E-01	4.097E+02
α_8	2.69E-17	2.31E-04	9.79E-07	1.35E-03	0.00E+00	9.469E-02	4.098E+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	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.27E-02	1.16E-02	1.18E-02	9.23E-03	7.00E-03	5.73E-03	4.92E-03
α_3		3.78E-03	3.77E-03	5.03E-03	4.96E-03	4.16E-03	3.39E-03
α_4			2.17E-03	1.83E-03	2.45E-03	2.76E-03	2.59E-03
α_5				3.68E-04	9.09E-04	1.44E-03	1.71E-03
α_6					4.51E-04	4.89E-04	8.53E-04
α_7						8.89E-05	2.63E-04
α_8							2.31E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.85E-01	9.82E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.27E-02	1.54E-02	1.78E-02	1.65E-02	1.58E-02	1.47E-02	1.40E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	14.10	14.10	14.10	14.10	14.10	14.10	14.10
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

2.13.1.2 480 V CIRCUIT BREAKERS FAIL TO CLOSE: ACP-CRB-480-OO

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 Volt
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 20.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9577302	0.9891998	0.9953022	0.9999672	1.0000000	4.291E+01	4.685E-01
α_2	3.03E-05	1.08E-02	4.70E-03	4.23E-02	0.00E+00	4.685E-01	4.291E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9595996	0.9858299	0.9896420	0.9990212	1.0000000	7.848E+01	1.128E+00
α_2	3.58E-04	1.07E-02	6.97E-03	3.37E-02	0.00E+00	8.512E-01	7.876E+01
α_3	1.74E-07	3.48E-03	7.44E-04	1.63E-02	0.00E+00	2.768E-01	7.933E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9598799	0.9832526	0.9860112	0.9971974	1.0000000	1.112E+02	1.894E+00
α_2	9.63E-04	1.11E-02	8.42E-03	3.06E-02	0.00E+00	1.260E+00	1.118E+02
α_3	3.87E-06	3.56E-03	1.31E-03	1.47E-02	0.00E+00	4.024E-01	1.127E+02
α_4	1.42E-08	2.05E-03	3.05E-04	1.01E-02	0.00E+00	2.315E-01	1.128E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9679029	0.9840194	0.9854953	0.9950907	1.0000000	2.113E+02	3.432E+00
α_2	1.52E-03	8.96E-03	7.49E-03	2.14E-02	0.00E+00	1.924E+00	2.128E+02
α_3	2.83E-04	4.88E-03	3.46E-03	1.44E-02	0.00E+00	1.049E+00	2.137E+02
α_4	1.35E-06	1.78E-03	6.13E-04	7.51E-03	0.00E+00	3.822E-01	2.144E+02
α_5	3.10E-20	3.57E-04	3.33E-07	2.08E-03	0.00E+00	7.674E-02	2.147E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9700404	0.9846329	0.9859068	0.9948707	1.0000000	2.457E+02	3.835E+00
α_2	9.77E-04	6.82E-03	5.55E-03	1.70E-02	0.00E+00	1.701E+00	2.479E+02
α_3	3.82E-04	4.84E-03	3.59E-03	1.35E-02	0.00E+00	1.207E+00	2.483E+02
α_4	2.19E-05	2.39E-03	1.25E-03	8.60E-03	0.00E+00	5.960E-01	2.490E+02

α_5	3.47E-09	8.86E-04	1.18E-04	4.44E-03	0.00E+00	2.211E-01	2.493E+02
α_6	3.46E-15	4.40E-04	4.45E-06	2.54E-03	0.00E+00	1.098E-01	2.494E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9745568	0.9855611	0.9863646	0.9938201	1.0000000	3.923E+02	5.747E+00
α_2	1.15E-03	5.64E-03	4.83E-03	1.29E-02	0.00E+00	2.243E+00	3.958E+02
α_3	5.49E-04	4.09E-03	3.30E-03	1.04E-02	0.00E+00	1.630E+00	3.964E+02
α_4	1.69E-04	2.72E-03	1.95E-03	7.91E-03	0.00E+00	1.083E+00	3.970E+02
α_5	1.03E-05	1.42E-03	7.16E-04	5.22E-03	0.00E+00	5.654E-01	3.975E+02
α_6	2.64E-10	4.81E-04	4.45E-05	2.51E-03	0.00E+00	1.916E-01	3.979E+02
α_7	5.99E-41	8.74E-05	3.25E-12	3.83E-04	0.00E+00	3.480E-02	3.980E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9757301	0.9862448	0.9870143	0.9941272	1.0000000	4.105E+02	5.726E+00
α_2	8.74E-04	4.85E-03	4.08E-03	1.14E-02	0.00E+00	2.018E+00	4.142E+02
α_3	3.45E-04	3.34E-03	2.59E-03	8.91E-03	0.00E+00	1.391E+00	4.149E+02
α_4	1.52E-04	2.55E-03	1.81E-03	7.47E-03	0.00E+00	1.062E+00	4.152E+02
α_5	2.98E-05	1.69E-03	9.86E-04	5.73E-03	0.00E+00	7.026E-01	4.155E+02
α_6	3.30E-07	8.40E-04	2.58E-04	3.65E-03	0.00E+00	3.497E-01	4.159E+02
α_7	1.27E-15	2.59E-04	2.38E-06	1.50E-03	0.00E+00	1.078E-01	4.161E+02
α_8	2.65E-17	2.27E-04	9.64E-07	1.32E-03	0.00E+00	9.469E-02	4.162E+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	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.08E-02	1.07E-02	1.11E-02	8.96E-03	6.82E-03	5.64E-03	4.85E-03
α_3		3.48E-03	3.56E-03	4.88E-03	4.84E-03	4.09E-03	3.34E-03
α_4			2.05E-03	1.78E-03	2.39E-03	2.72E-03	2.55E-03
α_5				3.57E-04	8.86E-04	1.42E-03	1.69E-03
α_6					4.40E-04	4.81E-04	8.40E-04
α_7						8.74E-05	2.59E-04
α_8							2.27E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.89E-01	9.86E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.08E-02	1.42E-02	1.67E-02	1.60E-02	1.54E-02	1.44E-02	1.38E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	20.50	20.50	20.50	20.50	20.50	20.50	20.50
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

2.13.1.3 480 V CIRCUIT BREAKERS SPURIOUS ACTUATION: ACP-CRB-480-SA

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: 2006 through 2020

Total Number of Independent Failure Events: 39.0

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9485562	0.9853014	0.9918316	0.9998174	0.9918033	4.258E+01	6.352E-01
α_2	1.79E-04	1.47E-02	8.17E-03	5.14E-02	8.20E-03	6.352E-01	4.258E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9542031	0.9817805	0.9852383	0.9975352	0.9834711	8.773E+01	1.628E+00
α_2	1.50E-03	1.51E-02	1.17E-02	4.05E-02	1.65E-02	1.351E+00	8.801E+01
α_3	1.55E-07	3.10E-03	6.62E-04	1.45E-02	0.00E+00	2.768E-01	8.908E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9541066	0.9781728	0.9805351	0.9941740	0.9750000	1.297E+02	2.894E+00
α_2	3.54E-03	1.70E-02	1.47E-02	3.86E-02	2.50E-02	2.260E+00	1.303E+02
α_3	3.30E-06	3.04E-03	1.11E-03	1.26E-02	0.00E+00	4.024E-01	1.322E+02
α_4	1.21E-08	1.75E-03	2.60E-04	8.65E-03	0.00E+00	2.315E-01	1.323E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9659263	0.9818370	0.9831353	0.9932992	0.9798995	2.396E+02	4.432E+00
α_2	2.54E-03	1.06E-02	9.31E-03	2.32E-02	1.34E-02	2.591E+00	2.414E+02
α_3	5.80E-04	5.66E-03	4.38E-03	1.51E-02	6.70E-03	1.382E+00	2.426E+02
α_4	1.19E-06	1.57E-03	5.40E-04	6.61E-03	0.00E+00	3.822E-01	2.436E+02
α_5	2.73E-20	3.14E-04	2.93E-07	1.83E-03	0.00E+00	7.674E-02	2.439E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9692314	0.9832443	0.9843462	0.9934811	0.9831933	2.837E+02	4.835E+00
α_2	1.45E-03	7.44E-03	6.33E-03	1.72E-02	7.47E-03	2.146E+00	2.864E+02

α_3	7.84E-04	5.72E-03	4.63E-03	1.44E-02	7.47E-03	1.651E+00	2.869E+02
α_4	4.43E-05	2.45E-03	1.44E-03	8.30E-03	1.87E-03	7.071E-01	2.878E+02
α_5	3.00E-09	7.66E-04	1.02E-04	3.84E-03	0.00E+00	2.211E-01	2.883E+02
α_6	2.99E-15	3.80E-04	3.85E-06	2.19E-03	0.00E+00	1.098E-01	2.884E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743522	0.9848984	0.9856139	0.9929984	0.9855596	4.401E+02	6.747E+00
α_2	1.33E-03	5.68E-03	4.97E-03	1.25E-02	4.28E-03	2.539E+00	4.443E+02
α_3	8.65E-04	4.64E-03	3.93E-03	1.09E-02	6.42E-03	2.074E+00	4.447E+02
α_4	2.68E-04	2.92E-03	2.22E-03	7.96E-03	3.21E-03	1.305E+00	4.455E+02
α_5	1.29E-05	1.35E-03	7.12E-04	4.84E-03	5.35E-04	6.024E-01	4.462E+02
α_6	2.35E-10	4.29E-04	3.96E-05	2.23E-03	0.00E+00	1.916E-01	4.466E+02
α_7	5.33E-41	7.79E-05	2.90E-12	3.42E-04	0.00E+00	3.480E-02	4.468E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9759172	0.9858333	0.9865080	0.9934401	0.9873418	4.680E+02	6.726E+00
α_2	9.40E-04	4.67E-03	3.99E-03	1.07E-02	2.50E-03	2.216E+00	4.725E+02
α_3	5.76E-04	3.76E-03	3.09E-03	9.24E-03	5.00E-03	1.786E+00	4.730E+02
α_4	2.83E-04	2.86E-03	2.20E-03	7.70E-03	3.75E-03	1.358E+00	4.734E+02
α_5	4.65E-05	1.69E-03	1.06E-03	5.47E-03	1.25E-03	8.014E-01	4.739E+02
α_6	3.90E-07	7.63E-04	2.45E-04	3.28E-03	1.56E-04	3.621E-01	4.744E+02
α_7	1.11E-15	2.27E-04	2.08E-06	1.31E-03	0.00E+00	1.078E-01	4.746E+02
α_8	2.32E-17	1.99E-04	8.45E-07	1.16E-03	0.00E+00	9.469E-02	4.747E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.85E-01	9.82E-01	9.78E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
α_2	1.47E-02	1.51E-02	1.70E-02	1.06E-02	7.44E-03	5.68E-03	4.67E-03
α_3		3.10E-03	3.04E-03	5.66E-03	5.72E-03	4.64E-03	3.76E-03
α_4			1.75E-03	1.57E-03	2.45E-03	2.92E-03	2.86E-03
α_5				3.14E-04	7.66E-04	1.35E-03	1.69E-03
α_6					3.80E-04	4.29E-04	7.63E-04
α_7						7.79E-05	2.27E-04
α_8							1.99E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.85E-01	9.82E-01	9.78E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
Beta	1.47E-02	1.82E-02	2.18E-02	1.82E-02	1.68E-02	1.51E-02	1.42E-02
Gamma		1.70E-01	2.19E-01	4.15E-01	5.56E-01	6.24E-01	6.71E-01
Delta			3.65E-01	2.49E-01	3.86E-01	5.07E-01	6.04E-01
Epsilon				1.67E-01	3.19E-01	3.88E-01	5.01E-01
Mu					3.32E-01	2.73E-01	4.13E-01
Omega						1.54E-01	3.59E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	19.50	29.25	39.00	48.75	58.50	68.25	78.00
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 V CIRCUIT BREAKERS FAIL TO OPEN/CLOSE: ACP-CRB-480-FTOC

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/480 V
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 35.6

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9686118	0.9919884	0.9965319	0.9999755	1.0000000	5.801E+01	4.685E-01
α_2	2.24E-05	8.01E-03	3.47E-03	3.14E-02	0.00E+00	4.685E-01	5.801E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9660014	0.9880892	0.9913095	0.9991781	1.0000000	9.358E+01	1.128E+00
α_2	3.00E-04	8.99E-03	5.85E-03	2.84E-02	0.00E+00	8.512E-01	9.386E+01
α_3	1.46E-07	2.92E-03	6.25E-04	1.37E-02	0.00E+00	2.768E-01	9.443E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9645788	0.9852257	0.9876676	0.9975309	1.0000000	1.263E+02	1.894E+00
α_2	8.48E-04	9.83E-03	7.42E-03	2.70E-02	0.00E+00	1.260E+00	1.269E+02
α_3	3.41E-06	3.14E-03	1.15E-03	1.30E-02	0.00E+00	4.024E-01	1.278E+02
α_4	1.25E-08	1.81E-03	2.69E-04	8.94E-03	0.00E+00	2.315E-01	1.279E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9699995	0.9850692	0.9864554	0.9954156	1.0000000	2.264E+02	3.432E+00
α_2	1.42E-03	8.37E-03	6.99E-03	2.00E-02	0.00E+00	1.924E+00	2.279E+02
α_3	2.64E-04	4.56E-03	3.23E-03	1.34E-02	0.00E+00	1.049E+00	2.288E+02
α_4	1.26E-06	1.66E-03	5.73E-04	7.01E-03	0.00E+00	3.822E-01	2.295E+02
α_5	2.90E-20	3.34E-04	3.11E-07	1.94E-03	0.00E+00	7.674E-02	2.298E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9717366	0.9855097	0.9867176	0.9951654	1.0000000	2.608E+02	3.835E+00

α_2	9.21E-04	6.43E-03	5.23E-03	1.60E-02	0.00E+00	1.701E+00	2.630E+02
α_3	3.60E-04	4.56E-03	3.39E-03	1.28E-02	0.00E+00	1.207E+00	2.634E+02
α_4	2.06E-05	2.25E-03	1.18E-03	8.11E-03	0.00E+00	5.960E-01	2.641E+02
α_5	3.27E-09	8.35E-04	1.12E-04	4.19E-03	0.00E+00	2.211E-01	2.644E+02
α_6	3.26E-15	4.15E-04	4.20E-06	2.39E-03	0.00E+00	1.098E-01	2.645E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9754778	0.9860888	0.9868639	0.9940420	1.0000000	4.074E+02	5.747E+00
α_2	1.11E-03	5.43E-03	4.65E-03	1.24E-02	0.00E+00	2.243E+00	4.109E+02
α_3	5.29E-04	3.94E-03	3.18E-03	9.98E-03	0.00E+00	1.630E+00	4.115E+02
α_4	1.63E-04	2.62E-03	1.88E-03	7.63E-03	0.00E+00	1.083E+00	4.121E+02
α_5	9.89E-06	1.37E-03	6.90E-04	5.03E-03	0.00E+00	5.654E-01	4.126E+02
α_6	2.55E-10	4.64E-04	4.28E-05	2.42E-03	0.00E+00	1.916E-01	4.130E+02
α_7	5.77E-41	8.42E-05	3.13E-12	3.69E-04	0.00E+00	3.480E-02	4.131E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9765750	0.9867263	0.9874744	0.9943286	1.0000000	4.256E+02	5.726E+00
α_2	8.43E-04	4.68E-03	3.94E-03	1.10E-02	0.00E+00	2.018E+00	4.293E+02
α_3	3.33E-04	3.22E-03	2.50E-03	8.60E-03	0.00E+00	1.391E+00	4.300E+02
α_4	1.46E-04	2.46E-03	1.75E-03	7.21E-03	0.00E+00	1.062E+00	4.303E+02
α_5	2.87E-05	1.63E-03	9.52E-04	5.53E-03	0.00E+00	7.026E-01	4.306E+02
α_6	3.18E-07	8.11E-04	2.49E-04	3.53E-03	0.00E+00	3.497E-01	4.310E+02
α_7	1.22E-15	2.50E-04	2.29E-06	1.44E-03	0.00E+00	1.078E-01	4.312E+02
α_8	2.55E-17	2.20E-04	9.30E-07	1.28E-03	0.00E+00	9.469E-02	4.313E+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	9.88E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
α_2	8.01E-03	8.99E-03	9.83E-03	8.37E-03	6.43E-03	5.43E-03	4.68E-03
α_3		2.92E-03	3.14E-03	4.56E-03	4.56E-03	3.94E-03	3.22E-03
α_4			1.81E-03	1.66E-03	2.25E-03	2.62E-03	2.46E-03
α_5				3.34E-04	8.35E-04	1.37E-03	1.63E-03
α_6					4.15E-04	4.64E-04	8.11E-04
α_7						8.42E-05	2.50E-04
α_8							2.20E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.88E-01	9.85E-01	9.85E-01	9.86E-01	9.86E-01	9.87E-01
Beta	8.01E-03	1.19E-02	1.48E-02	1.49E-02	1.45E-02	1.39E-02	1.33E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	35.60	35.60	35.60	35.60	35.60	35.60	35.60
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

