Enhanced Component Performance Study

Motor-Operated Valves

1998–2011

1 INTRODUCTION

This report presents an enhanced performance evaluation of motor-operated valves (MOVs) at U.S. commercial nuclear power plants. This report does not estimate values for use in probabilistic risk assessments (PRAs), but does evaluate component performance over time. The 2010 Component Reliability Update [Reference 1], which is an update to Reference 2 (NUREG/CR-6928) reports MOV unreliability estimates using Equipment Performance and Information Exchange (EPIX) data from 1998–2010 for use in PRAs.

The trend evaluations in this study are based on the operating experience failure reports from fiscal year (FY) 1998 through FY 2011 for the component reliability as reported in EPIX. The MOV failure modes considered are failure-to-open/close (failure to operate) (FTOC), (failure to operate or control) (FTOP) and spurious operation (SO).

Previously, the study relied on operating experience obtained from licensee event reports, Nuclear Plant Reliability Data System (NPRDS), and EPIX. The EPIX database (which includes as a subset the Mitigating Systems Performance Index (MSPI) designated devices) has matured to the point where component availability and reliability can be estimated with a higher degree of assurance of accuracy. In addition, the population of data is much larger than the population used in the previous study.

The objective of the effort for the updated component performance studies is to obtain annual performance trends of failure rates and probabilities. An overview of the trending methods, glossary of terms, and abbreviations can be found in the Overview and Reference document on the Reactor Operational Experience Results and Databases web page.

The objective of the enhanced component performance study is to present an analysis of factors that could influence the system and component trends in addition to annual performance trends of failure rates and probabilities. Engineering analyses were performed with respect to time period and failure mode (Section 4.1). The factors analyzed are: sub-component, failure cause, detection method, recovery.

2 SUMMARY OF FINDINGS

The results of this study are summarized in this section. Of particular interest is the existence of any statistically significant[1] increasing trends. In this update, no statistically significant increasing trends were identified in the MOV results. Statistically significant decreasing trends were identified in the MOV results for the following:

- Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with > 20 demands per year. (see Figure 2)
- Frequency (failures per reactor year) of MOV FTOC events > 20 demands per year. (see Figure 10)

Highly statistically significant decreasing trends were identified in the MOV results for the following:

- Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with ≤ 20 demands per year. (see Figure 1)
- Frequency (demands per reactor year) of MOV operation demands, ≤ 20 demands per year. (see Figure 7)

Extremely statistically significant decreasing trends were identified in the MOV results for the following:

- Frequency (failures per reactor year) of MOV FTOC events ≤ 20 demands per year. (see Figure 9)

Considering the low-demand MOVs; Table 3 shows that 75% of the MOV FTOC failures occurred in seven systems. Table 4 shows that 82% of the MOV FTOP failures occurred in six systems. Similarly, Table 5 shows that 90% of the MOV SO failures occurred in seven systems. And considering the high-demand MOVs; Table 6 shows that 83% of the MOV FTOC failures occurred in five systems. Table 7 shows that 92% of the MOV FTOP failures occurred in seven systems. Similarly, Table 8 shows that all of the MOV SO failures occurred in four systems.

3 FAILURE PROBABILITIES AND FAILURE RATES

3.1 Overview

Trends of industry-wide failure probabilities and failure rates of MOVs have been calculated from the operating experience for the FTOC and SO failure modes. The MOV data set obtained from EPIX was segregated to MOVs with ≤ 20 demands/year (d/yr) and MOVs with > 20 d/yr and includes MOVs in the systems listed in Table 1. NUREG/CR-6928 lists the industry failure data for MOVs with ≤ 20 d/yr. Table 2 shows industry-wide failure probability and failure rate results for the MOV with ≤ 20 d/yr from Reference 1. No results are shown for >20d/yr MOVs because Reference 1 does not present results for >20 d/yr.

[1] Statistical significance is defined in terms of the 'p-value.' A p-value is a probability indicating whether to accept or reject the null hypothesis that there is no trend in the data. P-values of less than or equal to 0.05 indicate that we are 95% confident that there is a trend in the data (reject the null hypothesis of no trend.) By convention, we use the "Michelin Guide" scale: p-value < 0.05 (statistically significant), p-value < 0.01 (highly statistically significant); p-value < 0.001 (extremely statistically significant).