2.13.2 4160 V and 6.9 kV Circuit Breakers

2.13.2.1 ACP 4160 V AND 6.9 kV CIRCUIT BREAKERS FAIL TO OPEN: ACP-CRB-4160-CC

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 6.5

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9377318	0.9840536	0.9930199	0.9999518	1.0000000	2.891E+01	4.685E-01
α_2	4.51E-05	1.59E-02	6.98E-03	6.23E-02	0.00E+00	4.685E-01	2.891E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9510473	0.9828061	0.9874090	0.9988142	1.0000000	6.448E+01	1.128E+00
α_2	4.35E-04	1.30E-02	8.47E-03	4.09E-02	0.00E+00	8.512E-01	6.476E+01
α_3	2.11E-07	4.22E-03	9.04E-04	1.98E-02	0.00E+00	2.768E-01	6.533E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9542594	0.9808860	0.9840211	0.9967962	1.0000000	9.718E+01	1.894E+00
α_2	1.10E-03	1.27E-02	9.62E-03	3.49E-02	0.00E+00	1.260E+00	9.781E+01
α_3	4.42E-06	4.06E-03	1.49E-03	1.68E-02	0.00E+00	4.024E-01	9.867E+01
α_4	1.62E-08	2.34E-03	3.48E-04	1.16E-02	0.00E+00	2.315E-01	9.884E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9656786	0.9829051	0.9844806	0.9947450	1.0000000	1.973E+02	3.432E+00
α_2	1.63E-03	9.58E-03	8.01E-03	2.29E-02	0.00E+00	1.924E+00	1.988E+02
α_3	3.03E-04	5.22E-03	3.70E-03	1.54E-02	0.00E+00	1.049E+00	1.997E+02
α_4	1.45E-06	1.90E-03	6.56E-04	8.03E-03	0.00E+00	3.822E-01	2.004E+02
α_5	3.32E-20	3.82E-04	3.56E-07	2.22E-03	0.00E+00	7.674E-02	2.007E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682699	0.9837196	0.9850668	0.9945583	1.0000000	2.317E+02	3.835E+00
α_2	1.04E-03	7.22E-03	5.88E-03	1.80E-02	0.00E+00	1.701E+00	2.339E+02
α_3	4.04E-04	5.12E-03	3.81E-03	1.43E-02	0.00E+00	1.207E+00	2.343E+02
α_4	2.32E-05	2.53E-03	1.33E-03	9.12E-03	0.00E+00	5.960E-01	2.350E+02
α_5	3.68E-09	9.39E-04	1.26E-04	4.71E-03	0.00E+00	2.211E-01	2.353E+02
α_6	3.67E-15	4.66E-04	4.72E-06	2.69E-03	0.00E+00	1.098E-01	2.354E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736327	0.9850348	0.9858667	0.9935893	1.0000000	3.783E+02	5.747E+00
α_2	1.19E-03	5.84E-03	5.01E-03	1.33E-02	0.00E+00	2.243E+00	3.818E+02
α_3	5.69E-04	4.24E-03	3.42E-03	1.07E-02	0.00E+00	1.630E+00	3.824E+02
α_4	1.75E-04	2.82E-03	2.02E-03	8.20E-03	0.00E+00	1.083E+00	3.830E+02
α_5	1.06E-05	1.47E-03	7.42E-04	5.41E-03	0.00E+00	5.654E-01	3.835E+02
α_6	2.74E-10	4.99E-04	4.61E-05	2.60E-03	0.00E+00	1.916E-01	3.839E+02
α_7	6.21E-41	9.06E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.840E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9748888	0.9857660	0.9865615	0.9939151	1.0000000	3.965E+02	5.726E+00
α_2	9.05E-04	5.02E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.002E+02
α_3	3.57E-04	3.46E-03	2.68E-03	9.22E-03	0.00E+00	1.391E+00	4.009E+02
α_4	1.57E-04	2.64E-03	1.88E-03	7.73E-03	0.00E+00	1.062E+00	4.012E+02
α_5	3.08E-05	1.75E-03	1.02E-03	5.93E-03	0.00E+00	7.026E-01	4.015E+02
α_6	3.41E-07	8.69E-04	2.67E-04	3.78E-03	0.00E+00	3.497E-01	4.019E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.021E+02
α_8	2.74E-17	2.35E-04	9.97E-07	1.37E-03	0.00E+00	9.469E-02	4.022E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.59E-02	1.30E-02	1.27E-02	9.58E-03	7.22E-03	5.84E-03	5.02E-03
α_3		4.22E-03	4.06E-03	5.22E-03	5.12E-03	4.24E-03	3.46E-03
α_4			2.34E-03	1.90E-03	2.53E-03	2.82E-03	2.64E-03
α_5				3.82E-04	9.39E-04	1.47E-03	1.75E-03
α_6					4.66E-04	4.99E-04	8.69E-04
α_7						9.06E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.59E-02	1.72E-02	1.91E-02	1.71E-02	1.63E-02	1.50E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

2.13.2.2 ACP 4160 V AND 6.9 kV CIRCUIT BREAKERS FAIL TO CLOSE: ACP-CRB-4160-OO

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 Volt
Failure Modes/Fail to Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 57.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9770006	0.9941347	0.9974700	0.9999820	1.0000000	7.941E+01	4.685E-01
α_2	1.63E-05	5.87E-03	2.53E-03	2.30E-02	0.00E+00	4.685E-01	7.941E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9722379	0.9902845	0.9929156	0.9993303	1.0000000	1.150E+02	1.128E+00
α_2	2.45E-04	7.33E-03	4.76E-03	2.32E-02	0.00E+00	8.512E-01	1.153E+02
α_3	1.19E-07	2.38E-03	5.09E-04	1.12E-02	0.00E+00	2.768E-01	1.158E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9696138	0.9873395	0.9894362	0.9978821	1.0000000	1.477E+02	1.894E+00
α_2	7.26E-04	8.42E-03	6.36E-03	2.32E-02	0.00E+00	1.260E+00	1.483E+02
α_3	2.92E-06	2.69E-03	9.87E-04	1.11E-02	0.00E+00	4.024E-01	1.492E+02
α_4	1.07E-08	1.55E-03	2.30E-04	7.66E-03	0.00E+00	2.315E-01	1.493E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9725370	0.9863408	0.9876117	0.9958037	1.0000000	2.478E+02	3.432E+00
α_2	1.30E-03	7.66E-03	6.40E-03	1.83E-02	0.00E+00	1.924E+00	2.493E+02
α_3	2.42E-04	4.17E-03	2.96E-03	1.23E-02	0.00E+00	1.049E+00	2.502E+02
α_4	1.16E-06	1.52E-03	5.24E-04	6.42E-03	0.00E+00	3.822E-01	2.509E+02
α_5	2.65E-20	3.05E-04	2.84E-07	1.77E-03	0.00E+00	7.674E-02	2.512E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738410	0.9865937	0.9877133	0.9955251	1.0000000	2.822E+02	3.835E+00
α_2	8.52E-04	5.95E-03	4.84E-03	1.48E-02	0.00E+00	1.701E+00	2.844E+02
α_3	3.33E-04	4.22E-03	3.14E-03	1.18E-02	0.00E+00	1.207E+00	2.848E+02

α_4	1.91E-05	2.08E-03	1.09E-03	7.51E-03	0.00E+00	5.960E-01	2.855E+02
α_5	3.03E-09	7.73E-04	1.03E-04	3.88E-03	0.00E+00	2.211E-01	2.858E+02
α_6	3.02E-15	3.84E-04	3.88E-06	2.21E-03	0.00E+00	1.098E-01	2.859E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9766861	0.9867739	0.9875166	0.9943377	1.0000000	4.288E+02	5.747E+00
α_2	1.06E-03	5.16E-03	4.43E-03	1.18E-02	0.00E+00	2.243E+00	4.323E+02
α_3	5.03E-04	3.75E-03	3.02E-03	9.49E-03	0.00E+00	1.630E+00	4.329E+02
α_4	1.55E-04	2.49E-03	1.78E-03	7.25E-03	0.00E+00	1.083E+00	4.335E+02
α_5	9.40E-06	1.30E-03	6.56E-04	4.78E-03	0.00E+00	5.654E-01	4.340E+02
α_6	2.42E-10	4.41E-04	4.07E-05	2.30E-03	0.00E+00	1.916E-01	4.344E+02
α_7	5.49E-41	8.01E-05	2.98E-12	3.51E-04	0.00E+00	3.480E-02	4.345E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9776776	0.9873537	0.9880669	0.9945975	1.0000000	4.470E+02	5.726E+00
α_2	8.03E-04	4.46E-03	3.75E-03	1.05E-02	0.00E+00	2.018E+00	4.507E+02
α_3	3.17E-04	3.07E-03	2.38E-03	8.20E-03	0.00E+00	1.391E+00	4.514E+02
α_4	1.40E-04	2.35E-03	1.67E-03	6.87E-03	0.00E+00	1.062E+00	4.517E+02
α_5	2.74E-05	1.55E-03	9.07E-04	5.27E-03	0.00E+00	7.026E-01	4.520E+02
α_6	3.03E-07	7.72E-04	2.37E-04	3.36E-03	0.00E+00	3.497E-01	4.524E+02
α_7	1.16E-15	2.38E-04	2.19E-06	1.38E-03	0.00E+00	1.078E-01	4.526E+02
α_8	2.43E-17	2.09E-04	8.86E-07	1.22E-03	0.00E+00	9.469E-02	4.527E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
α_2	5.87E-03	7.33E-03	8.42E-03	7.66E-03	5.95E-03	5.16E-03	4.46E-03
α_3		2.38E-03	2.69E-03	4.17E-03	4.22E-03	3.75E-03	3.07E-03
α_4			1.55E-03	1.52E-03	2.08E-03	2.49E-03	2.35E-03
α_5				3.05E-04	7.73E-04	1.30E-03	1.55E-03
α_6					3.84E-04	4.41E-04	7.72E-04
α_7						8.01E-05	2.38E-04
α_8							2.09E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.94E-01	9.90E-01	9.87E-01	9.86E-01	9.87E-01	9.87E-01	9.87E-01
Beta	5.87E-03	9.72E-03	1.27E-02	1.37E-02	1.34E-02	1.32E-02	1.26E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	57.00	57.00	57.00	57.00	57.00	57.00	57.00
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

2.13.2.3 ACP 4160 V AND 6.9 kV CIRCUIT BREAKERS SPURIOUS OPERATION: ACP-CRB-4160-SA

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: 2006 through 2020

Total Number of Independent Failure Events: 23.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9600232	0.9897883	0.9955650	0.9999689	1.0000000	4.541E+01	4.685E-01
α_2	2.86E-05	1.02E-02	4.44E-03	4.00E-02	0.00E+00	4.685E-01	4.541E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9608201	0.9862613	0.9899600	0.9990512	1.0000000	8.098E+01	1.128E+00
α_2	3.47E-04	1.04E-02	6.75E-03	3.27E-02	0.00E+00	8.512E-01	8.126E+01
α_3	1.68E-07	3.37E-03	7.21E-04	1.58E-02	0.00E+00	2.768E-01	8.183E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9607461	0.9836149	0.9863155	0.9972587	1.0000000	1.137E+02	1.894E+00
α_2	9.42E-04	1.09E-02	8.24E-03	3.00E-02	0.00E+00	1.260E+00	1.143E+02
α_3	3.78E-06	3.48E-03	1.28E-03	1.44E-02	0.00E+00	4.024E-01	1.152E+02
α_4	1.39E-08	2.00E-03	2.98E-04	9.92E-03	0.00E+00	2.315E-01	1.153E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9682701	0.9842033	0.9856676	0.9951477	1.0000000	2.138E+02	3.432E+00
α_2	1.51E-03	8.86E-03	7.40E-03	2.12E-02	0.00E+00	1.924E+00	2.153E+02
α_3	2.79E-04	4.83E-03	3.42E-03	1.42E-02	0.00E+00	1.049E+00	2.162E+02
α_4	1.34E-06	1.76E-03	6.06E-04	7.42E-03	0.00E+00	3.822E-01	2.169E+02
α_5	3.07E-20	3.53E-04	3.29E-07	2.05E-03	0.00E+00	7.674E-02	2.172E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9703359	0.9847853	0.9860470	0.9949220	1.0000000	2.482E+02	3.835E+00

α_2	9.67E-04	6.75E-03	5.50E-03	1.68E-02	0.00E+00	1.701E+00	2.504E+02
α_3	3.78E-04	4.79E-03	3.56E-03	1.34E-02	0.00E+00	1.207E+00	2.508E+02
α_4	2.17E-05	2.36E-03	1.24E-03	8.52E-03	0.00E+00	5.960E-01	2.515E+02
α_5	3.43E-09	8.77E-04	1.17E-04	4.40E-03	0.00E+00	2.211E-01	2.518E+02
α_6	3.43E-15	4.36E-04	4.41E-06	2.51E-03	0.00E+00	1.098E-01	2.519E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9747100	0.9856512	0.9864499	0.9938586	1.0000000	3.948E+02	5.747E+00
α_2	1.15E-03	5.60E-03	4.80E-03	1.28E-02	0.00E+00	2.243E+00	3.983E+02
α_3	5.46E-04	4.07E-03	3.28E-03	1.03E-02	0.00E+00	1.630E+00	3.989E+02
α_4	1.68E-04	2.70E-03	1.93E-03	7.86E-03	0.00E+00	1.083E+00	3.995E+02
α_5	1.02E-05	1.41E-03	7.12E-04	5.19E-03	0.00E+00	5.654E-01	4.000E+02
α_6	2.63E-10	4.78E-04	4.42E-05	2.49E-03	0.00E+00	1.916E-01	4.004E+02
α_7	5.95E-41	8.69E-05	3.23E-12	3.81E-04	0.00E+00	3.480E-02	4.005E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9758792	0.9863269	0.9870919	0.9941562	1.0000000	4.130E+02	5.726E+00
α_2	8.69E-04	4.82E-03	4.06E-03	1.14E-02	0.00E+00	2.018E+00	4.167E+02
α_3	3.43E-04	3.32E-03	2.57E-03	8.86E-03	0.00E+00	1.391E+00	4.174E+02
α_4	1.51E-04	2.54E-03	1.80E-03	7.43E-03	0.00E+00	1.062E+00	4.177E+02
α_5	2.96E-05	1.68E-03	9.80E-04	5.70E-03	0.00E+00	7.026E-01	4.180E+02
α_6	3.28E-07	8.35E-04	2.56E-04	3.63E-03	0.00E+00	3.497E-01	4.184E+02
α_7	1.26E-15	2.58E-04	2.36E-06	1.49E-03	0.00E+00	1.078E-01	4.186E+02
α_8	2.63E-17	2.26E-04	9.58E-07	1.32E-03	0.00E+00	9.469E-02	4.187E+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	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
α_2	1.02E-02	1.04E-02	1.09E-02	8.86E-03	6.75E-03	5.60E-03	4.82E-03
α_3		3.37E-03	3.48E-03	4.83E-03	4.79E-03	4.07E-03	3.32E-03
α_4			2.00E-03	1.76E-03	2.36E-03	2.70E-03	2.54E-03
α_5				3.53E-04	8.77E-04	1.41E-03	1.68E-03
α_6					4.36E-04	4.78E-04	8.35E-04
α_7						8.69E-05	2.58E-04
α_8							2.26E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.90E-01	9.86E-01	9.84E-01	9.84E-01	9.85E-01	9.86E-01	9.86E-01
Beta	1.02E-02	1.37E-02	1.64E-02	1.58E-02	1.52E-02	1.43E-02	1.37E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	23.00	23.00	23.00	23.00	23.00	23.00	23.00
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

2.13.2.4 ACP 4160 V AND 6.9 kV CIRCUIT BREAKERS FAIL TO OPEN/CLOSE: ACP-CRB-4160-FTOC

Systems/Electrical/Plant ac power
Components/Electrical/Circuit Breaker/4160 - 6900 V
Failure Modes/Fail to Close
Failure Modes/Fail to Open
Failure Modes/Fail to Open and-or Close
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 70.0

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9802074	0.9949556	0.9978268	0.9999845	1.0000000	9.241E+01	4.685E-01
α_2	1.40E-05	5.04E-03	2.18E-03	1.98E-02	0.00E+00	4.685E-01	9.241E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9750172	0.9912628	0.9936331	0.9993980	1.0000000	1.280E+02	1.128E+00
α_2	2.20E-04	6.59E-03	4.28E-03	2.08E-02	0.00E+00	8.512E-01	1.283E+02
α_3	1.07E-07	2.14E-03	4.57E-04	1.01E-02	0.00E+00	2.768E-01	1.288E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9720346	0.9883519	0.9902889	0.9980531	1.0000000	1.607E+02	1.894E+00
α_2	6.68E-04	7.75E-03	5.85E-03	2.13E-02	0.00E+00	1.260E+00	1.613E+02
α_3	2.68E-06	2.48E-03	9.08E-04	1.03E-02	0.00E+00	4.024E-01	1.622E+02
α_4	9.86E-09	1.42E-03	2.12E-04	7.05E-03	0.00E+00	2.315E-01	1.623E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9738815	0.9870127	0.9882224	0.9960120	1.0000000	2.608E+02	3.432E+00
α_2	1.24E-03	7.28E-03	6.08E-03	1.74E-02	0.00E+00	1.924E+00	2.623E+02
α_3	2.30E-04	3.97E-03	2.81E-03	1.17E-02	0.00E+00	1.049E+00	2.632E+02
α_4	1.10E-06	1.45E-03	4.98E-04	6.10E-03	0.00E+00	3.822E-01	2.639E+02
α_5	2.52E-20	2.90E-04	2.70E-07	1.69E-03	0.00E+00	7.674E-02	2.642E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749725	0.9871765	0.9882483	0.9957264	1.0000000	2.952E+02	3.835E+00

α_2	8.15E-04	5.69E-03	4.63E-03	1.42E-02	0.00E+00	1.701E+00	2.974E+02
α_3	3.18E-04	4.04E-03	3.00E-03	1.13E-02	0.00E+00	1.207E+00	2.978E+02
α_4	1.83E-05	1.99E-03	1.05E-03	7.18E-03	0.00E+00	5.960E-01	2.985E+02
α_5	2.89E-09	7.39E-04	9.88E-05	3.71E-03	0.00E+00	2.211E-01	2.988E+02
α_6	2.89E-15	3.67E-04	3.71E-06	2.12E-03	0.00E+00	1.098E-01	2.989E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9773604	0.9871581	0.9878795	0.9945025	1.0000000	4.418E+02	5.747E+00
α_2	1.02E-03	5.01E-03	4.30E-03	1.14E-02	0.00E+00	2.243E+00	4.453E+02
α_3	4.88E-04	3.64E-03	2.93E-03	9.21E-03	0.00E+00	1.630E+00	4.459E+02
α_4	1.51E-04	2.42E-03	1.73E-03	7.04E-03	0.00E+00	1.083E+00	4.465E+02
α_5	9.13E-06	1.26E-03	6.37E-04	4.64E-03	0.00E+00	5.654E-01	4.470E+02
α_6	2.35E-10	4.28E-04	3.95E-05	2.23E-03	0.00E+00	1.916E-01	4.474E+02
α_7	5.33E-41	7.78E-05	2.89E-12	3.41E-04	0.00E+00	3.480E-02	4.475E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9783039	0.9877067	0.9884002	0.9947545	1.0000000	4.600E+02	5.726E+00
α_2	7.81E-04	4.33E-03	3.65E-03	1.02E-02	0.00E+00	2.018E+00	4.637E+02
α_3	3.08E-04	2.99E-03	2.31E-03	7.97E-03	0.00E+00	1.391E+00	4.644E+02
α_4	1.36E-04	2.28E-03	1.62E-03	6.68E-03	0.00E+00	1.062E+00	4.647E+02
α_5	2.66E-05	1.51E-03	8.81E-04	5.12E-03	0.00E+00	7.026E-01	4.650E+02
α_6	2.95E-07	7.51E-04	2.30E-04	3.27E-03	0.00E+00	3.497E-01	4.654E+02
α_7	1.13E-15	2.32E-04	2.12E-06	1.34E-03	0.00E+00	1.078E-01	4.656E+02
α_8	2.37E-17	2.03E-04	8.61E-07	1.18E-03	0.00E+00	9.469E-02	4.657E+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	9.88E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
α_2	5.04E-03	6.59E-03	7.75E-03	7.28E-03	5.69E-03	5.01E-03	4.33E-03
α_3		2.14E-03	2.48E-03	3.97E-03	4.04E-03	3.64E-03	2.99E-03
α_4			1.42E-03	1.45E-03	1.99E-03	2.42E-03	2.28E-03
α_5				2.90E-04	7.39E-04	1.26E-03	1.51E-03
α_6					3.67E-04	4.28E-04	7.51E-04
α_7						7.78E-05	2.32E-04
α_8							2.03E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.95E-01	9.91E-01	9.88E-01	9.87E-01	9.87E-01	9.87E-01	9.88E-01
Beta	5.04E-03	8.74E-03	1.16E-02	1.30E-02	1.28E-02	1.28E-02	1.23E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	70.00	70.00	70.00	70.00	70.00	70.00	70.00
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 DC Power System - Batteries, Chargers, and Breakers

2.14.1 Batteries

2.14.1.1 DC POWER BATTERIES FAIL TO OPERATE: DCP-BAT-LP

Systems/Electrical/dc power
Components/Electrical/Battery
Failure Modes/Fail to Operate
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 24.8

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9458996	0.9857247	0.9932728	0.9999338	0.9967596	3.523E+01	5.102E-01
α_2	6.37E-05	1.43E-02	6.73E-03	5.41E-02	3.24E-03	5.102E-01	3.523E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9560571	0.9840035	0.9878966	0.9986279	0.9934980	7.708E+01	1.253E+00
α_2	6.09E-04	1.25E-02	8.63E-03	3.74E-02	6.50E-03	9.762E-01	7.736E+01
α_3	1.76E-07	3.53E-03	7.56E-04	1.66E-02	0.00E+00	2.768E-01	7.806E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9582089	0.9818521	0.9844987	0.9964531	0.9902153	1.160E+02	2.144E+00
α_2	1.53E-03	1.28E-02	1.02E-02	3.30E-02	9.78E-03	1.510E+00	1.166E+02
α_3	3.70E-06	3.41E-03	1.25E-03	1.41E-02	0.00E+00	4.024E-01	1.177E+02
α_4	1.36E-08	1.96E-03	2.92E-04	9.71E-03	0.00E+00	2.315E-01	1.179E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9673909	0.9833477	0.9847498	0.9945062	0.9895356	2.224E+02	3.766E+00
α_2	1.98E-03	9.80E-03	8.40E-03	2.24E-02	9.16E-03	2.216E+00	2.239E+02
α_3	3.06E-04	4.82E-03	3.46E-03	1.40E-02	1.31E-03	1.091E+00	2.250E+02
α_4	1.28E-06	1.69E-03	5.82E-04	7.13E-03	0.00E+00	3.822E-01	2.257E+02
α_5	2.95E-20	3.39E-04	3.16E-07	1.97E-03	0.00E+00	7.674E-02	2.260E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9697930	0.9840751	0.9852652	0.9942900	0.9889846	2.629E+02	4.255E+00

α_2	1.38E-03	7.60E-03	6.41E-03	1.79E-02	8.65E-03	2.031E+00	2.652E+02
α_3	4.35E-04	4.83E-03	3.66E-03	1.32E-02	2.18E-03	1.290E+00	2.659E+02
α_4	2.17E-05	2.26E-03	1.19E-03	8.10E-03	1.82E-04	6.029E-01	2.666E+02
α_5	3.24E-09	8.27E-04	1.11E-04	4.15E-03	0.00E+00	2.211E-01	2.670E+02
α_6	3.23E-15	4.11E-04	4.16E-06	2.37E-03	0.00E+00	1.098E-01	2.671E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9743865	0.9851780	0.9859357	0.9933711	0.9885858	4.157E+02	6.254E+00
α_2	1.48E-03	6.17E-03	5.41E-03	1.35E-02	8.14E-03	2.605E+00	4.194E+02
α_3	6.21E-04	4.16E-03	3.40E-03	1.03E-02	2.80E-03	1.754E+00	4.202E+02
α_4	1.69E-04	2.61E-03	1.88E-03	7.55E-03	4.43E-04	1.103E+00	4.209E+02
α_5	9.79E-06	1.34E-03	6.78E-04	4.93E-03	2.61E-05	5.665E-01	4.214E+02
α_6	2.49E-10	4.54E-04	4.19E-05	2.37E-03	0.00E+00	1.916E-01	4.218E+02
α_7	5.65E-41	8.25E-05	3.07E-12	3.62E-04	0.00E+00	3.480E-02	4.219E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9755979	0.9858499	0.9865671	0.9936471	0.9883304	4.401E+02	6.317E+00
α_2	1.19E-03	5.38E-03	4.67E-03	1.20E-02	7.61E-03	2.404E+00	4.440E+02
α_3	4.34E-04	3.48E-03	2.77E-03	8.95E-03	3.24E-03	1.554E+00	4.449E+02
α_4	1.58E-04	2.46E-03	1.77E-03	7.13E-03	7.33E-04	1.099E+00	4.453E+02
α_5	2.86E-05	1.58E-03	9.28E-04	5.37E-03	8.37E-05	7.068E-01	4.457E+02
α_6	3.09E-07	7.84E-04	2.41E-04	3.41E-03	3.81E-06	3.499E-01	4.461E+02
α_7	1.18E-15	2.42E-04	2.22E-06	1.40E-03	0.00E+00	1.078E-01	4.463E+02
α_8	2.47E-17	2.12E-04	8.98E-07	1.24E-03	0.00E+00	9.469E-02	4.463E+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	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.43E-02	1.25E-02	1.28E-02	9.80E-03	7.60E-03	6.17E-03	5.38E-03
α_3		3.53E-03	3.41E-03	4.82E-03	4.83E-03	4.16E-03	3.48E-03
α_4			1.96E-03	1.69E-03	2.26E-03	2.61E-03	2.46E-03
α_5				3.39E-04	8.27E-04	1.34E-03	1.58E-03
α_6					4.11E-04	4.54E-04	7.84E-04
α_7						8.25E-05	2.42E-04
α_8							2.12E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.86E-01	9.84E-01	9.82E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.43E-02	1.60E-02	1.81E-02	1.67E-02	1.59E-02	1.48E-02	1.42E-02
Gamma		2.21E-01	2.96E-01	4.12E-01	5.23E-01	5.84E-01	6.19E-01
Delta			3.65E-01	2.96E-01	4.20E-01	5.19E-01	6.03E-01
Epsilon				1.67E-01	3.54E-01	4.18E-01	5.34E-01
Mu					3.32E-01	2.86E-01	4.39E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	12.40	18.60	24.80	31.00	37.20	43.40	49.60
N_1	0.4167	0.5000	0.5000	0.5208	0.5208	0.5064	0.4823
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 CHARGERS LOSS OF FUNCTION: DCP-BCH-LP

Systems/Electrical/dc power
Components/Electrical/Battery Charger
Failure Modes/Fail to Operate
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 164.6

Total Number of Common-Cause Failure Events: 2

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9733688	0.9917241	0.9947523	0.9997666	0.9954555	9.689E+01	8.085E-01
α_2	2.36E-04	8.28E-03	5.25E-03	2.66E-02	4.54E-03	8.085E-01	9.689E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9709901	0.9874252	0.9892697	0.9975451	0.9908695	1.687E+02	2.148E+00
α_2	1.80E-03	1.10E-02	9.11E-03	2.64E-02	9.13E-03	1.871E+00	1.689E+02
α_3	8.06E-08	1.62E-03	3.45E-04	7.60E-03	0.00E+00	2.768E-01	1.705E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744258	0.9878361	0.9891545	0.9967256	0.9930016	2.382E+02	2.934E+00
α_2	1.16E-03	7.46E-03	6.15E-03	1.82E-02	3.63E-03	1.800E+00	2.394E+02
α_3	1.47E-04	3.74E-03	2.49E-03	1.16E-02	3.36E-03	9.024E-01	2.403E+02
α_4	6.64E-09	9.60E-04	1.43E-04	4.75E-03	0.00E+00	2.315E-01	2.409E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9778176	0.9881535	0.9889966	0.9955989	0.9942494	3.753E+02	4.499E+00
α_2	1.21E-03	5.90E-03	5.06E-03	1.35E-02	1.71E-03	2.241E+00	3.775E+02
α_3	5.06E-04	4.08E-03	3.25E-03	1.05E-02	2.70E-03	1.549E+00	3.782E+02
α_4	1.96E-05	1.66E-03	9.10E-04	5.87E-03	1.35E-03	6.322E-01	3.791E+02
α_5	1.75E-20	2.02E-04	1.88E-07	1.17E-03	0.00E+00	7.674E-02	3.797E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9799896	0.9890680	0.9897792	0.9957044	0.9950532	4.465E+02	4.935E+00
α_2	7.25E-04	4.27E-03	3.56E-03	1.02E-02	1.01E-03	1.926E+00	4.495E+02
α_3	4.49E-04	3.50E-03	2.80E-03	8.95E-03	1.69E-03	1.582E+00	4.498E+02

α_4	1.03E-04	2.15E-03	1.48E-03	6.50E-03	1.69E-03	9.710E-01	4.505E+02
α_5	2.77E-07	7.67E-04	2.32E-04	3.35E-03	5.62E-04	3.461E-01	4.511E+02
α_6	1.91E-15	2.43E-04	2.46E-06	1.40E-03	0.00E+00	1.098E-01	4.513E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9817013	0.9891905	0.9896964	0.9949506	0.9956179	6.299E+02	6.883E+00
α_2	8.58E-04	3.83E-03	3.33E-03	8.53E-03	7.58E-04	2.440E+00	6.343E+02
α_3	4.86E-04	2.95E-03	2.45E-03	7.14E-03	9.72E-04	1.882E+00	6.349E+02
α_4	2.56E-04	2.29E-03	1.79E-03	6.01E-03	1.45E-03	1.458E+00	6.353E+02
α_5	3.73E-05	1.28E-03	8.11E-04	4.12E-03	9.64E-04	8.154E-01	6.360E+02
α_6	8.06E-09	3.99E-04	7.21E-05	1.92E-03	2.41E-04	2.541E-01	6.365E+02
α_7	3.74E-41	5.47E-05	2.03E-12	2.40E-04	0.00E+00	3.480E-02	6.368E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9831134	0.9900228	0.9904936	0.9953337	0.9960245	6.849E+02	6.903E+00
α_2	6.49E-04	3.21E-03	2.75E-03	7.36E-03	6.88E-04	2.222E+00	6.896E+02
α_3	2.78E-04	2.24E-03	1.78E-03	5.77E-03	5.43E-04	1.551E+00	6.903E+02
α_4	2.01E-04	1.99E-03	1.53E-03	5.33E-03	1.06E-03	1.375E+00	6.905E+02
α_5	7.82E-05	1.47E-03	1.02E-03	4.37E-03	1.06E-03	1.015E+00	6.908E+02
α_6	3.06E-06	7.31E-04	3.37E-04	2.80E-03	5.28E-04	5.060E-01	6.913E+02
α_7	4.00E-13	2.01E-04	6.22E-06	1.12E-03	1.06E-04	1.391E-01	6.917E+02
α_8	1.59E-17	1.37E-04	5.79E-07	7.97E-04	0.00E+00	9.469E-02	6.918E+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	9.87E-01	9.88E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01
α_2	8.28E-03	1.10E-02	7.46E-03	5.90E-03	4.27E-03	3.83E-03	3.21E-03
α_3		1.62E-03	3.74E-03	4.08E-03	3.50E-03	2.95E-03	2.24E-03
α_4			9.60E-04	1.66E-03	2.15E-03	2.29E-03	1.99E-03
α_5				2.02E-04	7.67E-04	1.28E-03	1.47E-03
α_6					2.43E-04	3.99E-04	7.31E-04
α_7						5.47E-05	2.01E-04
α_8							1.37E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.92E-01	9.87E-01	9.88E-01	9.88E-01	9.89E-01	9.89E-01	9.90E-01
Beta	8.28E-03	1.26E-02	1.22E-02	1.18E-02	1.09E-02	1.08E-02	9.98E-03
Gamma		1.29E-01	3.87E-01	5.02E-01	6.10E-01	6.46E-01	6.78E-01
Delta			2.04E-01	3.14E-01	4.74E-01	5.77E-01	6.69E-01
Epsilon				1.08E-01	3.19E-01	4.31E-01	5.61E-01
Mu					2.41E-01	2.62E-01	4.22E-01
Omega						1.20E-01	3.16E-01
Sigma							4.05E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	73.16	109.73	146.31	182.89	219.47	256.04	292.62
N_1	1.3200	0.9600	1.2533	1.5333	1.8000	2.0580	2.3050
N_2	0.3400	1.0200	0.5400	0.3167	0.2250	0.1965	0.2037
N_3		0.0000	0.5000	0.5000	0.3750	0.2520	0.1609
N_4			0.0000	0.2500	0.3750	0.3750	0.3125
N_5				0.0000	0.1250	0.2500	0.3125
N_6					0.0000	0.0625	0.1563
N_7						0.0000	0.0313
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: RPS-RTB-CC

Systems/Electrical/Reactor protection
Components/Electrical/Circuit Breaker/Reactor Trip Breaker
Failure Modes/Fail to Open
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 7.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9389691	0.9843727	0.9931626	0.9999527	1.0000000	2.951E+01	4.685E-01
α_2	4.41E-05	1.56E-02	6.84E-03	6.10E-02	0.00E+00	4.685E-01	2.951E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9514870	0.9829619	0.9875242	0.9988253	1.0000000	6.508E+01	1.128E+00
α_2	4.31E-04	1.29E-02	8.39E-03	4.05E-02	0.00E+00	8.512E-01	6.536E+01
α_3	2.09E-07	4.18E-03	8.96E-04	1.96E-02	0.00E+00	2.768E-01	6.593E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9545324	0.9810010	0.9841180	0.9968157	1.0000000	9.778E+01	1.894E+00
α_2	1.09E-03	1.26E-02	9.56E-03	3.47E-02	0.00E+00	1.260E+00	9.841E+01
α_3	4.39E-06	4.04E-03	1.48E-03	1.67E-02	0.00E+00	4.024E-01	9.927E+01
α_4	1.61E-08	2.32E-03	3.46E-04	1.15E-02	0.00E+00	2.315E-01	9.944E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9657802	0.9829560	0.9845270	0.9947609	1.0000000	1.979E+02	3.432E+00
α_2	1.63E-03	9.56E-03	7.99E-03	2.28E-02	0.00E+00	1.924E+00	1.994E+02
α_3	3.02E-04	5.21E-03	3.69E-03	1.53E-02	0.00E+00	1.049E+00	2.003E+02
α_4	1.44E-06	1.90E-03	6.54E-04	8.01E-03	0.00E+00	3.822E-01	2.010E+02
α_5	3.31E-20	3.81E-04	3.55E-07	2.21E-03	0.00E+00	7.674E-02	2.013E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9683501	0.9837610	0.9851049	0.9945722	1.0000000	2.323E+02	3.835E+00

α_2	1.03E-03	7.20E-03	5.87E-03	1.79E-02	0.00E+00	1.701E+00	2.345E+02
α_3	4.03E-04	5.11E-03	3.80E-03	1.43E-02	0.00E+00	1.207E+00	2.349E+02
α_4	2.31E-05	2.52E-03	1.33E-03	9.09E-03	0.00E+00	5.960E-01	2.356E+02
α_5	3.67E-09	9.36E-04	1.25E-04	4.70E-03	0.00E+00	2.211E-01	2.359E+02
α_6	3.66E-15	4.65E-04	4.71E-06	2.68E-03	0.00E+00	1.098E-01	2.360E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9736734	0.9850581	0.9858887	0.9935993	1.0000000	3.789E+02	5.747E+00
α_2	1.19E-03	5.83E-03	5.00E-03	1.33E-02	0.00E+00	2.243E+00	3.824E+02
α_3	5.68E-04	4.24E-03	3.41E-03	1.07E-02	0.00E+00	1.630E+00	3.830E+02
α_4	1.75E-04	2.82E-03	2.01E-03	8.19E-03	0.00E+00	1.083E+00	3.836E+02
α_5	1.06E-05	1.47E-03	7.41E-04	5.40E-03	0.00E+00	5.654E-01	3.841E+02
α_6	2.74E-10	4.98E-04	4.60E-05	2.60E-03	0.00E+00	1.916E-01	3.845E+02
α_7	6.20E-41	9.05E-05	3.37E-12	3.97E-04	0.00E+00	3.480E-02	3.846E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9749260	0.9857872	0.9865815	0.9939244	1.0000000	3.971E+02	5.726E+00
α_2	9.03E-04	5.01E-03	4.22E-03	1.18E-02	0.00E+00	2.018E+00	4.008E+02
α_3	3.56E-04	3.45E-03	2.67E-03	9.21E-03	0.00E+00	1.391E+00	4.015E+02
α_4	1.57E-04	2.64E-03	1.87E-03	7.72E-03	0.00E+00	1.062E+00	4.018E+02
α_5	3.08E-05	1.74E-03	1.02E-03	5.92E-03	0.00E+00	7.026E-01	4.021E+02
α_6	3.41E-07	8.68E-04	2.66E-04	3.78E-03	0.00E+00	3.497E-01	4.025E+02
α_7	1.31E-15	2.68E-04	2.46E-06	1.55E-03	0.00E+00	1.078E-01	4.027E+02
α_8	2.74E-17	2.35E-04	9.96E-07	1.37E-03	0.00E+00	9.469E-02	4.028E+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	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
α_2	1.56E-02	1.29E-02	1.26E-02	9.56E-03	7.20E-03	5.83E-03	5.01E-03
α_3		4.18E-03	4.04E-03	5.21E-03	5.11E-03	4.24E-03	3.45E-03
α_4			2.32E-03	1.90E-03	2.52E-03	2.82E-03	2.64E-03
α_5				3.81E-04	9.36E-04	1.47E-03	1.74E-03
α_6					4.65E-04	4.98E-04	8.68E-04
α_7						9.05E-05	2.68E-04
α_8							2.35E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.84E-01	9.83E-01	9.81E-01	9.83E-01	9.84E-01	9.85E-01	9.86E-01
Beta	1.56E-02	1.70E-02	1.90E-02	1.70E-02	1.62E-02	1.49E-02	1.42E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01

Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	7.10	7.10	7.10	7.10	7.10	7.10	7.10
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

2.16 Air Compressors

2.16.1 Motor-Driven Air Compressors

2.16.1.1 MOTOR-DRIVEN AIR COMPRESSORS FAIL TO START: ALL-MDC-FS

Components/Other/Compressor/Motor-Driven
Failure Modes/Fail to Start
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 176.1