The MOVs are assumed to operate both when the reactor is critical and during shutdown periods. The number of valves in operation is assumed to be constant throughout the study period. All demand types are considered—testing, non-testing, and, as applicable, emergency safeguard feature (ESF) demands.

Table 1. MOV systems.

System	Description	MOV Component Count		
		Total	≤20 d/yr	>20 d/yr
AFW	Auxiliary feedwater	582	444	138
CCW	Component cooling water	834	674	160
CIS	Containment isolation system	23	19	4
CRD	Control rod drive	25	10	15
CSR	Containment spray recirculation	345	328	17
CTS	Condensate transfer system	6	6	
CVC	Chemical and volume control	575	539	36
HCI	High pressure coolant injection	269	246	23
HCS	High pressure core spray	47	28	19
HPI	High pressure injection	1077	965	112
HVC	Heating ventilation and air conditioning	27	23	4
ISO	Isolation condenser	20	14	6
LCS	Low pressure core spray	234	205	29
MFW	Main feedwater	305	286	19
MSS	Main steam	169	159	10
RCI	Reactor core isolation	335	304	31
RCS	Reactor coolant	167	160	7
RHR	Residual heat removal	2122	1823	299
SWN	Emergency service water (Standby)	952	685	267
SWS	Standby service water	284	195	89
VSS	Vapor suppression	14	14	
	Total	8412	7127	1285

Table 2. Industry-wide distributions of p (failure probability) and λ (hourly rate) for MOVs.

Failure Mode	5%	Median	Mean	95%	Distribution		
					Type	α	β
FTOC	1.76E-04	8.12E-04	9.63E-04	2.27E-03	Beta	2.05	2.123E+03
FTOP	7.40E-09	5.18E-08	6.62E-08	1.74E-07	Gamma	1.46	2.205E+07
SO	2.54E-10	1.72E-08	3.39E-08	1.24E-07	Gamma	0.57	1.684E+07

3.2 MOV Failure Probability and Failure Rate Trends

Trends in failure probabilities and failure rates are shown in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6. The data for the trend plots are contained in Table 10, Table 11, Table 12, Table 13, Table 14, and Table 15, respectively.

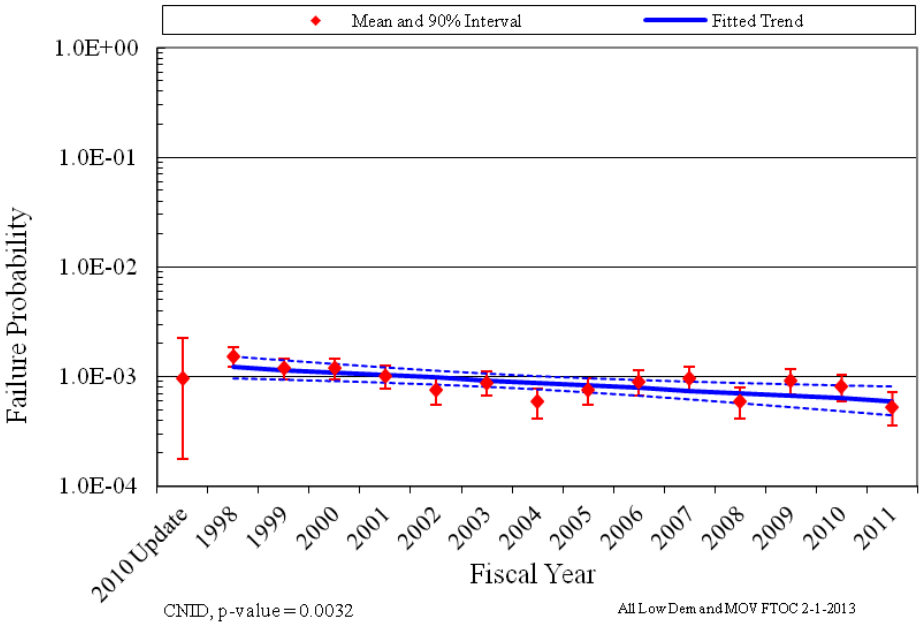

Figure 1. Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with ≤ 20 demands per year.