Total Number of Common-Cause Failure Events: 0

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9907548	0.9976454	0.9989900	0.9999872	1.0000000	1.985E+02	4.685E-01
α_2	6.51E-06	2.35E-03	1.01E-03	9.25E-03	0.00E+00	4.685E-01	1.985E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9862587	0.9952041	0.9965120	0.9996701	1.0000000	2.341E+02	1.128E+00
α_2	1.20E-04	3.62E-03	2.35E-03	1.15E-02	0.00E+00	8.512E-01	2.344E+02
α_3	5.84E-08	1.18E-03	2.51E-04	5.52E-03	0.00E+00	2.768E-01	2.349E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9830449	0.9929519	0.9941292	0.9988292	1.0000000	2.668E+02	1.894E+00
α_2	4.03E-04	4.69E-03	3.53E-03	1.29E-02	0.00E+00	1.260E+00	2.674E+02
α_3	1.62E-06	1.50E-03	5.48E-04	6.21E-03	0.00E+00	4.024E-01	2.683E+02
α_4	5.96E-09	8.62E-04	1.28E-04	4.27E-03	0.00E+00	2.315E-01	2.684E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9813419	0.9907332	0.9916036	0.9971591	1.0000000	3.669E+02	3.432E+00
α_2	8.82E-04	5.20E-03	4.34E-03	1.24E-02	0.00E+00	1.924E+00	3.684E+02
α_3	1.64E-04	2.83E-03	2.00E-03	8.33E-03	0.00E+00	1.049E+00	3.693E+02
α_4	7.84E-07	1.03E-03	3.55E-04	4.35E-03	0.00E+00	3.822E-01	3.700E+02
α_5	1.80E-20	2.07E-04	1.93E-07	1.20E-03	0.00E+00	7.674E-02	3.703E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9815086	0.9905347	0.9913319	0.9968515	1.0000000	4.013E+02	3.835E+00
α_2	6.01E-04	4.20E-03	3.42E-03	1.05E-02	0.00E+00	1.701E+00	4.035E+02

α_3	2.35E-04	2.98E-03	2.21E-03	8.34E-03	0.00E+00	1.207E+00	4.039E+02
α_4	1.35E-05	1.47E-03	7.71E-04	5.30E-03	0.00E+00	5.960E-01	4.046E+02
α_5	2.13E-09	5.46E-04	7.29E-05	2.74E-03	0.00E+00	2.211E-01	4.049E+02
α_6	2.13E-15	2.71E-04	2.74E-06	1.56E-03	0.00E+00	1.098E-01	4.050E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9816851	0.9896191	0.9902006	0.9955637	1.0000000	5.479E+02	5.747E+00
α_2	8.28E-04	4.05E-03	3.47E-03	9.26E-03	0.00E+00	2.243E+00	5.514E+02
α_3	3.95E-04	2.94E-03	2.37E-03	7.45E-03	0.00E+00	1.630E+00	5.520E+02
α_4	1.22E-04	1.96E-03	1.40E-03	5.69E-03	0.00E+00	1.083E+00	5.526E+02
α_5	7.38E-06	1.02E-03	5.15E-04	3.75E-03	0.00E+00	5.654E-01	5.531E+02
α_6	1.90E-10	3.46E-04	3.20E-05	1.80E-03	0.00E+00	1.916E-01	5.535E+02
α_7	4.30E-41	6.29E-05	2.34E-12	2.76E-04	0.00E+00	3.480E-02	5.536E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9823180	0.9899876	0.9905553	0.9957307	1.0000000	5.661E+02	5.726E+00
α_2	6.36E-04	3.53E-03	2.97E-03	8.33E-03	0.00E+00	2.018E+00	5.698E+02
α_3	2.51E-04	2.43E-03	1.88E-03	6.49E-03	0.00E+00	1.391E+00	5.705E+02
α_4	1.10E-04	1.86E-03	1.32E-03	5.44E-03	0.00E+00	1.062E+00	5.708E+02
α_5	2.17E-05	1.23E-03	7.17E-04	4.17E-03	0.00E+00	7.026E-01	5.711E+02
α_6	2.40E-07	6.12E-04	1.88E-04	2.66E-03	0.00E+00	3.497E-01	5.715E+02
α_7	9.22E-16	1.89E-04	1.73E-06	1.09E-03	0.00E+00	1.078E-01	5.717E+02
α_8	1.93E-17	1.66E-04	7.01E-07	9.64E-04	0.00E+00	9.469E-02	5.718E+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	9.91E-01	9.90E-01	9.90E-01
α_2	2.35E-03	3.62E-03	4.69E-03	5.20E-03	4.20E-03	4.05E-03	3.53E-03
α_3		1.18E-03	1.50E-03	2.83E-03	2.98E-03	2.94E-03	2.43E-03
α_4			8.62E-04	1.03E-03	1.47E-03	1.96E-03	1.86E-03
α_5				2.07E-04	5.46E-04	1.02E-03	1.23E-03
α_6					2.71E-04	3.46E-04	6.12E-04
α_7						6.29E-05	1.89E-04
α_8							1.66E-04

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	9.91E-01	9.90E-01	9.90E-01
Beta	2.35E-03	4.80E-03	7.05E-03	9.27E-03	9.47E-03	1.04E-02	1.00E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01

Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	176.10	176.10	176.10	176.10	176.10	176.10	176.10
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

2.16.1.2 MOTOR-DRIVEN AIR COMPRESSORS FAIL TO RUN: ALL-MDC-FR

Components/Other/Compressor/Motor-Driven
Failure Modes/Fail to Run (Normally running equipment)
Date Range: 2006 through 2020

Total Number of Independent Failure Events: 314.4

Total Number of Common-Cause Failure Events: 1

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9886326	0.9956589	0.9965853	0.9995048	0.9968294	3.368E+02	1.469E+00
α_2	4.93E-04	4.34E-03	3.41E-03	1.14E-02	3.17E-03	1.469E+00	3.368E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9907080	0.9959977	0.9965969	0.9992326	0.9978840	5.296E+02	2.128E+00
α_2	2.49E-04	2.54E-03	1.95E-03	6.85E-03	1.06E-03	1.351E+00	5.304E+02
α_3	3.64E-05	1.46E-03	9.03E-04	4.79E-03	1.06E-03	7.768E-01	5.309E+02

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9915149	0.9959943	0.9964449	0.9989384	0.9984122	7.195E+02	2.894E+00
α_2	2.48E-04	2.09E-03	1.65E-03	5.43E-03	3.97E-04	1.510E+00	7.209E+02
α_3	4.90E-05	1.25E-03	8.30E-04	3.88E-03	7.94E-04	9.024E-01	7.215E+02
α_4	2.14E-06	6.67E-04	2.93E-04	2.59E-03	3.97E-04	4.815E-01	7.219E+02

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9914905	0.9954832	0.9958181	0.9983462	0.9987294	9.768E+02	4.432E+00
α_2	3.83E-04	2.09E-03	1.76E-03	4.91E-03	1.59E-04	2.049E+00	9.792E+02
α_3	1.56E-04	1.45E-03	1.13E-03	3.84E-03	4.76E-04	1.424E+00	9.798E+02
α_4	1.77E-05	7.72E-04	4.70E-04	2.55E-03	4.76E-04	7.572E-01	9.805E+02
α_5	2.37E-10	2.06E-04	2.18E-05	1.06E-03	1.59E-04	2.017E-01	9.811E+02

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9924044	0.9958790	0.9961599	0.9984077	0.9989409	1.168E+03	4.835E+00
α_2	2.26E-04	1.50E-03	1.23E-03	3.71E-03	6.62E-05	1.764E+00	1.171E+03
α_3	1.39E-04	1.24E-03	9.73E-04	3.26E-03	2.65E-04	1.457E+00	1.172E+03
α_4	3.94E-05	8.28E-04	5.67E-04	2.50E-03	3.97E-04	9.710E-01	1.172E+03
α_5	1.14E-06	4.02E-04	1.73E-04	1.58E-03	2.65E-04	4.711E-01	1.173E+03

α_6	1.53E-11	1.47E-04	9.86E-06	7.85E-04	6.62E-05	1.723E-01	1.173E+03

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9922250	0.9954377	0.9956607	0.9978895	0.9990921	1.472E+03	6.747E+00
α_2	3.19E-04	1.54E-03	1.32E-03	3.50E-03	2.84E-05	2.274E+00	1.477E+03
α_3	1.85E-04	1.21E-03	9.92E-04	2.97E-03	1.42E-04	1.786E+00	1.477E+03
α_4	9.78E-05	9.44E-04	7.30E-04	2.52E-03	2.84E-04	1.395E+00	1.478E+03
α_5	2.15E-05	5.94E-04	3.89E-04	1.86E-03	2.84E-04	8.779E-01	1.478E+03
α_6	8.84E-08	2.35E-04	7.16E-05	1.02E-03	1.42E-04	3.478E-01	1.479E+03
α_7	8.04E-24	4.47E-05	1.11E-08	2.55E-04	2.84E-05	6.605E-02	1.479E+03

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9930668	0.9959346	0.9961298	0.9981276	0.9992055	1.648E+03	6.726E+00
α_2	2.23E-04	1.23E-03	1.04E-03	2.90E-03	1.24E-05	2.034E+00	1.652E+03
α_3	1.03E-04	8.97E-04	7.06E-04	2.34E-03	7.45E-05	1.484E+00	1.653E+03
α_4	7.10E-05	7.84E-04	5.94E-04	2.14E-03	1.86E-04	1.296E+00	1.653E+03
α_5	3.27E-05	6.14E-04	4.28E-04	1.83E-03	2.48E-04	1.015E+00	1.653E+03
α_6	2.95E-06	3.53E-04	1.82E-04	1.28E-03	1.86E-04	5.841E-01	1.654E+03
α_7	1.39E-10	1.22E-04	1.29E-05	6.27E-04	7.45E-05	2.016E-01	1.654E+03
α_8	5.95E-16	6.67E-05	6.92E-07	3.84E-04	1.24E-05	1.103E-01	1.654E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.96E-01	9.96E-01	9.96E-01	9.95E-01	9.96E-01	9.95E-01	9.96E-01
α_2	4.34E-03	2.54E-03	2.09E-03	2.09E-03	1.50E-03	1.54E-03	1.23E-03
α_3		1.46E-03	1.25E-03	1.45E-03	1.24E-03	1.21E-03	8.97E-04
α_4			6.67E-04	7.72E-04	8.28E-04	9.44E-04	7.84E-04
α_5				2.06E-04	4.02E-04	5.94E-04	6.14E-04
α_6					1.47E-04	2.35E-04	3.53E-04
α_7						4.47E-05	1.22E-04
α_8							6.67E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.96E-01	9.96E-01	9.96E-01	9.95E-01	9.96E-01	9.95E-01	9.96E-01
Beta	4.34E-03	4.00E-03	4.01E-03	4.52E-03	4.12E-03	4.56E-03	4.07E-03
Gamma		3.65E-01	4.78E-01	5.38E-01	6.35E-01	6.63E-01	6.98E-01
Delta			3.48E-01	4.02E-01	5.26E-01	6.01E-01	6.84E-01
Epsilon				2.10E-01	3.99E-01	4.81E-01	5.96E-01
Mu					2.68E-01	3.20E-01	4.69E-01
Omega						1.60E-01	3.48E-01
Sigma							3.54E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	314.40	471.60	628.80	786.00	943.20	1100.40	1257.60
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

3. GENERIC CCF DISTRIBUTIONS

This section shows generic CCF distributions including the Generic Demand (Section 3.1.1), Generic Rate (Section 3.1.2), and CCF Prior (Section 3.1.3) distributions. The distributions for the Generic Demand and Generic Rate are updated with the latest data (i.e., up to 2020). The CCF Prior section shows the newly developed priors [13, 14] that are used for the 2020 Update, which can be obtained in RADS with a rule with zero CCF event and zero independent event. When an interested CCF template (component type, system, and failure mode) is not provided in this report, the parameters in Section 3.1.3, CCF Prior, are recommended to be used.

3.1 Generic Distributions

3.1.1 Generic Demand CCF Distribution

3.1.1.1 ALL CCF DEMAND BASED EVENTS 2006 TO 2020: 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: 2006 through 2020

Total Number of Independent Failure Events: 2188.9

Total Number of Common-Cause Failure Events: 43

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9796310	0.9865346	0.9868944	0.9922033	0.9867191	8.801E+02	1.201E+01
α_2	7.80E-03	1.35E-02	1.31E-02	2.04E-02	1.33E-02	1.201E+01	8.801E+02

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9799117	0.9856081	0.9858435	0.9904901	0.9858224	1.334E+03	1.948E+01
α_2	6.02E-03	1.00E-02	9.78E-03	1.48E-02	9.82E-03	1.357E+01	1.340E+03
α_3	1.89E-03	4.37E-03	4.13E-03	7.67E-03	4.36E-03	5.915E+00	1.348E+03

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9807922	0.9856673	0.9858425	0.9899377	0.9859972	1.785E+03	2.595E+01
α_2	5.30E-03	8.52E-03	8.33E-03	1.23E-02	8.24E-03	1.542E+01	1.795E+03
α_3	1.98E-03	4.10E-03	3.92E-03	6.84E-03	4.08E-03	7.418E+00	1.803E+03
α_4	4.85E-04	1.72E-03	1.54E-03	3.57E-03	1.68E-03	3.116E+00	1.808E+03

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9830349	0.9870961	0.9872371	0.9906882	0.9875283	2.305E+03	3.014E+01
α_2	3.57E-03	5.92E-03	5.78E-03	8.75E-03	5.56E-03	1.383E+01	2.322E+03
α_3	2.16E-03	4.06E-03	3.92E-03	6.44E-03	3.94E-03	9.481E+00	2.326E+03
α_4	9.06E-04	2.24E-03	2.10E-03	4.05E-03	2.26E-03	5.230E+00	2.330E+03
α_5	8.80E-05	6.82E-04	5.46E-04	1.74E-03	7.08E-04	1.592E+00	2.334E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9846665	0.9882140	0.9883327	0.9913646	0.9886568	2.760E+03	3.291E+01
α_2	2.55E-03	4.38E-03	4.26E-03	6.62E-03	4.11E-03	1.223E+01	2.780E+03
α_3	1.91E-03	3.53E-03	3.41E-03	5.56E-03	3.38E-03	9.866E+00	2.783E+03
α_4	1.04E-03	2.30E-03	2.18E-03	3.97E-03	2.28E-03	6.429E+00	2.786E+03
α_5	3.83E-04	1.24E-03	1.13E-03	2.50E-03	1.27E-03	3.471E+00	2.789E+03
α_6	1.34E-05	3.28E-04	2.19E-04	1.01E-03	3.15E-04	9.167E-01	2.792E+03

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9859921	0.9890913	0.9891900	0.9918608	0.9896369	3.326E+03	3.669E+01
α_2	2.04E-03	3.54E-03	3.44E-03	5.37E-03	3.23E-03	1.190E+01	3.351E+03
α_3	1.53E-03	2.86E-03	2.77E-03	4.53E-03	2.68E-03	9.634E+00	3.354E+03
α_4	1.06E-03	2.20E-03	2.10E-03	3.67E-03	2.11E-03	7.390E+00	3.356E+03
α_5	5.88E-04	1.49E-03	1.39E-03	2.72E-03	1.49E-03	5.010E+00	3.358E+03
α_6	1.41E-04	6.80E-04	5.84E-04	1.55E-03	7.01E-04	2.286E+00	3.361E+03
α_7	3.99E-07	1.40E-04	6.04E-05	5.50E-04	1.46E-04	4.712E-01	3.363E+03

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9871132	0.9899134	0.9899964	0.9924258	0.9904223	3.765E+03	3.836E+01
α_2	1.63E-03	2.90E-03	2.81E-03	4.47E-03	2.65E-03	1.104E+01	3.792E+03
α_3	1.25E-03	2.38E-03	2.30E-03	3.81E-03	2.25E-03	9.062E+00	3.794E+03
α_4	8.80E-04	1.86E-03	1.78E-03	3.14E-03	1.77E-03	7.087E+00	3.796E+03
α_5	6.52E-04	1.52E-03	1.44E-03	2.69E-03	1.49E-03	5.793E+00	3.797E+03
α_6	3.03E-04	9.52E-04	8.66E-04	1.90E-03	9.60E-04	3.622E+00	3.800E+03
α_7	4.05E-05	3.75E-04	2.92E-04	9.94E-04	3.87E-04	1.428E+00	3.802E+03
α_8	2.44E-08	8.80E-05	2.54E-05	3.89E-04	7.05E-05	3.348E-01	3.803E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.87E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01	9.89E-01
α_2	1.27E-02	1.21E-02	9.78E-03	6.47E-03	4.65E-03	3.71E-03	2.96E-03
α_3		3.20E-03	4.32E-03	4.57E-03	3.88E-03	3.22E-03	2.72E-03
α_4			1.35E-03	2.20E-03	2.52E-03	2.39E-03	2.03E-03

α_5				5.36E-04	1.18E-03	1.55E-03	1.62E-03
α_6					2.91E-04	6.41E-04	9.65E-04
α_7						1.25E-04	3.60E-04
α_8							9.52E-05

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.87E-01	9.85E-01	9.85E-01	9.86E-01	9.87E-01	9.88E-01	9.89E-01
Beta	1.27E-02	1.53E-02	1.55E-02	1.38E-02	1.25E-02	1.16E-02	1.08E-02
Gamma		2.09E-01	3.67E-01	5.30E-01	6.29E-01	6.81E-01	7.25E-01
Delta			2.38E-01	3.74E-01	5.07E-01	5.93E-01	6.51E-01
Epsilon				1.96E-01	3.68E-01	4.92E-01	6.00E-01
Mu					1.98E-01	3.31E-01	4.66E-01
Omega						1.63E-01	3.20E-01
Sigma							2.09E-01

Avg. Impact Vector	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
Adj. Ind	517.02	775.53	1034.04	1292.54	1551.05	1809.56	2068.07
N_1	11.7090	9.5202	7.5357	7.5110	7.3573	7.1407	6.9373
N_2	6.6447	9.5433	9.9873	7.8609	6.6899	5.9704	5.3592
N_3		2.4636	4.5657	5.8661	5.8095	5.5102	5.3955
N_4			1.3223	2.9412	3.9598	4.2071	4.0015
N_5				0.7341	1.9067	2.8634	3.3461
N_6					0.4163	1.2268	2.0559
N_7						0.2411	0.7887
N_8							0.1425

3.1.2 Generic Rate CCF Distribution

3.1.2.1 ALL CCF RATE BASED EVENTS 2006 TO 2020: 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: 2006 through 2020

Total Number of Independent Failure Events: 2104.8

Total Number of Common-Cause Failure Events: 55

ALPHA FACTOR DISTRIBUTIONS

CCCG = 2

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9703838	0.9783413	0.9786536	0.9852416	0.9783143	1.005E+03	2.224E+01
α_2	1.48E-02	2.17E-02	2.13E-02	2.96E-02	2.17E-02	2.224E+01	1.005E+03

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9728172	0.9791223	0.9793303	0.9847248	0.9790511	1.517E+03	3.235E+01
α_2	8.33E-03	1.26E-02	1.24E-02	1.76E-02	1.25E-02	1.953E+01	1.530E+03
α_3	4.89E-03	8.28E-03	8.07E-03	1.24E-02	8.42E-03	1.283E+01	1.537E+03