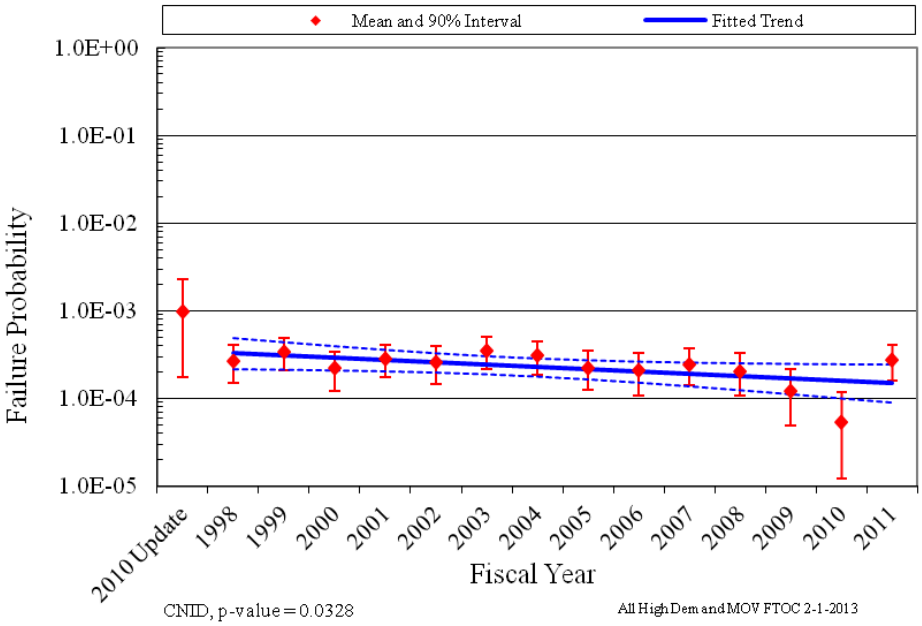

Figure 2. Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with > 20 demands per year.

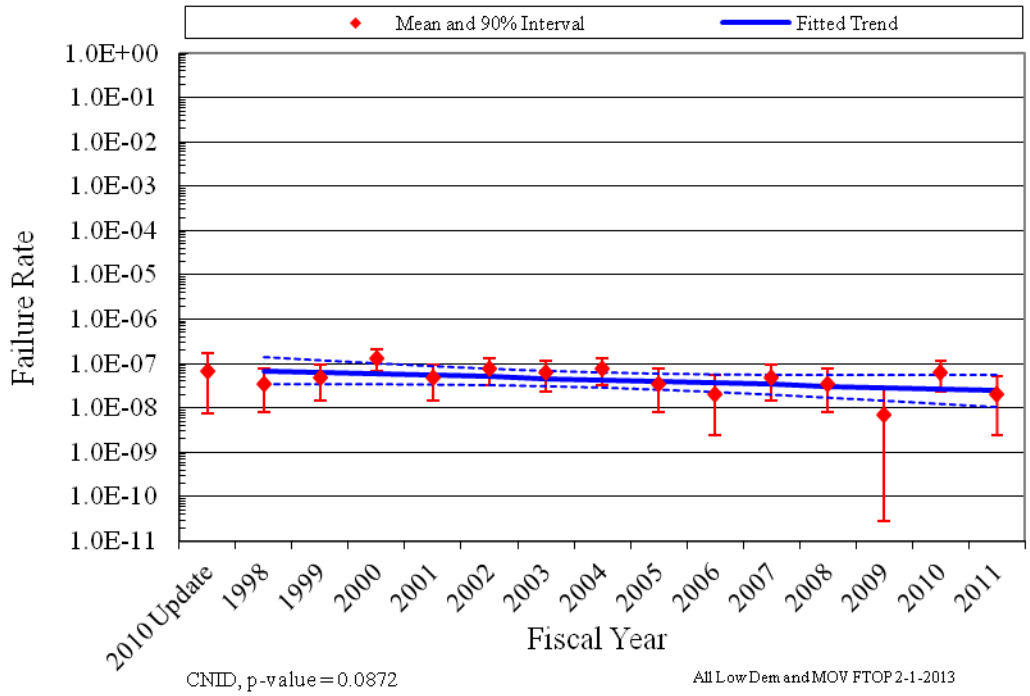

Figure 3. Failure rate estimate trend for MOV FTOP, all systems, industry-wide trend of MOVs with ≤ 20 demands per year.

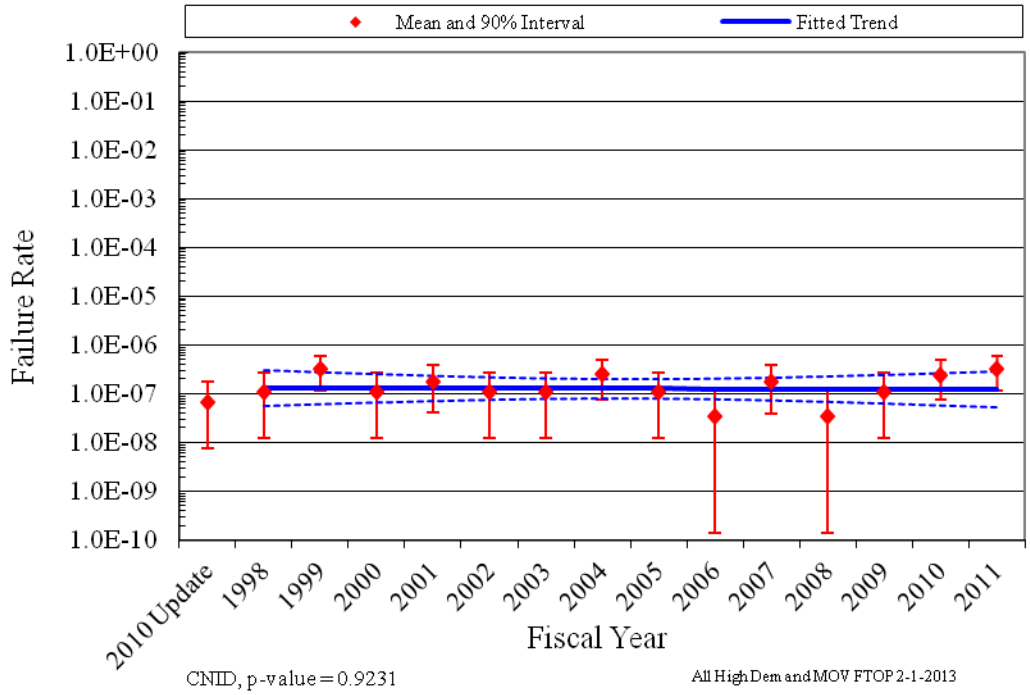

Figure 4. Failure rate estimate trend for MOV FTOP, all systems, industry-wide trend of MOVs with > 20 demands per year.