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9753472	0.9805861	0.9807438	0.9852962	0.9806350	2.027E+03	4.013E+01
α_2	6.43E-03	9.68E-03	9.53E-03	1.35E-02	9.50E-03	2.002E+01	2.047E+03
α_3	3.66E-03	6.20E-03	6.04E-03	9.29E-03	6.29E-03	1.282E+01	2.054E+03
α_4	1.69E-03	3.53E-03	3.37E-03	5.91E-03	3.58E-03	7.297E+00	2.060E+03

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9786345	0.9829613	0.9830846	0.9868787	0.9830110	2.607E+03	4.519E+01
α_2	4.22E-03	6.58E-03	6.45E-03	9.35E-03	6.31E-03	1.744E+01	2.635E+03
α_3	3.28E-03	5.39E-03	5.26E-03	7.92E-03	5.39E-03	1.429E+01	2.638E+03
α_4	2.01E-03	3.71E-03	3.59E-03	5.85E-03	3.85E-03	9.853E+00	2.642E+03
α_5	4.31E-04	1.36E-03	1.24E-03	2.71E-03	1.44E-03	3.608E+00	2.649E+03

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9809658	0.9847172	0.9848216	0.9881208	0.9848309	3.121E+03	4.844E+01
α_2	2.79E-03	4.56E-03	4.46E-03	6.69E-03	4.34E-03	1.446E+01	3.155E+03
α_3	2.86E-03	4.66E-03	4.56E-03	6.81E-03	4.61E-03	1.477E+01	3.155E+03
α_4	1.84E-03	3.32E-03	3.22E-03	5.16E-03	3.38E-03	1.054E+01	3.159E+03
α_5	9.94E-04	2.14E-03	2.04E-03	3.65E-03	2.24E-03	6.798E+00	3.163E+03
α_6	9.68E-05	5.92E-04	4.91E-04	1.43E-03	6.00E-04	1.875E+00	3.168E+03

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9829153	0.9861676	0.9862503	0.9891335	0.9863210	3.748E+03	5.257E+01
α_2	2.21E-03	3.66E-03	3.57E-03	5.40E-03	3.41E-03	1.390E+01	3.786E+03
α_3	2.01E-03	3.40E-03	3.32E-03	5.09E-03	3.30E-03	1.294E+01	3.787E+03
α_4	1.78E-03	3.10E-03	3.01E-03	4.71E-03	3.12E-03	1.176E+01	3.789E+03
α_5	1.16E-03	2.27E-03	2.18E-03	3.67E-03	2.35E-03	8.620E+00	3.792E+03
α_6	4.26E-04	1.17E-03	1.08E-03	2.20E-03	1.24E-03	4.429E+00	3.796E+03
α_7	9.90E-06	2.41E-04	1.62E-04	7.46E-04	2.58E-04	9.176E-01	3.799E+03

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9843590	0.9872927	0.9873710	0.9899691	0.9874711	4.246E+03	5.465E+01
α_2	1.82E-03	3.07E-03	2.99E-03	4.57E-03	2.86E-03	1.319E+01	4.287E+03
α_3	1.43E-03	2.55E-03	2.48E-03	3.94E-03	2.46E-03	1.099E+01	4.290E+03
α_4	1.47E-03	2.60E-03	2.53E-03	4.00E-03	2.60E-03	1.120E+01	4.289E+03
α_5	1.19E-03	2.22E-03	2.15E-03	3.52E-03	2.27E-03	9.562E+00	4.291E+03
α_6	6.79E-04	1.50E-03	1.42E-03	2.59E-03	1.56E-03	6.457E+00	4.294E+03
α_7	1.57E-04	6.31E-04	5.56E-04	1.36E-03	6.68E-04	2.715E+00	4.298E+03
α_8	6.99E-07	1.25E-04	6.02E-05	4.67E-04	1.13E-04	5.361E-01	4.300E+03

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.78E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01
α_2	2.17E-02	1.26E-02	9.68E-03	6.58E-03	4.56E-03	3.66E-03	3.07E-03
α_3		8.28E-03	6.20E-03	5.39E-03	4.66E-03	3.40E-03	2.55E-03
α_4			3.53E-03	3.71E-03	3.32E-03	3.10E-03	2.60E-03
α_5				1.36E-03	2.14E-03	2.27E-03	2.22E-03
α_6					5.92E-04	1.17E-03	1.50E-03
α_7						2.41E-04	6.31E-04
α_8							1.25E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.78E-01	9.79E-01	9.81E-01	9.83E-01	9.85E-01	9.86E-01	9.87E-01

Beta	2.17E-02	2.09E-02	1.94E-02	1.70E-02	1.53E-02	1.38E-02	1.27E-02
Gamma		3.96E-01	5.01E-01	6.14E-01	7.01E-01	7.36E-01	7.59E-01
Delta			3.63E-01	4.85E-01	5.65E-01	6.65E-01	7.35E-01
Epsilon				2.68E-01	4.52E-01	5.43E-01	6.32E-01
Mu					2.16E-01	3.83E-01	5.04E-01
Omega						1.72E-01	3.35E-01
Sigma							1.65E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	960.70	1441.05	1921.39	2401.74	2882.09	3362.44	3842.79
N_1	21.6435	18.2894	15.0340	14.3952	13.8564	13.5809	13.1187
N_2	21.7749	18.6759	18.7574	15.5155	12.7606	11.6583	11.1712
N_3		12.5496	12.4166	13.2400	13.5626	11.3073	9.5958
N_4			7.0653	9.4703	9.9397	10.6812	10.1407
N_5				3.5314	6.5769	8.0542	8.8594
N_6					1.7656	4.2372	6.1073
N_7						0.8828	2.6071
N_8							0.4414

3.1.3 CCF Prior Distribution

3.1.3.1 No Data (Prior Only)

Prior Version : 2015/12/31[2]

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	0.9202127	0.9795237	0.9909751	0.9999381	--	2.241E+01	4.685E-01
α_2	5.83E-05	2.05E-02	9.02E-03	7.98E-02	--	4.685E-01	2.241E+01

CCCG = 3

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9457174	0.9809153	0.9860142	0.9986769	--	5.798E+01	1.128E+00
α_2	4.84E-04	1.44E-02	9.41E-03	4.54E-02	--	8.512E-01	5.826E+01
α_3	2.34E-07	4.68E-03	1.00E-03	2.20E-02	--	2.768E-01	5.883E+01

CCCG = 4

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9510776	0.9795438	0.9828910	0.9965680	--	9.068E+01	1.894E+00
α_2	1.18E-03	1.36E-02	1.03E-02	3.74E-02	--	1.260E+00	9.131E+01
α_3	4.73E-06	4.35E-03	1.60E-03	1.80E-02	--	4.024E-01	9.217E+01
α_4	1.74E-08	2.50E-03	3.73E-04	1.24E-02	--	2.315E-01	9.234E+01

CCCG = 5

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9645377	0.9823331	0.9839596	0.9945673	--	1.908E+02	3.432E+00
α_2	1.69E-03	9.90E-03	8.28E-03	2.37E-02	--	1.924E+00	1.923E+02
α_3	3.13E-04	5.40E-03	3.83E-03	1.59E-02	--	1.049E+00	1.932E+02
α_4	1.50E-06	1.97E-03	6.78E-04	8.30E-03	--	3.822E-01	1.939E+02
α_5	3.43E-20	3.95E-04	3.68E-07	2.30E-03	--	7.674E-02	1.942E+02

[2] See INL/EXT-21-43723 for the development of the 2015 CCF prior distribution, which used data from 1997–2015.

CCCG = 6

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9673747	0.9832576	0.9846419	0.9944035	--	2.252E+02	3.835E+00
α_2	1.06E-03	7.43E-03	6.05E-03	1.85E-02	--	1.701E+00	2.274E+02
α_3	4.16E-04	5.27E-03	3.92E-03	1.47E-02	--	1.207E+00	2.278E+02
α_4	2.39E-05	2.60E-03	1.37E-03	9.37E-03	--	5.960E-01	2.285E+02
α_5	3.78E-09	9.65E-04	1.29E-04	4.84E-03	--	2.211E-01	2.288E+02
α_6	3.77E-15	4.79E-04	4.85E-06	2.76E-03	--	1.098E-01	2.289E+02

CCCG = 7

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9731763	0.9847771	0.9856229	0.9934781	--	3.718E+02	5.747E+00
α_2	1.22E-03	5.94E-03	5.09E-03	1.36E-02	--	2.243E+00	3.753E+02
α_3	5.79E-04	4.32E-03	3.48E-03	1.09E-02	--	1.630E+00	3.759E+02
α_4	1.78E-04	2.87E-03	2.05E-03	8.34E-03	--	1.083E+00	3.765E+02
α_5	1.08E-05	1.50E-03	7.55E-04	5.50E-03	--	5.654E-01	3.770E+02
α_6	2.79E-10	5.07E-04	4.69E-05	2.64E-03	--	1.916E-01	3.774E+02
α_7	6.31E-41	9.22E-05	3.43E-12	4.04E-04	--	3.480E-02	3.775E+02

CCCG = 8

Alpha Factor	5th%	Mean	Median	95th%	MLE	a	b
α_1	0.9744830	0.9855322	0.9863403	0.9938201	--	3.900E+02	5.726E+00
α_2	9.19E-04	5.10E-03	4.29E-03	1.20E-02	--	2.018E+00	3.937E+02
α_3	3.63E-04	3.51E-03	2.72E-03	9.37E-03	--	1.391E+00	3.944E+02
α_4	1.60E-04	2.68E-03	1.91E-03	7.86E-03	--	1.062E+00	3.947E+02
α_5	3.13E-05	1.78E-03	1.04E-03	6.03E-03	--	7.026E-01	3.950E+02
α_6	3.47E-07	8.84E-04	2.71E-04	3.84E-03	--	3.497E-01	3.954E+02
α_7	1.33E-15	2.72E-04	2.50E-06	1.57E-03	--	1.078E-01	3.956E+02
α_8	2.79E-17	2.39E-04	1.01E-06	1.39E-03	--	9.469E-02	3.957E+02

ALPHA FACTOR and MGL PARAMETERS

Alpha Factor	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
α_1	9.80E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01
α_2	2.05E-02	1.44E-02	1.36E-02	9.90E-03	7.43E-03	5.94E-03	5.10E-03
α_3		4.68E-03	4.35E-03	5.40E-03	5.27E-03	4.32E-03	3.51E-03
α_4			2.50E-03	1.97E-03	2.60E-03	2.87E-03	2.68E-03
α_5				3.95E-04	9.65E-04	1.50E-03	1.78E-03
α_6					4.79E-04	5.07E-04	8.84E-04
α_7						9.22E-05	2.72E-04
α_8							2.39E-04

MGL	CCCG=2	CCCG=3	CCCG=4	CCCG=5	CCCG=6	CCCG=7	CCCG=8
1-Beta	9.80E-01	9.81E-01	9.80E-01	9.82E-01	9.83E-01	9.85E-01	9.86E-01

Beta	2.05E-02	1.91E-02	2.05E-02	1.77E-02	1.67E-02	1.52E-02	1.45E-02
Gamma		2.45E-01	3.35E-01	4.39E-01	5.56E-01	6.10E-01	6.48E-01
Delta			3.65E-01	3.04E-01	4.34E-01	5.35E-01	6.25E-01
Epsilon				1.67E-01	3.57E-01	4.22E-01	5.42E-01
Mu					3.32E-01	2.86E-01	4.40E-01
Omega						1.54E-01	3.67E-01
Sigma							4.68E-01

Avg. Impact Vector	**CCCG=2**	**CCCG=3**	**CCCG=4**	**CCCG=5**	**CCCG=6**	**CCCG=7**	**CCCG=8**
Adj. Ind	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

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.

Alpha Factor. The fraction of the total frequency of failure events that occur in the system involving the failure of k components in a system of m components due to a common-cause.

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. ASME/ANS PRA standard ASME/ANS RA-Sa-2009 defines *common cause failure* as a failure of two or more components during a short period of time as a results of a single 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.

Coupling Factor. The condition or mechanism through which failures of multiple components are coupled.

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.

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Appendix A
CCF SECTION COMPARISON BETWEEN 2015 AND 2020 UPDATE

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
2.1 Motor-Driven Pumps (MDPs)	2.1.1 Pooled MDPs	2.1.1.1	ALL-MDP-FS	2.1.1.1	ALL-MDP-FS	
		2.1.1.2	ALL-MDP-FH	2.1.1.2	ALL-MDP-FH	
		2.1.1.3	ALL-MDP-FHRH	2.1.1.3	ALL-MDP-FHRH	
		2.1.1.4	ALL-MDP-RH	2.1.1.4	ALL-MDP-RH	
		2.1.1.5	ALL-MDP-FR-NR	2.1.1.5	ALL-MDP-FR-NR	
		2.1.1.6	ALL-MDP-FS-NS	2.1.1.6	ALL-MDP-FS-NS	
		2.1.1.7	ALL-MDP-FS-NR	2.1.1.7	ALL-MDP-FS-NR	
	2.1.2 Pooled Pump Volutes	2.1.2.1	ALL-PMP-FR	2.1.2.1	CLN-PMP-FR	
	2.1.3 Pooled Clean System MDPs	2.1.3.1	CLN-MDP-FS	2.1.3.1	CLN-MDP-FS	
		2.1.3.2	CLN-MDP-FH	2.1.3.2	CLN-MDP-FH	
		2.1.3.3	CLN-MDP-FHRH	2.1.3.3	CLN-MDP-FHRH	
		2.1.3.4	CLN-MDP-RH	2.1.3.4	CLN-MDP-RH	
	2.1.4 PWR Containment Spray MDPs	2.1.4.1	CSS-MDP-FS	2.1.4.1	CSS-MDP-FS	
		2.1.4.2	CSS-MDP-FH	2.1.4.2	CSS-MDP-FH	
		2.1.4.3	CSS-MDP-FHRH	2.1.4.3	CSS-MDP-FHRH	
		2.1.4.4	CSS-MDP-RH	2.1.4.4	CSS-MDP-RH	
	2.1.5 BWR RHR MDPs	2.1.5.1	BWR-RHR-MDP-FS	2.1.5.1	BWR-RHR-MDP-FS	
		2.1.5.2	BWR-RHR-MDP-FH	2.1.5.2	BWR-RHR-MDP-FH	
		2.1.5.3	BWR-RHR-MDP-FHRH	2.1.5.3	BWR-RHR-MDP-FHRH	
		2.1.5.4	BWR-RHR-MDP-RH	2.1.5.4	BWR-RHR-MDP-RH	
	2.1.6 AFW MDPs	2.1.6.1	AFW-MDP-FS	2.1.6.1	AFW-MDP-FS	
		2.1.6.2	AFW-MDP-FH	2.1.6.2	AFW-MDP-FH	
		2.1.6.3	AFW-MDP-FHRH	2.1.6.3	AFW-MDP-FHRH	
		2.1.6.4	AFW-MDP-RH	2.1.6.4	AFW-MDP-RH	

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
	2.1.7 AFW Pump Volutes	2.1.7.1	AFW-PMP-FR	2.1.7.1	AFW-PMP-FR	
	2.1.8 ESW MDPs	2.1.8.1	SWN-MDP-FS	2.1.8.1	SWN-MDP-FS	
		2.1.8.2	SWN-MDP-FR	2.1.8.2	SWN-MDP-FR	
		2.1.8.3	SSW-MDP-FS	2.1.8.3	SSW-MDP-FS	
		2.1.8.4	SSW-MDP-FR	2.1.8.4	SSW-MDP-FR	
		2.1.8.5	SWS-MDP-FS	2.1.8.5	SWS-MDP-FS	
		2.1.8.6	SWS-MDP-FR	2.1.8.6	SWS-MDP-FR	
		2.1.8.7	SWS-MDP-FR-EE	~~2.1.8.7~~	~~SWS-MDP-FR-EE~~	*Note 1*
	2.1.9PWR HPSI MDPs	2.1.9.1	HPI-MDP-FS	2.1.9.1	HPI-MDP-FS	
		2.1.9.2	HPI-MDP-FH	2.1.9.2	HPI-MDP-FH	
		2.1.9.3	HPI-MDP-FHRH	2.1.9.3	HPI-MDP-FHRH	
		2.1.9.4	HPI-MDP-RH	2.1.9.4	HPI-MDP-RH	
	2.1.10 PWR RHR MDPs	2.1.10.1	PWR-RHR-MDP-FS	2.1.10.1	PWR-RHR-MDP-FS	
		2.1.10.2	PWR-RHR-MDP-FH	2.1.10.2	PWR-RHR-MDP-FH	
		2.1.10.3	PWR-RHR-MDP-FHRH	2.1.10.3	PWR-RHR-MDP-FHRH	
		2.1.10.4	PWR-RHR-MDP-RH	2.1.10.4	PWR-RHR-MDP-RH	
	2.1.11 BWR SLC Pump	2.1.11.1	SLC-MDP-FS	~~2.1.11.1~~	~~SLC-MDP-FS~~	*Note 1*
		2.1.11.2	SLC-MDP-FH	~~2.1.11.2~~	~~SLC-MDP-FH~~	*Note 1*
		2.1.11.3	SLC-MDP-FHRH	~~2.1.11.3~~	~~SLC-MDP-FHRH~~	*Note 1*
		2.1.11.4	SLC-MDP-RH	~~2.1.11.4~~	~~SLC-MDP-RH~~	*Note 1*
	2.1.12 CCW Pump	2.1.12.1	CCW-MDP-FS	2.1.11.1	CCW-MDP-FS	
		2.1.12.2	CCW-MDP-FR	2.1.11.2	CCW-MDP-FR	
	2.1.13 PDPs	2.1.13.1	ALL-PDP-FS	2.1.12.1	ALL-PDP-FS	
		2.1.13.2	ALL-PDP-FR	2.1.12.2	ALL-PDP-FR	
2.2 Turbine-Driven Pumps (TDPs)	2.2.1 Pooled TDPs	2.2.1.1	ALL-TDP-FS	2.2.1.1	ALL-TDP-FS	
		2.2.1.2	ALL-TDP-FH	2.2.1.2	ALL-TDP-FH	
		2.2.1.3	ALL-TDP-FHRH	2.2.1.3	ALL-TDP-FHRH	
		2.2.1.4	ALL-TDP-RH	2.2.1.4	ALL-TDP-RH	
		2.2.1.5	ALL-TDP-FR-NR	2.2.1.5	ALL-TDP-FR-NR	