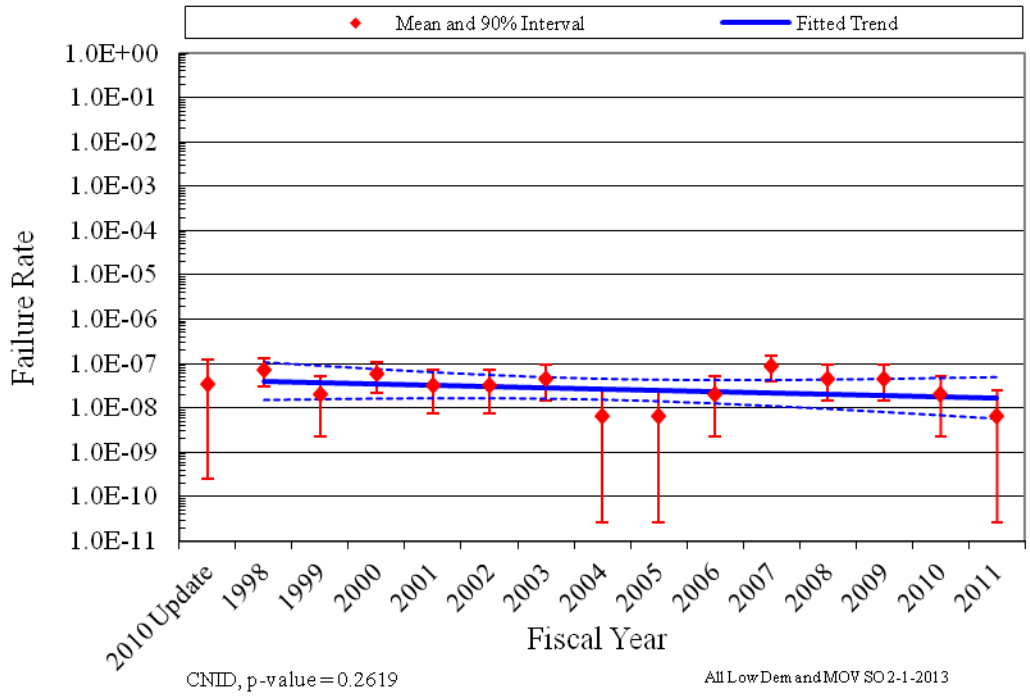

Figure 5. Failure rate estimate trend for MOV SO, all systems, industry-wide trend of MOVs with ≤ 20 demands per year.

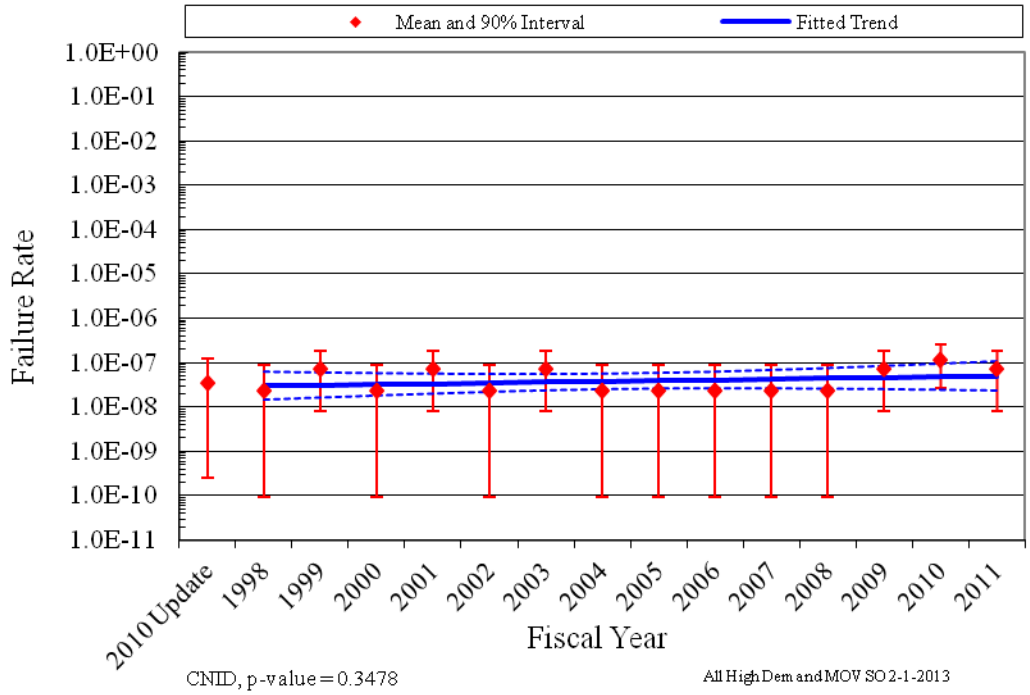

Figure 6. Failure rate estimate trend for MOV SO, all systems, industry-wide trend of MOVs with > 20 demands per year.

In the plots, the means of the posterior distributions from the Bayesian update process were trended across the years. The posterior distributions were also used for the vertical bounds for each year. The 5th and 95th percentiles of these distributions give an indication of the relative variation from year to year in the data. When there are no failures, the interval is larger than the interval for years when there are one or more failures. The larger interval reflects the uncertainty that comes from having little information in that year's data. Such uncertainty intervals are determined by the prior distribution. In each plot, a relatively "flat" constrained noninformative prior distribution (CNID) is used, which has large bounds.

The horizontal curves plotted around the regression lines in the graphs form 90 percent simultaneous confidence bands for the fitted lines. The bounds are larger than ordinary confidence intervals for the trended values because they form a band that has a 90% probability of containing the entire line. In the lower left hand corner of the trend figures, the regression p-values are reported. They come from a statistical test on whether the slope of the regression line might be zero. Low p-values indicate that the slopes are not likely to be zero, and that trends exist. Further information on the trending methods is provided in Section 2 of the Overview and Reference document. A final feature of the trend graphs is that the baseline industry values from Table 2 are shown for comparison.

4 ENGINEERING TRENDS

This section presents frequency trends for MOV failures and demands. The data are normalized by reactor year for plants that have the equipment being trended. Figure 7 shows the trend for total MOV demands of ≤20 demands per reactor-year MOVs. Figure 9 shows the trend in failure events for FTOC mode for MOV ≤20 demands, Figure 11 shows the trend in failure events for FTOP mode for MOV ≤20 demands, and Figure 13 shows the trend for the SO failure events for MOV ≤20 demands.

Figure 8 shows the trend for total MOV demands of >20 demands per reactor-year MOVs. Figure 10 shows the trend in failure events for FTOC mode for MOV >20 demands, Figure 12 shows the trend in failure events for FTOP mode for MOV >20 demands, and Figure 14 shows the trend for the SO failure events for MOV >20 demands.

Table 3 summarizes the failures by system, year, and the FTOC failure mode of MOV >20 demands. The top five (and ties) contributing systems for the FTOC failure mode in Table 3 are AFW, HCI, HPI, RHR, and SWN. Table 4 summarizes the failures by system, year, and the FTOP failure mode of MOV >20 demands. The top five (and ties) contributing systems for the FTOC failure mode in Table 4 are AFW, CCW, HPI, MFW, RHR, and SWN. Table 5 summarizes the failures by system, year, and the SO failure mode of MOV >20 demands. The top five (and ties) contributing systems in Table 5 for the SO failure mode are CCW, HCI, LCS, RCI, and RHR.

Table 6 summarizes the failures by system, year, and the FTOC failure mode of MOV >20 demands. The top five (and ties) contributing systems for the FTOC failure mode in Table 6 are AFW, CCW, RHR, SWS, and SWN. Table 7 summarizes the failures by system, year, and the FTOP failure mode of MOV >20 demands. The top five (and ties) contributing systems for the FTOC failure mode in Table 7 are AFW, CCW, LCS, MFW, RHR, SWS, and SWN. Table 8 summarizes the failures by system, year, and the SO failure mode of MOV >20 demands. The top five (and ties) contributing systems in Table 8 for the SO failure mode are MFW, RCI, RHR, and SWN.

Table 16, Table 17, Table 18, Table 19, Table 20, Table 21, Table 22, and Table 23 provide the frequency (per reactor year) of MOV demands, FTOC events, FTOP events, and SO events, respectively. The systems from Table 2 are trended together for each figure. The rate methods described in Section 2 of the Overview and Reference document are used.