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
	2.2.2 AFW TDPs	2.2.2.1	AFW-TDP-FS	2.2.2.1	AFW-TDP-FS	
		2.2.2.2	AFW-TDP-FH	2.2.2.2	AFW-TDP-FH	
		2.2.2.3	AFW-TDP-FHRH	2.2.2.3	AFW-TDP-FHRH	
		2.2.2.4	AFW-TDP-RH	2.2.2.4	AFW-TDP-RH	
	2.2.3 BWR HPCI/RCIC TDPs	2.2.3.1	HCI-RCI-TDP-FS	2.2.3.1	HCI-RCI-TDP-FS	
		2.2.3.2	HCI-RCI-TDP-FH	2.2.3.2	HCI-RCI-TDP-FH	
		2.2.3.3	HCI-RCI-TDP-FHRH	2.2.3.3	HCI-RCI-TDP-FHRH	
		2.2.3.4	HCI-RCI-TDP-RH	2.2.3.4	HCI-RCI-TDP-RH	
2.3 Motor-Operated Valves (MOVs)	2.3.1 Pooled MOVs	2.3.1.1	ALL-MOV-FTOC	2.3.1.1	ALL-MOV-FTOC	
		2.3.1.2	ALL-MOV-CC	2.3.1.2	ALL-MOV-CC	
		2.3.1.3	ALL-MOV-OO	2.3.1.3	ALL-MOV-OO	
		2.3.1.4	ALL-MOV-CO	2.3.1.4	ALL-MOV-SO	
		2.3.1.5	ALL-MOV-LK	2.3.1.5	ALL-MOV-LK	
	2.3.2 PWR Containment Spray MOVs	2.3.2.1	CSS-MOV-FTOC	2.3.2.1	CSS-MOV-FTOC	
		2.3.2.2	CSS-MOV-CC	2.3.2.2	CSS-MOV-CC	
		2.3.2.3	CSS-MOV-OO	2.3.2.3	CSS-MOV-OO	
	2.3.3 BWR RHR MOVs	2.3.3.1	BWR-RHR-MOV-FTOC	2.3.3.1	BWR-RHR-MOV-FTOC	
		2.3.3.2	BWR-RHR-MOV-CC	2.3.3.2	BWR-RHR-MOV-CC	
		2.3.3.3	BWR-RHR-MOV-OO	2.3.3.3	BWR-RHR-MOV-OO	
	2.3.4 BWR Isolation Condenser MOVs	2.3.4.1	ISO-MOV-FTOC	~~2.3.4.1~~	~~ISO-MOV-FTOC~~	*Note 1*
		2.3.4.2	ISO-MOV-CC	~~2.3.4.2~~	~~ISO-MOV-CC~~	*Note 1*
		2.3.4.3	ISO-MOV-OO	~~2.3.4.3~~	~~ISO-MOV-OO~~	*Note 1*
	2.3.5 PWR AFW MOVs	2.3.5.1	AFW-MOV-FTOC	2.3.5.1	AFW-MOV-FTOC	
		2.3.5.2	AFW-MOV-CC	2.3.5.2	AFW-MOV-CC	
		2.3.5.3	AFW-MOV-OO	2.3.5.3	AFW-MOV-OO	
	2.3.6 PWR HPSI MOVs	2.3.6.1	HPI-MOV-FTOC	2.3.6.1	HPI-MOV-FTOC	
		2.3.6.2	HPI-MOV-CC	2.3.6.2	HPI-MOV-CC	
		2.3.6.3	HPI-MOV-OO	2.3.6.3	HPI-MOV-OO	

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
	2.3.7 PWR RHR MOVs	2.3.7.1	PWR-RHR-MOV-FTOC	2.3.7.1	PWR-RHR-MOV-FTOC	
		2.3.7.2	PWR-RHR-MOV-CC	2.3.7.2	PWR-RHR-MOV-CC	
		2.3.7.3	PWR-RHR-MOV-OO	2.3.7.3	PWR-RHR-MOV-OO	
	2.3.8 BWR HPCI/RCIC MOVs	2.3.8.1	HCI-RCI-MOV-FTOC	2.3.8.1	HCI-RCI-MOV-FTOC	
		2.3.8.2	HCI-RCI-MOV-CC	2.3.8.2	HCI-RCI-MOV-CC	
		2.3.8.3	HCI-RCI-MOV-OO	2.3.8.3	HCI-RCI-MOV-OO	
	2.3.9 Pressurizer PORV Block MOVs			2.3.4.1	PWR-RCS-MOV-FTOC	
		2.3.9.1	PWR-RCS-MOV-CC	2.3.4.2	PWR-RCS-MOV-CC	
		2.3.9.2	PWR-RCS-MOV-OO	2.3.4.3	PWR-RCS-MOV-OO	
2.4 Air-Operated Valves (AOVs)	2.4.1 Pooled AOVs	2.4.1.1	ALL-AOV-FTOC	2.4.1.1	ALL-AOV-FTOC	
		2.4.1.2	ALL-AOV-CC	2.4.1.2	ALL-AOV-CC	
		2.4.1.3	ALL-AOV-OO	2.4.1.3	ALL-AOV-OO	
		2.4.1.4	ALL-AOV-SO	2.4.1.4	ALL-AOV-SO	
	2.4.2 BWR Isolation Condenser AOVs	2.4.2.1	ISO-AOV-FTOC	~~2.4.2.1~~	~~ISO-AOV-FTOC~~	*Note 1*
		2.4.2.2	ISO-AOV-CC	~~2.4.2.2~~	~~ISO-AOV-CC~~	*Note 1*
		2.4.2.3	ISO-AOV-OO	~~2.4.2.3~~	~~ISO-AOV-OO~~	*Note 1*
	2.4.3 PWR AFW AOVs	2.4.3.1	AFW-AOV-FTOC	2.4.2.1	AFW-AOV-FTOC	
		2.4.3.2	AFW-AOV-CC	2.4.2.2	AFW-AOV-CC	
		2.4.3.3	AFW-AOV-OO	2.4.2.3	AFW-AOV-OO	
	2.4.4 HPCI/RCIC AOVs	2.4.4.1	HCI-RCI-AOV-FTOC	~~2.4.4.1~~	~~HCI-RCI-AOV-FTOC~~	*Note 1*
		2.4.4.2	HCI-RCI-AOV-CC	~~2.4.4.2~~	~~HCI-RCI-AOV-CC~~	*Note 1*
		2.4.4.3	HCI-RCI-AOV-OO	~~2.4.4.3~~	~~HCI-RCI-AOV-OO~~	*Note 1*
2.5 Check Valves (CKVs)	2.5.1 Pooled CKVs	2.5.1.1	ALL-CKV-CC	2.5.1.1	ALL-CKV-CC	
		2.5.1.2	ALL-CKV-OO	2.5.1.2	ALL-CKV-OO	

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
		2.5.1.3	ALL-CKV-CO	~~2.5.1.3~~	~~ALL-CKV-CO~~	*Note 1*
		2.5.1.4	ALL-CKV-LK	2.5.1.3	ALL-CKV-LK	
	2.5.2 BWR RHR CKVs	2.5.2.1	BWR-RHR-CKV-CC	~~2.5.2.1~~	~~BWR-RHR-CKV-CC~~	*Note 1*
		2.5.2.2	BWR-RHR-CKV-OO	~~2.5.2.2~~	~~BWR-RHR-CKV-OO~~	*Note 1*
	2.5.3 PWR AFW CKVs	2.5.3.1	AFW-CKV-CC	~~2.5.3.1~~	~~AFW-CKV-CC~~	*Note 1*
		2.5.3.2	AFW-CKV-OO	2.5.2.1	AFW-CKV-OO	
	2.5.4 PWR HPSI CKVs	2.5.4.1	HPI-CKV-CC	~~2.5.4.1~~	~~HPI-CKV-CC~~	*Note 1*
		2.5.4.2	HPI-CKV-OO	~~2.5.4.2~~	~~HPI-CKV-OO~~	*Note 1*
	2.5.5 PWR RHR CKVs	2.5.5.1	PWR-RHR-CKV-CC	~~2.5.5.1~~	~~PWR-RHR-CKV-CC~~	*Note 1*
		2.5.5.2	PWR-RHR-CKV-OO	2.5.3.1	PWR-RHR-CKV-OO	
	2.5.6 BWR HPCI/RCIC CKVs	2.5.6.1	HCI-RCI-CKV-CC	~~2.5.6.1~~	~~HCI-RCI-CKV-CC~~	*Note 1*
		2.5.6.2	HCI-RCI-CKV-OO	2.5.4.1	HCI-RCI-CKV-OO	
2.6 Strainers, Trash Racks, and Filters (STRs/TSAs/SMPs)	2.6.1 Pooled Strainers	2.6.1.1	ALL-TSA-PG	2.6.1.1	ALL-TSA-PG	
		2.6.1.2	ALL-TSA-PG-EE	2.6.1.2	ALL-TSA-PG-EE	
		2.6.1.3	ALL-TSA-PG-NE	2.6.1.3	ALL-TSA-PG-NE	
		2.6.1.4	ALL-TSA-FO-NE	2.6.1.4	ALL-TSA-FTOP-NE	
		2.6.1.5	CLN-STR-PG	~~2.6.1.5~~	~~CLN-STR-PG~~	*Note 1*
	2.6.2 SWS Strainers	2.6.2.1	SWS-TSA-FO-NE	2.6.2.1	SWS-TSA-FTOP-NE	
		2.6.2.2	SWS-TSA-PG	~~2.6.2.2~~	~~SWS-TSA-PG~~	*Note 1*
		2.6.2.3	SWS-TSA-PG-EE	~~2.6.2.3~~	~~SWS-TSA-PG-EE~~	*Note 1*
		2.6.2.4	SWS-TSA-PG-NE	~~2.6.2.4~~	~~SWS-TSA-PG-NE~~	*Note 1*
		2.6.2.5	SWS-STR-PG	2.6.2.2	SWS-STR-PG	
		2.6.2.6	SWS-STR-PG-EE	2.6.2.3	SWS-STR-PG-EE	
		2.6.2.7	SWS-STR-PG-NE	2.6.2.4	SWS-STR-PG-NE	
	2.6.3 Pooled Sump Strainers	2.6.3.1	ALL-SMP-PG	~~2.6.3.1~~	~~ALL-SMP-PG~~	*Note 1*

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
	2.6.4 PWR Containment Sump Strainers	2.6.4.1	CSS-STR-PG	~~2.6.4.1~~	~~CSS-STR-PG~~	*Note 1*
	2.6.5 BWR Suppression Pool Strainers	2.6.5.1	BWR-RHR-STR-PG	~~2.6.5.1~~	~~BWR-RHR-STR-PG~~	*Note 1*
	2.6.6 CWS Strainers	2.6.6.1	CWS-TSA-PG-EE	2.6.3.1	CWS-TSA-PG-EE	
		2.6.6.2	CWS-TSA-PG-NE	2.6.3.2	CWS-TSA-PG-NE	
2.7 Heat Exchangers (HTXs)	2.7.1 Pooled HTXs	2.7.1.1	ALL-HTX-HT	2.7.1.1	ALL-HTX-HT	
		2.7.1.2	ALL-HTX-HT-EE	~~2.7.1.2~~	~~ALL-HTX-HT-EE~~	*Note 1*
		2.7.1.3	ALL-HTX-HT-NE	~~2.7.1.3~~	~~ALL-HTX-HT-NE~~	*Note 1*
	2.7.2 PWR HTXs	2.7.2.1	PWR-RHR-HTX-HT	~~2.7.2.1~~	~~PWR-RHR-HTX-HT~~	*Note 1*
	2.7.3 CS HTXs	2.7.3.1	CSS-HTX-HT	~~2.7.3.1~~	~~CSS-HTX-HT~~	*Note 1*
	2.7.4 BWR RHR HTXs	2.7.4.1	BWR-RHR-HTX-HT	~~2.7.4.1~~	~~BWR-RHR-HTX-HT~~	*Note 1*
	2.7.5 BWR IS HTXs	2.7.5.1	ISO-HTX-HT-NE	~~2.7.5.1~~	~~ISO-HTX-HT-NE~~	*Note 1*
	2.7.6 CCW HTXs	2.7.6.1	CCW-HTX-HT	2.7.2.1	CCW-HTX-HT	
		2.7.6.2	CCW-HTX-HT-EE	~~2.7.6.2~~	~~CCW-HTX-HT-EE~~	*Note 1*
		2.7.6.3	CCW-HTX-HT-NE	~~2.7.6.3~~	~~CCW-HTX-HT-NE~~	*Note 1*
2.8 Safety and Relief Valves (SVVs/SRVs)	2.8.1 Pooled SVVs	2.8.1.1	ALL-SVV-CC	2.8.1.1	ALL-SVV-CC	
		2.8.1.2	ALL-SVV-OO	2.8.1.2	ALL-SVV-OO	
	2.8.2 PWR MSS SVVs	2.8.2.1	PWR-MSS-SVV-CC	~~2.8.2.1~~	~~PWR-MSS-SVV-CC~~	*Note 1*
		2.8.2.2	PWR-MSS-SVV-OO	~~2.8.2.2~~	~~PWR-MSS-SVV-OO~~	*Note 1*
	2.8.3 BWR SRVs	2.8.3.1	BWR-MSS-SRV-CC	2.8.2.1	BWR-MSS-SRV-CC	
		2.8.3.2	BWR-MSS-SRV-OO	2.8.2.2	BWR-MSS-SRV-OO	
		2.8.3.3	BWR-MSS-SRV-CO	~~2.8.3.3~~	~~BWR-MSS-SRV-CO~~	*Note 1*
	2.8.4 PWR RCS SVVs	2.8.4.1	PWR-RCS-SVV-CC	~~2.8.4.1~~	~~PWR-RCS-SVV-CC~~	*Note 1*
		2.8.4.2	PWR-RCS-SVV-OO	~~2.8.4.2~~	~~PWR-RCS-SVV-OO~~	*Note 1*
	2.9.1 Pooled PORVs	2.9.1.1	ALL-PORV-CC	2.9.1.1	ALL-PORV-CC	
		2.9.1.2	ALL-PORV-OO	2.9.1.2	ALL-PORV-OO	

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
2.9 Power-Operated Relief Valves (PORVs)	2.9.2 PWR SG PORVs	2.9.2.1	PWR-MSS-PRV-CC	2.9.2.1	PWR-MSS-PRV-CC	
		2.9.2.2	PWR-MSS-PRV-OO	2.9.2.2	PWR-MSS-PRV-OO	
	2.9.3 PWR PZR PORVs	2.9.3.1	PWR-RCS-PORV-CC	2.9.3.1	PWR-RCS-PORV-CC	
		2.9.3.2	PWR-RCS-PORV-OO	2.9.3.2	PWR-RCS-PORV-OO	
2.10 Main Steam Isolation Valves (MSIVs)	2.10.1 PWR MSIVs	2.10.1.1	PWR-MSS-MSV-CC	2.10.1.1	PWR-MSS-MSV-CC	
		2.10.1.2	PWR-MSS-MSV-OO	2.10.1.2	PWR-MSS-MSV-OO	
	2.10.2 BWR MSIVs	2.10.2.1	BWR-MSS-MSV-CC	2.10.2.1	BWR-MSS-MSV-CC	
		2.10.2.2	BWR-MSS-MSV-OO	2.10.2.2	BWR-MSS-MSV-OO	
2.11 Generators	2.11.1 EDGs	2.11.1.1	EPS-EDG-FS	2.11.1.1	EPS-EDG-FS	
		2.11.1.2	EPS-EDG-LR	2.11.1.2	EPS-EDG-LR	
		2.11.1.3	EPS-EDG-FR	2.11.1.3	EPS-EDG-FR	
2.12 Vacuum Breakers (VACs)	2.12.1 BWR Suppression VACs	2.12.1.1	CVR-VAC-CC	2.12.1.1	CVR-VAC-CC	
2.13 AC Power Distribution Breakers (CRB)	2.13.1 480VAC Circuit Breakers	2.13.1.1	ACP-CRB-480-CC	2.13.1.1	ACP-CRB-480-CC	
		2.13.1.2	ACP-CRB-480-OO	2.13.1.2	ACP-CRB-480-OO	
		2.13.1.3	ACP-CRB-480-SA	2.13.1.3	ACP-CRB-480-SA	
		2.13.1.4	ACP-CRB-480-FTOC	2.13.1.4	ACP-CRB-480-FTOC	
	2.13.2 4160VAC Circuit Breakers	2.13.2.1	ACP-CRB-4160-CC	2.13.2.1	ACP-CRB-4160-CC	
		2.13.2.2	ACP-CRB-4160-OO	2.13.2.2	ACP-CRB-4160-OO	
		2.13.2.3	ACP-CRB-4160-SA	2.13.2.3	ACP-CRB-4160-SA	
		2.13.2.4	ACP-CRB-4160-FTOC	2.13.2.4	ACP-CRB-4160-FTOC	
2.14 DC Systems	2.14.1 Batteries	2.14.1.1	DCP-BAT-NO	2.14.1.1	DCP-BAT-LP	
	2.14.2 Battery Chargers	2.14.2.1	DCP-BCH-FC	2.14.2.1	DCP-BCH-LP	
	2.14.3 Circuit Breakers	2.14.3.1	DCP-CRB-CC	~~2.14.3.1~~	~~DCP-CRB-CC~~	*Note 1*

CCF Report		2015 Update		2020 Update		Note
Component Type	**Sub-Group**	**Section**	**CCF Template**	**Section**	**CCF Template**	
		2.14.3.2	DCP-CRB-OO	~~2.14.3.2~~	~~DCP-CRB-OO~~	*Note 1*
		2.14.3.3	DCP-CRB-SA	~~2.14.3.3~~	~~DCP-CRB-SA~~	*Note 1*
		2.14.3.4	DCP-CRB-FTOC	~~2.14.3.4~~	~~DCP-CRB-FTOC~~	*Note 1*
2.15 Reactor Trip Breakers (RTBs)	2.15.1 RPS Rx Trip Breakers	2.15.1.1	RPS-RTB-CC	2.15.1.1	RPS-RTB-CC	
2.16 Air Compressors (MDCs)	2.16.1 Motor-Driven Air Compressors	2.16.1.1	ALL-MDC-FS	2.16.1.1	ALL-MDC-FS	
		2.16.1.2	ALL-MDC-FR	2.16.1.2	ALL-MDC-FR	
3.1 Generic Distributions	3.1.1 Demand	3.1.1.1	CCF-DEM	3.1.1.1	CCF-DEM	
	3.1.2 Rate	3.1.2.1	CCF-RATE	3.1.2.1	CCF-RATE	
	3.1.3 CCF Prior	3.1.3.1	CCF (No Data)	3.1.3.1	CCF (No Data)	

Note:
1. These 2015 templates are removed from the 2020 analysis. Most of them are system specific templates with zero CCF event and zero to two independent events. The Bayesian update results, if conducted, would be very close to those in Section 3.1.3, CCF Prior Distribution, of this report.