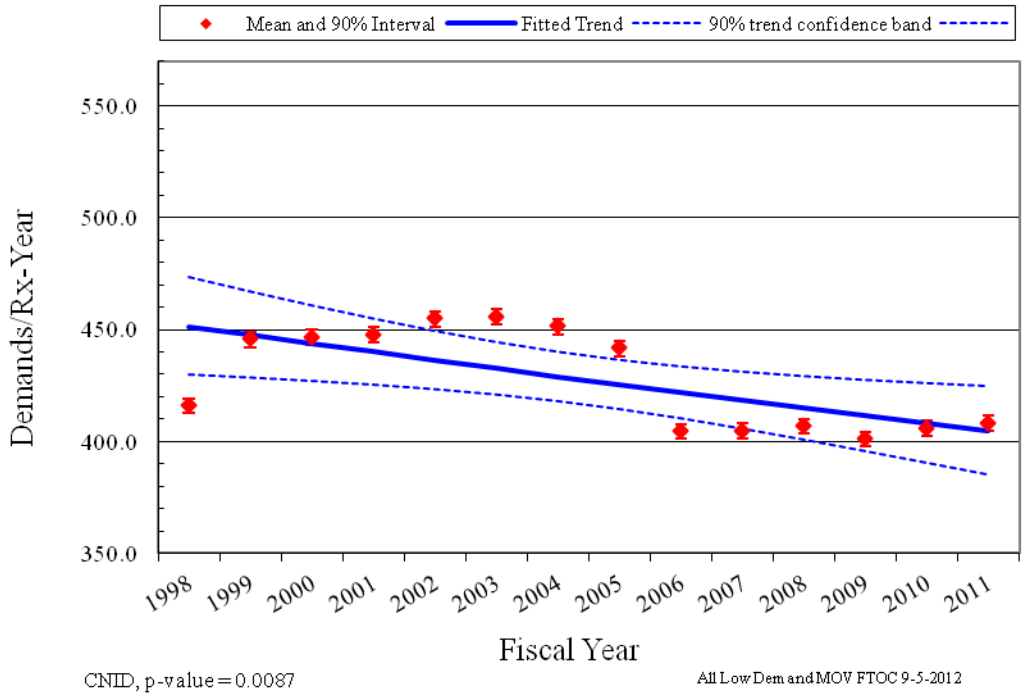

Figure 7. Frequency (demands per reactor year) of MOV operation demands, ≤ 20 demands per year.

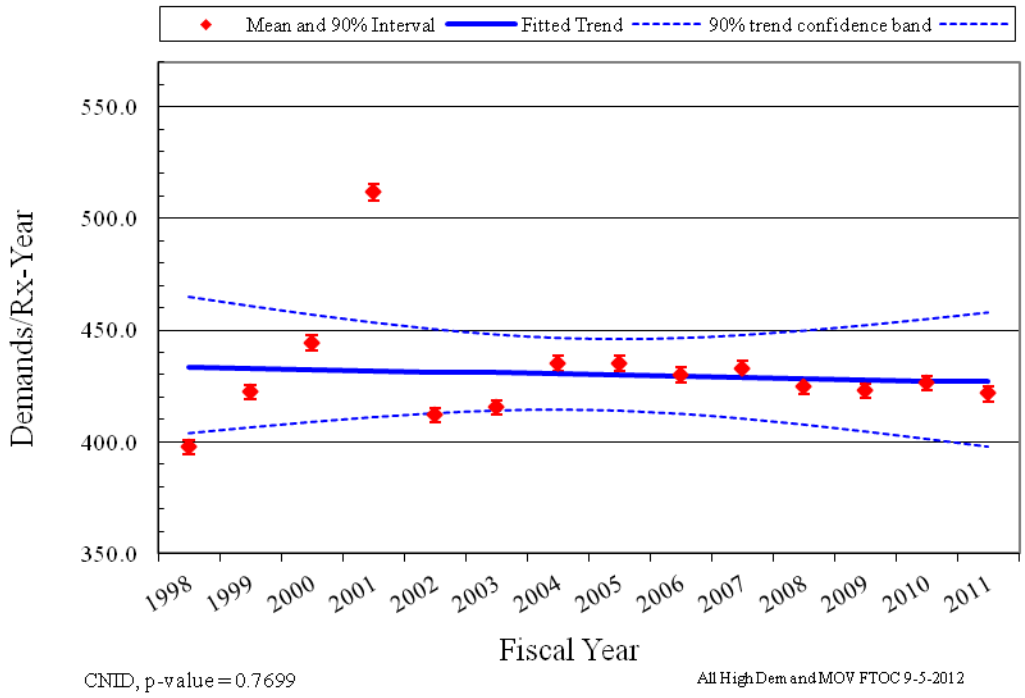

Figure 8. Frequency (demands per reactor year) of MOV operation demands, > 20 demands per year.