Appendix B
COMPARISON OF CCF 2020 UPDATE AND 2015 UPDATE RESULTS

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.1.1.1	ALL-MDP-FS	21	679.0	1.66E-02	5.23E-03	2.04E-03	4	339.9	1.08E-02	-35%	5.05E-03	-3%	2.07E-03	1%
2.1.1.2	ALL-MDP-FH	4	56.8	3.52E-02	8.34E-03	3.64E-03	0	32.5	8.46E-03	-76%	3.02E-03	-64%	1.85E-03	-49%
2.1.1.3	ALL-MDP-FHRH	15	217.3	3.01E-02	7.45E-03	2.61E-03	6	127.5	1.62E-02	-46%	4.18E-03	-44%	1.33E-03	-49%
2.1.1.4	ALL-MDP-RH	11	160.5	2.81E-02	7.08E-03	2.41E-03	6	95.0	1.97E-02	-30%	4.92E-03	-31%	1.55E-03	-36%
2.1.1.5	ALL-MDP-FR-NR	9	354.2	1.39E-02	4.31E-03	1.76E-03	5	134.5	2.05E-02	47%	6.68E-03	55%	2.74E-03	56%
2.1.1.6	ALL-MDP-FS-NS	21	428.2	2.54E-02	7.93E-03	3.09E-03	4	254.8	1.36E-02	-46%	6.26E-03	-21%	2.55E-03	-17%
2.1.1.7	ALL-MDP-FS-NR	0	247.8	1.68E-03	9.60E-04	7.53E-04	2	191.1	6.48E-03	286%	1.77E-03	84%	1.04E-03	38%
2.1.2.1	ALL-PMP-FR	2	92.1	1.45E-02	4.51E-03	2.00E-03	0	51.1	6.33E-03	-56%	2.51E-03	-44%	1.61E-03	-20%
2.1.3.1	CLN-MDP-FS	13	464.6	1.76E-02	6.13E-03	2.39E-03	2	193.3	1.27E-02	-28%	6.18E-03	1%	2.52E-03	5%
2.1.3.2	CLN-MDP-FH	3	32.1	4.42E-02	1.09E-02	4.66E-03	0	15.1	1.23E-02	-72%	3.73E-03	-66%	2.15E-03	-54%
2.1.3.3	CLN-MDP-FHRH	7	89.6	3.59E-02	9.81E-03	4.01E-03	2	46.6	1.18E-02	-67%	3.46E-03	-65%	1.75E-03	-56%
2.1.3.4	CLN-MDP-RH	4	57.5	3.12E-02	8.69E-03	3.73E-03	2	31.5	1.47E-02	-53%	4.10E-03	-53%	2.04E-03	-45%
2.1.4.1	CSS-MDP-FS	3	37.0	4.81E-02	NA	NA	0	17.0	1.17E-02	-76%	3.64E-03	*(Note 1)*	2.11E-03	*(Note 1)*
2.1.4.2	CSS-MDP-FH	0	8.0	2.33E-02	NA	NA	0	3.0	1.81E-02	-22%	4.46E-03	*(Note 1)*	2.42E-03	*(Note 1)*
2.1.4.3	CSS-MDP-FHRH	0	14.1	1.75E-02	NA	NA	0	5.0	1.68E-02	-4%	4.32E-03	*(Note 1)*	2.37E-03	*(Note 1)*
2.1.4.4	CSS-MDP-RH	0	6.1	2.59E-02	NA	NA	0	2.0	1.88E-02	-27%	4.53E-03	*(Note 1)*	2.45E-03	*(Note 1)*
2.1.5.1	BWR-RHR-MDP-FS	2	39.0	2.41E-02	4.32E-03	2.50E-03	1	23.7	2.03E-02	-16%	5.17E-03	20%	2.51E-03	0%
2.1.5.2	BWR-RHR-MDP-FH	0	5.0	2.77E-02	7.49E-03	4.20E-03	0	2.0	1.88E-02	-32%	4.53E-03	-40%	2.45E-03	-42%
2.1.5.3	BWR-RHR-MDP-FHRH	0	16.5	1.60E-02	5.67E-03	3.45E-03	1	13.1	1.49E-02	-7%	3.82E-03	-33%	2.10E-03	-39%
2.1.5.4	BWR-RHR-MDP-RH	0	11.5	1.96E-02	6.34E-03	3.74E-03	1	11.1	1.55E-02	-21%	3.93E-03	-38%	2.15E-03	-43%
2.1.6.1	AFW-MDP-FS	2	44.7	3.95E-02	1.74E-02	6.93E-03	1	24.5	3.65E-02	-8%	1.51E-02	-13%	5.79E-03	-16%
2.1.6.2	AFW-MDP-FH	2	8.5	3.67E-02	6.47E-03	3.51E-03	0	3.0	1.81E-02	-51%	4.46E-03	-31%	2.42E-03	-31%
2.1.6.3	AFW-MDP-FHRH	2	18.2	2.74E-02	5.27E-03	2.92E-03	0	6.5	1.59E-02	-42%	4.22E-03	-20%	2.34E-03	-20%
2.1.6.4	AFW-MDP-RH	0	9.7	2.13E-02	6.62E-03	3.86E-03	0	3.5	1.78E-02	-16%	4.42E-03	-33%	2.41E-03	-38%
2.1.7.1	AFW-PMP-FR	1	22.1	1.54E-02	4.17E-03	2.34E-03	0	9.0	1.47E-02	-5%	4.06E-03	-3%	2.28E-03	-3%

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.1.8.1	SWN-MDP-FS	0	30.5	1.06E-02	4.37E-03	2.84E-03	0	26.1	9.57E-03	-10%	3.25E-03	-26%	1.95E-03	-31%
2.1.8.2	SWN-MDP-FR	3	71.0	2.88E-02	1.20E-02	4.91E-03	3	45.0	3.21E-02	11%	1.18E-02	-2%	4.66E-03	-5%
2.1.8.3	SSW-MDP-FS	8	152.9	1.55E-02	2.55E-03	1.35E-03	2	108.0	9.45E-03	-39%	2.41E-03	-5%	1.39E-03	3%
2.1.8.4	SSW-MDP-FR	7	121.2	2.26E-02	4.58E-03	1.41E-03	4	78.9	2.04E-02	-10%	4.78E-03	4%	1.45E-03	3%
2.1.8.5	SWS-MDP-FS	8	183.4	1.34E-02	2.22E-03	1.18E-03	2	134.1	8.26E-03	-38%	2.16E-03	-3%	1.26E-03	7%
2.1.8.6	SWS-MDP-FR	11	198.7	2.53E-02	8.30E-03	2.89E-03	7	130.4	2.72E-02	8%	9.46E-03	14%	3.22E-03	11%
2.1.8.7	SWS-MDP-FR-EE	2	6.1	4.50E-02	6.72E-03	3.73E-03	*(Note 2)*							
2.1.9.1	HPI-MDP-FS	1	162.7	8.23E-03	2.78E-03	1.26E-03	0	42.1	7.21E-03	-12%	2.74E-03	-1%	1.72E-03	37%
2.1.9.2	HPI-MDP-FH	0	2.5	3.30E-02	8.06E-03	4.41E-03	0	2.0	1.88E-02	-43%	4.53E-03	-44%	2.45E-03	-44%
2.1.9.3	HPI-MDP-FHRH	8	146.4	2.46E-02	5.55E-03	2.36E-03	1	18.1	1.72E-02	-30%	4.61E-03	-17%	2.27E-03	-4%
2.1.9.4	HPI-MDP-RH	8	143.9	2.50E-02	5.63E-03	2.40E-03	1	16.1	1.81E-02	-28%	4.78E-03	-15%	2.34E-03	-2%
2.1.10.1	PWR-RHR-MDP-FS	3	34.5	3.73E-02	1.01E-02	4.30E-03	0	16.0	1.21E-02	-68%	3.69E-03	-63%	2.13E-03	-50%
2.1.10.2	PWR-RHR-MDP-FH	1	5.0	8.60E-02	1.96E-02	8.01E-03	0	3.0	1.81E-02	-79%	4.46E-03	-77%	2.42E-03	-70%
2.1.10.3	PWR-RHR-MDP-FHRH	1	15.4	5.30E-02	1.40E-02	5.92E-03	0	7.7	1.53E-02	-71%	4.14E-03	-70%	2.31E-03	-61%
2.1.10.4	PWR-RHR-MDP-RH	0	10.4	2.06E-02	6.51E-03	3.81E-03	0	4.7	1.70E-02	-17%	4.34E-03	-33%	2.38E-03	-38%
2.1.11.1	SLC-MDP-FS	1	18.5	1.51E-02	4.57E-03	2.61E-03	*(Note 2)*							
2.1.11.2	SLC-MDP-FH	0	2.0	3.43E-02	8.18E-03	4.45E-03	*(Note 2)*							
2.1.11.3	SLC-MDP-FHRH	0	4.2	2.92E-02	7.67E-03	4.27E-03	*(Note 2)*							
2.1.11.4	SLC-MDP-RH	0	2.2	3.37E-02	8.13E-03	4.44E-03	*(Note 2)*							
2.1.12.1	CCW-MDP-FS	0	92.7	4.20E-03	2.17E-03	NA	0	38.0	7.70E-03	83%	2.85E-03	31%	1.77E-03	*(Note 1)*
2.1.12.2	CCW-MDP-FR	1	72.1	1.09E-02	3.11E-03	NA	0	43.3	7.08E-03	-35%	2.70E-03	-13%	1.70E-03	*(Note 1)*
2.1.13.1	ALL-PDP-FS	1	112.6	3.60E-03	1.34E-03	8.14E-04	0	76.0	4.74E-03	32%	2.05E-03	53%	1.37E-03	68%
2.1.13.2	ALL-PDP-FR	4	99.4	2.02E-02	3.60E-03	1.76E-03	2	75.2	1.29E-02	-36%	2.03E-03	-44%	1.19E-03	-32%
2.2.1.1	ALL-TDP-FS	1	213.0	6.38E-03	2.18E-03	9.95E-04	0	145.1	2.79E-03	-56%	1.36E-03	-38%	9.74E-04	-2%
2.2.1.2	ALL-TDP-FH	0	69.6	5.41E-03	2.67E-03	1.89E-03	0	41.0	7.33E-03	35%	2.77E-03	4%	1.73E-03	-8%
2.2.1.3	ALL-TDP-FHRH	0	91.0	4.27E-03	2.20E-03	1.60E-03	0	58.9	5.73E-03	34%	2.35E-03	7%	1.53E-03	-4%
2.2.1.4	ALL-TDP-RH	0	21.4	1.35E-02	5.13E-03	3.21E-03	0	17.9	1.15E-02	-15%	3.59E-03	-30%	2.10E-03	-35%
2.2.1.5	ALL-TDP-FR-NR	0	98.2	3.99E-03	2.07E-03	1.52E-03	0	76.9	4.70E-03	18%	2.04E-03	-1%	1.37E-03	-10%
2.2.2.1	AFW-TDP-FS	0	89.0	4.36E-03	2.23E-03	1.63E-03	0	60.1	5.65E-03	30%	2.32E-03	4%	1.52E-03	-7%

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.2.2.2	AFW-TDP-FH	0	44.0	7.95E-03	3.58E-03	2.42E-03	0	22.5	1.03E-02	30%	3.39E-03	-5%	2.01E-03	-17%
2.2.2.3	AFW-TDP-FHRH	0	59.3	6.21E-03	2.97E-03	2.08E-03	0	33.3	8.34E-03	34%	3.00E-03	1%	1.84E-03	-12%
2.2.2.4	AFW-TDP-RH	0	15.3	1.67E-02	5.81E-03	3.52E-03	0	10.8	1.39E-02	-17%	3.96E-03	-32%	2.24E-03	-36%
2.2.3.1	HCI-RCI-TDP-FS	1	108.0	1.20E-02	NA	NA	0	81.0	4.51E-03	-62%	1.98E-03	*(Note 1)*	1.33E-03	*(Note 1)*
2.2.3.2	HCI-RCI-TDP-FH	0	25.6	1.20E-02	NA	NA	0	18.5	1.13E-02	-6%	3.57E-03	*(Note 1)*	2.08E-03	*(Note 1)*
2.2.3.3	HCI-RCI-TDP-FHRH	0	31.7	1.03E-02	NA	NA	0	25.6	9.66E-03	-6%	3.27E-03	*(Note 1)*	1.96E-03	*(Note 1)*
2.2.3.4	HCI-RCI-TDP-RH	0	6.1	2.59E-02	NA	NA	0	7.1	1.56E-02	-40%	4.18E-03	*(Note 1)*	2.32E-03	*(Note 1)*
2.3.1.1	ALL-MOV-FTOC	9	625.7	9.36E-03	2.27E-03	9.68E-04	2	349.0	3.61E-03	-61%	8.57E-04	-62%	5.21E-04	-46%
2.3.1.2	ALL-MOV-CC	4	356.9	1.52E-02	4.65E-03	1.96E-03	0	207.2	2.04E-03	-87%	1.04E-03	-78%	7.72E-04	-61%
2.3.1.3	ALL-MOV-OO	5	239.3	7.89E-03	1.38E-03	8.25E-04	2	119.8	8.50E-03	8%	1.83E-03	33%	1.08E-03	31%
2.3.1.4	ALL-MOV-CO	1	43.0	2.92E-02	7.10E-03	3.36E-03	1	32.0	3.68E-02	26%	1.52E-02	114%	9.81E-03	192%
2.3.1.5	ALL-MOV-LK	3	67.1	3.87E-02	9.96E-03	4.33E-03	0	32.1	8.52E-03	-78%	3.04E-03	-69%	1.86E-03	-57%
2.3.2.1	CSS-MOV-FTOC	0	38.0	8.93E-03	3.89E-03	2.59E-03	0	24.5	9.89E-03	11%	3.31E-03	-15%	1.98E-03	-24%
2.3.2.2	CSS-MOV-CC	0	24.0	1.25E-02	4.89E-03	3.09E-03	0	14.5	1.25E-02	0%	3.76E-03	-23%	2.16E-03	-30%
2.3.2.3	CSS-MOV-OO	0	14.0	1.76E-02	5.98E-03	3.59E-03	0	10.0	1.42E-02	-19%	4.01E-03	-33%	2.26E-03	-37%
2.3.3.1	BWR-RHR-MOV-FTOC	2	143.0	1.41E-02	4.36E-03	1.96E-03	1	85.6	8.29E-03	-41%	2.22E-03	-49%	1.29E-03	-34%
2.3.3.2	BWR-RHR-MOV-CC	1	87.2	1.45E-02	4.72E-03	2.12E-03	0	53.0	6.17E-03	-57%	2.47E-03	-48%	1.59E-03	-25%
2.3.3.3	BWR-RHR-MOV-OO	1	52.8	1.36E-02	3.74E-03	2.18E-03	1	29.6	1.43E-02	5%	3.35E-03	-10%	1.87E-03	-14%
2.3.4.1	ISO-MOV-FTOC	0	8.1	2.31E-02	6.89E-03	3.97E-03	*(Note 2)*							
2.3.4.2	ISO-MOV-CC	0	6.1	2.59E-02	7.72E-03	4.12E-03	*(Note 2)*							
2.3.4.3	ISO-MOV-OO	0	2.0	3.43E-02	8.18E-03	4.45E-03	*(Note 2)*							
2.3.5.1	AFW-MOV-FTOC	3	84.8	1.94E-02	3.91E-03	1.94E-03	0	56.1	5.93E-03	-69%	2.40E-03	-39%	1.56E-03	-20%
2.3.5.2	AFW-MOV-CC	1	44.2	2.42E-02	5.91E-03	2.84E-03	0	31.5	8.62E-03	-64%	3.06E-03	-48%	1.87E-03	-34%
2.3.5.3	AFW-MOV-OO	2	37.6	2.46E-02	4.86E-03	2.78E-03	0	21.6	1.05E-02	-57%	3.43E-03	-29%	2.03E-03	-27%
2.3.6.1	HPI-MOV-FTOC	0	72.6	5.22E-03	2.59E-03	1.85E-03	0	25.5	9.68E-03	85%	3.27E-03	26%	1.96E-03	6%
2.3.6.2	HPI-MOV-CC	0	36.1	9.29E-03	4.00E-03	2.65E-03	0	13.5	1.29E-02	39%	3.81E-03	-5%	2.18E-03	-18%
2.3.6.3	HPI-MOV-OO	0	32.0	1.02E-02	4.26E-03	2.78E-03	0	9.5	1.45E-02	42%	4.03E-03	-5%	2.27E-03	-18%
2.3.7.1	PWR-RHR-MOV-FTOC	1	103.7	1.85E-02	5.30E-03	2.99E-03	0	50.0	6.43E-03	-65%	2.54E-03	-52%	1.62E-03	-46%
2.3.7.2	PWR-RHR-MOV-CC	1	65.6	2.32E-02	6.17E-03	3.43E-03	0	29.0	9.03E-03	-61%	3.14E-03	-49%	1.90E-03	-45%

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.3.7.3	PWR-RHR-MOV-OO	0	32.1	1.02E-02	4.26E-03	2.78E-03	0	15.5	1.22E-02	20%	3.71E-03	-13%	2.14E-03	-23%
2.3.8.1	HCI-RCI-MOV-FTOC	2	94.4	1.00E-02	3.12E-03	1.79E-03	0	53.1	6.17E-03	-38%	2.47E-03	-21%	1.59E-03	-11%
2.3.8.2	HCI-RCI-MOV-CC	1	50.1	1.59E-02	4.79E-03	2.73E-03	0	34.1	8.22E-03	-48%	2.97E-03	-38%	1.83E-03	-33%
2.3.8.3	HCI-RCI-MOV-OO	1	38.3	1.61E-02	4.57E-03	2.56E-03	0	16.0	1.21E-02	-25%	3.69E-03	-19%	2.13E-03	-17%
	PWR-RCS-MOV-FTOC	*(Note 3)*					0	10.0	1.42E-02	*(Note 3)*	4.01E-03	*(Note 3)*	2.26E-03	*(Note 3)*
2.3.9.1	PWR-RCS-MOV-CC	0	7.0	2.46E-02	7.10E-03	4.05E-03	0	4.0	1.74E-02	-29%	4.39E-03	-38%	2.40E-03	-41%
2.3.9.2	PWR-RCS-MOV-OO	0	7.0	2.46E-02	7.10E-03	4.05E-03	0	5.0	1.68E-02	-32%	4.32E-03	-39%	2.37E-03	-41%
2.4.1.1	ALL-AOV-FTOC	14	266.2	3.77E-02	1.45E-02	7.70E-03	7	144.2	2.92E-02	-23%	7.45E-03	-49%	3.28E-03	-57%
2.4.1.2	ALL-AOV-CC	6	156.8	1.97E-02	6.11E-03	3.08E-03	4	91.8	3.28E-02	66%	9.41E-03	54%	4.13E-03	34%
2.4.1.3	ALL-AOV-OO	7	98.4	5.04E-02	2.01E-02	1.16E-02	3	45.4	2.13E-02	-58%	3.34E-03	-83%	1.77E-03	-85%
2.4.1.4	ALL-AOV-SO	1	56.1	2.12E-02	6.63E-03	2.93E-03	1	29.0	2.78E-02	31%	7.50E-03	13%	3.18E-03	9%
2.4.2.1	ISO-AOV-FTOC	1	1.0	1.18E-01	3.91E-02	2.45E-02	*(Note 2)*							
2.4.2.2	ISO-AOV-CC	0	1.0	3.72E-02	8.44E-03	4.55E-03	*(Note 2)*							
2.4.2.3	ISO-AOV-OO	1	0.0	1.23E-01	4.00E-02	2.50E-02	*(Note 2)*							
2.4.3.1	AFW-AOV-FTOC	6	65.1	4.48E-02	1.30E-02	5.77E-03	2	33.3	3.38E-02	-25%	9.99E-03	-23%	4.36E-03	-24%
2.4.3.2	AFW-AOV-CC	3	35.1	3.67E-02	1.12E-02	5.45E-03	2	16.1	4.80E-02	31%	1.30E-02	16%	5.55E-03	2%
2.4.3.3	AFW-AOV-OO	2	28.0	2.35E-02	5.06E-03	2.89E-03	0	15.2	1.23E-02	-48%	3.73E-03	-26%	2.15E-03	-26%
2.4.4.1	HCI-RCI-AOV-FTOC	0	5.0	2.77E-02	7.49E-03	4.20E-03	*(Note 2)*							
2.4.4.2	HCI-RCI-AOV-CC	0	4.0	2.96E-02	7.71E-03	4.28E-03	*(Note 2)*							
2.4.4.3	HCI-RCI-AOV-OO	0	1.0	3.72E-02	8.44E-03	4.55E-03	*(Note 2)*							
2.5.1.1	ALL-CKV-CC	0	10.0	2.10E-02	6.57E-03	3.84E-03	0	2.0	1.88E-02	-10%	4.53E-03	-31%	2.45E-03	-36%
2.5.1.2	ALL-CKV-OO	2	49.1	4.27E-02	1.18E-02	5.07E-03	1	29.1	2.77E-02	-35%	7.49E-03	-37%	3.17E-03	-37%
2.5.1.3	ALL-CKV-CO	0	0.0	4.07E-02	8.72E-03	4.64E-03	*(Note 2)*							
2.5.1.4	ALL-CKV-LK	7	53.1	1.04E-01	3.46E-02	1.28E-02	0	20.6	1.08E-02	-90%	3.47E-03	-90%	2.05E-03	-84%
2.5.2.1	BWR-RHR-CKV-CC	0	2.0	3.43E-02	8.18E-03	4.45E-03	*(Note 2)*							
2.5.2.2	BWR-RHR-CKV-OO	0	6.0	2.60E-02	7.29E-03	4.12E-03	*(Note 2)*							
2.5.3.1	AFW-CKV-CC	0	2.0	3.43E-02	8.18E-03	4.45E-03	*(Note 2)*							
2.5.3.2	AFW-CKV-OO	1	6.6	3.45E-02	7.87E-03	4.25E-03	0	4.6	1.70E-02	-51%	4.35E-03	-45%	2.38E-03	-44%
2.5.4.1	HPI-CKV-CC	0	3.0	3.18E-02	7.94E-03	4.37E-03	*(Note 2)*							

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		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.5.4.2	HPI-CKV-OO	0	8.5	2.27E-02	6.82E-03	3.94E-03	*(Note 2)*							
2.5.5.1	PWR-RHR-CKV-CC	0	0.0	4.07E-02	8.72E-03	4.64E-03	*(Note 2)*							
2.5.5.2	PWR-RHR-CKV-OO	0	8.5	2.27E-02	6.82E-03	3.94E-03	0	7.0	1.57E-02	-31%	4.19E-03	-39%	2.32E-03	-41%
2.5.6.1	HCI-RCI-CKV-CC	0	1.0	3.72E-02	8.44E-03	4.55E-03	*(Note 2)*							
2.5.6.2	HCI-RCI-CKV-OO	0	6.0	2.60E-02	7.29E-03	4.12E-03	0	6.5	1.59E-02	-39%	4.22E-03	-42%	2.34E-03	-43%
2.6.1.1	ALL-TSA-PG	18	40.0	2.21E-02	6.74E-03	3.91E-03	8	22.0	1.46E-01	561%	5.89E-02	774%	2.45E-02	527%
2.6.1.2	ALL-TSA-PG-EE	18	31.0	2.64E-01	1.10E-01	4.49E-02	8	18.0	1.53E-01	-42%	6.10E-02	-45%	2.53E-02	-44%
2.6.1.3	ALL-TSA-PG-NE	0	9.0	2.21E-02	6.74E-03	3.91E-03	0	4.0	1.74E-02	-21%	4.39E-03	-35%	2.40E-03	-39%
2.6.1.4	ALL-TSA-FO-NE	13	79.0	1.41E-01	6.80E-02	4.50E-02	4	36.5	3.88E-02	-72%	8.63E-03	-87%	3.62E-03	-92%
2.6.1.5	CLN-STR-PG	0	0.0	4.07E-02	8.72E-03	4.64E-03	*(Note 2)*							
2.6.2.1	SWS-TSA-FO-NE	3	32.0	5.07E-02	1.32E-02	5.63E-03	2	15.0	4.69E-02	-7%	1.08E-02	-18%	4.39E-03	-22%
2.6.2.2	SWS-TSA-PG	1	4.0	5.97E-02	1.40E-02	6.56E-03	*(Note 2)*							
2.6.2.3	SWS-TSA-PG-EE	1	3.0	6.20E-02	1.43E-02	6.69E-03	*(Note 2)*							
2.6.2.4	SWS-TSA-PG-NE	0	1.0	3.72E-02	8.44E-03	4.55E-03	*(Note 2)*							
2.6.2.5	SWS-STR-PG	7	47.0	8.02E-02	1.99E-02	8.17E-03	4	24.5	7.00E-02	-13%	1.58E-02	-21%	5.87E-03	-28%
2.6.2.6	SWS-STR-PG-EE	6	16.0	1.26E-01	2.90E-02	1.20E-02	3	7.0	8.51E-02	-32%	1.82E-02	-37%	6.90E-03	-43%
2.6.2.7	SWS-STR-PG-NE	1	31.0	2.91E-02	6.73E-03	3.20E-03	1	17.5	2.27E-02	-22%	4.75E-03	-29%	2.20E-03	-31%
2.6.3.1	ALL-SMP-PG	0	1.5	3.57E-02	8.31E-03	4.50E-03	*(Note 2)*							
2.6.4.1	CSS-STR-PG	0	0.0	4.07E-02	NA	NA	*(Note 2)*							
2.6.5.1	BWR-RHR-STR-PG	0	0.0	4.07E-02	8.72E-03	4.64E-03	*(Note 2)*							
2.6.6.1	CWS-TSA-PG-EE	17	28.0	2.70E-01	1.12E-01	4.55E-02	8	18.0	1.53E-01	-43%	6.10E-02	-46%	2.53E-02	-44%
2.6.6.2	CWS-TSA-PG-NE	0	8.0	2.33E-02	6.91E-03	3.98E-03	0	4.0	1.74E-02	-25%	4.39E-03	-36%	2.40E-03	-40%
2.7.1.1	ALL-HTX-HT	2	26.2	2.72E-02	5.60E-03	3.16E-03	1	15.0	1.86E-02	-32%	4.87E-03	-13%	2.38E-03	-25%
2.7.1.2	ALL-HTX-HT-EE	1	6.5	4.07E-02	7.31E-03	4.01E-03	*(Note 2)*							
2.7.1.3	ALL-HTX-HT-NE	1	19.7	2.51E-02	6.55E-03	3.62E-03	*(Note 2)*							
2.7.2.1	PWR-RHR-HTX-HT	0	1.1	3.69E-02	8.41E-03	4.54E-03	*(Note 2)*							
2.7.3.1	CSS-HTX-HT	0	3.5	3.06E-02	NA	NA	*(Note 2)*							
2.7.4.1	BWR-RHR-HTX-HT	0	2.0	3.43E-02	8.18E-03	4.45E-03	*(Note 2)*							
2.7.5.1	ISO-HTX-HT-NE	0	0.0	4.07E-02	8.72E-03	4.64E-03	*(Note 2)*							
2.7.6.1	CCW-HTX-HT	2	19.1	3.12E-02	6.15E-03	3.44E-03	1	11.5	2.05E-02	-34%	5.20E-03	-15%	2.52E-03	-27%

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.7.6.2	CCW-HTX-HT-EE	1	6.0	4.14E-02	7.39E-03	4.05E-03	*(Note 2)*							
2.7.6.3	CCW-HTX-HT-NE	1	13.1	2.87E-02	7.12E-03	3.89E-03	*(Note 2)*							
2.8.1.1	ALL-SVV-CC	3	3.5	4.17E-02	8.49E-03	4.46E-03	1	2.1	2.20E-02	-47%	4.72E-03	-44%	2.47E-03	-45%
2.8.1.2	ALL-SVV-OO	1	7.0	3.75E-02	8.27E-03	4.44E-03	0	1.0	1.96E-02	-48%	4.61E-03	-44%	2.47E-03	-44%
2.8.2.1	PWR-MSS-SVV-CC	3	1.0	4.28E-02	8.62E-03	4.51E-03	*(Note 2)*							
2.8.2.2	PWR-MSS-SVV-OO	1	6.0	3.79E-02	8.32E-03	4.46E-03	*(Note 2)*							
2.8.3.1	BWR-MSS-SRV-CC	7	29.6	4.16E-02	8.79E-03	4.09E-03	6	23.4	3.20E-02	-23%	5.74E-03	-35%	2.69E-03	-34%
2.8.3.2	BWR-MSS-SRV-OO	0	7.6	2.38E-02	6.99E-03	4.01E-03	0	2.6	1.84E-02	-23%	4.49E-03	-36%	2.43E-03	-39%
2.8.3.3	BWR-MSS-SRV-CO	1	11.0	3.11E-02	7.46E-03	4.06E-03	*(Note 2)*							
2.8.4.1	PWR-RCS-SVV-CC	0	2.5	3.30E-02	8.06E-03	4.41E-03	*(Note 2)*							
2.8.4.2	PWR-RCS-SVV-OO	0	1.0	3.72E-02	8.44E-03	4.55E-03	*(Note 2)*							
2.9.1.1	ALL-PORV-CC	8	109.4	2.77E-02	1.12E-02	4.60E-03	3	74.3	3.08E-02	11%	1.31E-02	17%	5.12E-03	11%
2.9.1.2	ALL-PORV-OO	1	40.1	1.41E-02	4.39E-03	2.52E-03	0	24.1	9.97E-03	-29%	3.33E-03	-24%	1.98E-03	-21%
2.9.2.1	PWR-MSS-PRV-CC	6	86.7	3.70E-02	1.45E-02	5.88E-03	3	58.2	3.44E-02	-7%	1.43E-02	-1%	5.51E-03	-6%
2.9.2.2	PWR-MSS-PRV-OO	1	32.6	1.61E-02	4.84E-03	2.76E-03	0	19.1	1.12E-02	-30%	3.54E-03	-27%	2.07E-03	-25%
2.9.3.1	PWR-RCS-PORV-CC	2	20.6	1.44E-02	4.34E-03	2.48E-03	0	13.0	1.31E-02	-9%	3.84E-03	-12%	2.19E-03	-12%
2.9.3.2	PWR-RCS-PORV-OO	0	5.5	2.69E-02	7.39E-03	4.16E-03	0	3.0	1.81E-02	-33%	4.46E-03	-40%	2.42E-03	-42%
2.10.1.1	PWR-MSS-MSV-CC	2	21.9	3.17E-02	7.21E-03	3.60E-03	1	11.1	2.17E-02	-32%	4.05E-03	-44%	2.21E-03	-39%
2.10.1.2	PWR-MSS-MSV-OO	6	35.3	4.56E-02	7.42E-03	3.34E-03	5	20.7	2.98E-02	-35%	4.30E-03	-42%	1.99E-03	-40%
2.10.2.1	BWR-MSS-MSV-CC	1	4.3	3.68E-02	8.26E-03	4.43E-03	0	2.8	1.82E-02	-51%	4.47E-03	-46%	2.43E-03	-45%
2.10.2.2	BWR-MSS-MSV-OO	3	11.4	3.37E-02	7.37E-03	4.02E-03	3	9.2	1.87E-02	-45%	4.39E-03	-40%	2.37E-03	-41%
2.11.1.1	EPS-EDG-FS	4	258.4	9.58E-03	3.02E-03	1.26E-03	1	153.4	8.28E-03	-14%	2.68E-03	-11%	1.20E-03	-5%
2.11.1.2	EPS-EDG-LR	5	271.3	5.77E-03	1.20E-03	7.20E-04	2	181.6	5.56E-03	-4%	1.41E-03	18%	8.41E-04	17%
2.11.1.3	EPS-EDG-FR	6	222.0	1.57E-02	4.48E-03	1.88E-03	3	181.6	1.38E-02	-12%	3.48E-03	-22%	1.54E-03	-18%
2.12.1.1	CVR-VAC-CC	1	9.5	3.70E-02	6.89E-03	3.81E-03	0	6.2	1.61E-02	-56%	4.24E-03	-38%	2.34E-03	-39%
2.13.1.1	ACP-CRB-480-CC	3	32.3	3.07E-02	7.28E-03	3.93E-03	0	14.1	1.27E-02	-59%	3.78E-03	-48%	2.17E-03	-45%
2.13.1.2	ACP-CRB-480-OO	1	59.2	2.49E-02	6.37E-03	3.51E-03	0	20.5	1.08E-02	-57%	3.48E-03	-45%	2.05E-03	-42%
2.13.1.3	ACP-CRB-480-SA	1	65.2	1.36E-02	3.32E-03	1.95E-03	1	39.0	1.47E-02	8%	3.10E-03	-7%	1.75E-03	-10%
2.13.1.4	ACP-CRB-480-FTOC	4	92.5	2.13E-02	5.57E-03	3.08E-03	0	35.6	8.01E-03	-62%	2.92E-03	-48%	1.81E-03	-41%
2.13.2.1	ACP-CRB-4160-CC	2	17.6	3.32E-02	7.41E-03	4.04E-03	0	6.5	1.59E-02	-52%	4.22E-03	-43%	2.34E-03	-42%

2015 Section	CCF Template	2015 Update					2020 Update							
		CCF Events	Ind. Events	α2 (CCCG=2)	α3 (CCCG=3)	α4 (CCCG=4)	CCF Events	Ind. Events	α2 (CCCG=2)	α2 Change %	α3 (CCCG=3)	α3 Change %	α4 (CCCG=4)	α4 Change %
2.13.2.2	ACP-CRB-4160-OO	0	78.3	4.88E-03	2.45E-03	1.76E-03	0	57.0	5.87E-03	20%	2.38E-03	-3%	1.55E-03	-12%
2.13.2.3	ACP-CRB-4160-SA	3	44.5	2.75E-02	6.29E-03	3.50E-03	0	23.0	1.02E-02	-63%	3.37E-03	-46%	2.00E-03	-43%
2.13.2.4	ACP-CRB-4160-FTOC	2	103.4	1.66E-02	4.65E-03	2.66E-03	0	70.0	5.04E-03	-70%	2.14E-03	-54%	1.42E-03	-47%
2.14.1.1	DCP-BAT-NO	1	32.1	1.75E-02	4.83E-03	2.75E-03	1	24.8	1.43E-02	-18%	3.53E-03	-27%	1.96E-03	-29%
2.14.2.1	DCP-BCH-FC	9	319.0	1.27E-02	3.41E-03	1.47E-03	2	164.6	8.28E-03	-35%	1.62E-03	-52%	9.60E-04	-35%
2.14.3.1	DCP-CRB-CC	0	1.5	3.57E-02	8.31E-03	4.50E-03	*(Note 2)*							
2.14.3.2	DCP-CRB-OO	0	13.0	1.83E-02	6.12E-03	3.65E-03	*(Note 2)*							
2.14.3.3	DCP-CRB-SA	0	8.6	2.25E-02	6.81E-03	3.93E-03	*(Note 2)*							
2.14.3.4	DCP-CRB-FTOC	0	14.5	1.73E-02	5.92E-03	3.56E-03	*(Note 2)*							
2.15.1.1	RPS-RTB-CC	0	8.6	2.25E-02	6.81E-03	3.93E-03	0	7.1	1.56E-02	-31%	4.18E-03	-39%	2.32E-03	-41%
2.16.1.1	ALL-MDC-FS	2	297.2	4.77E-03	1.05E-03	6.41E-04	0	176.1	2.35E-03	-51%	1.18E-03	12%	8.62E-04	34%
2.16.1.2	ALL-MDC-FR	4	729.7	6.30E-03	2.49E-03	1.00E-03	1	314.4	4.34E-03	-31%	1.46E-03	-41%	6.67E-04	-33%
3.1.1.1	CCF-DEM	107	3598.9	1.97E-02	6.31E-03	2.60E-03	43	2188.9	1.35E-02	-31%	4.37E-03	-31%	1.72E-03	-34%
3.1.2.1	CCF-RATE	116	3224.0	3.05E-02	1.19E-02	5.46E-03	55	2104.8	2.17E-02	-29%	8.28E-03	-30%	3.53E-03	-35%
3.1.3.1	CCF (No Data)	*(Note 4)*		2.57E-02	5.79E-03	2.98E-03	0	0.0	2.05E-02	-20%	4.68E-03	-19%	2.50E-03	-16%
		(Note 5)		4.06E-02	8.71E-03	4.64E-03			2.05E-02	-50%	4.68E-03	-46%	2.50E-03	-46%

Note:
1. These templates have only CCF parameters for CCCG = 2 (and CCCG = 3) in the 2015 Update, and thus have no comparison on α3 (and α4) parameter results between the 2015 Update and the 2020 Update.
2. These 2015 templates were removed from the 2020 analysis. Most of them are system specific templates with zero CCF event and zero to two independent events. The Bayesian update results, if conducted, would be very close to those in Section 3.1.3.1, CCF (No Data), i.e., CCF priors, in the 2020 Update.
3. This is a new template in the 2020 Update that is not in the 2015 Update. There are no comparison values on alpha parameters between the 2015 Update and the 2020 Update.
4. These are Section 3.1.3.1, CCF (No Data), or CCF prior mean values in the 2015 Update Report, however, they were not used in the 2015 CCF parameter estimations (refer to INL/EXT-21-43723, Developing Generic Prior Distributions for Common Cause Failure Alpha Factors and Causal Alpha Factors).
5. These are mean values of CCF prior distributions that were used in the 2015 CCF parameter update.
6. The top 10 largest alpha parameters (α2, α3, and α4) in the 2015 and 2020 Updates are highlighted.