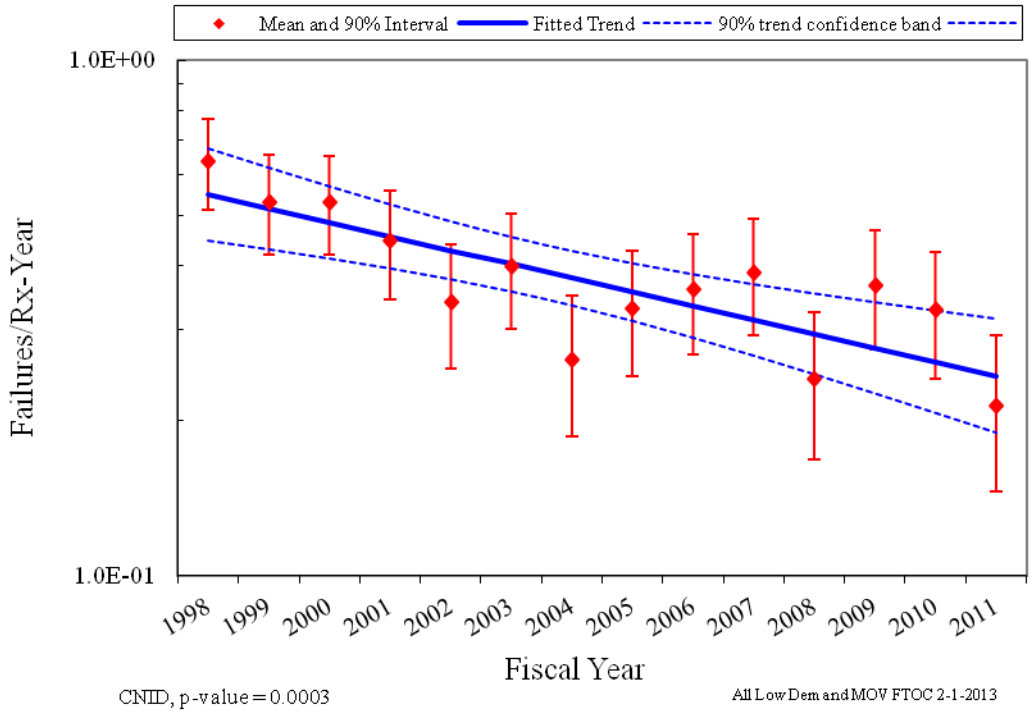

Figure 9. Frequency (failures per reactor year) of MOV FTOC events ≤ 20 demands per year.

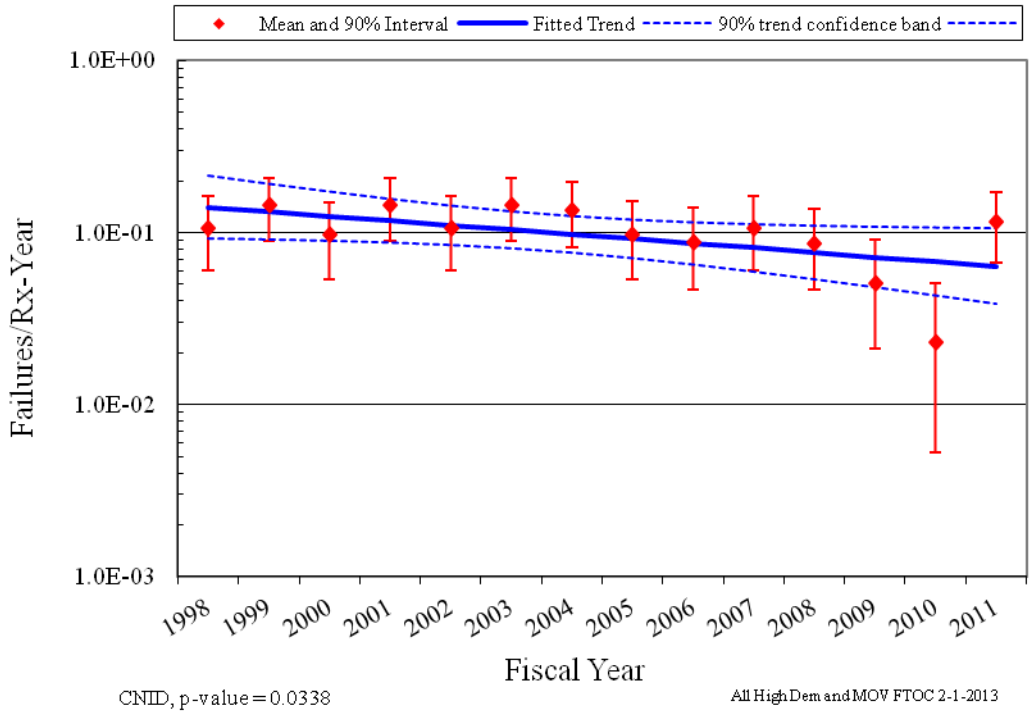

Figure 10. Frequency (failures per reactor year) of MOV FTOC events > 20 demands per year.

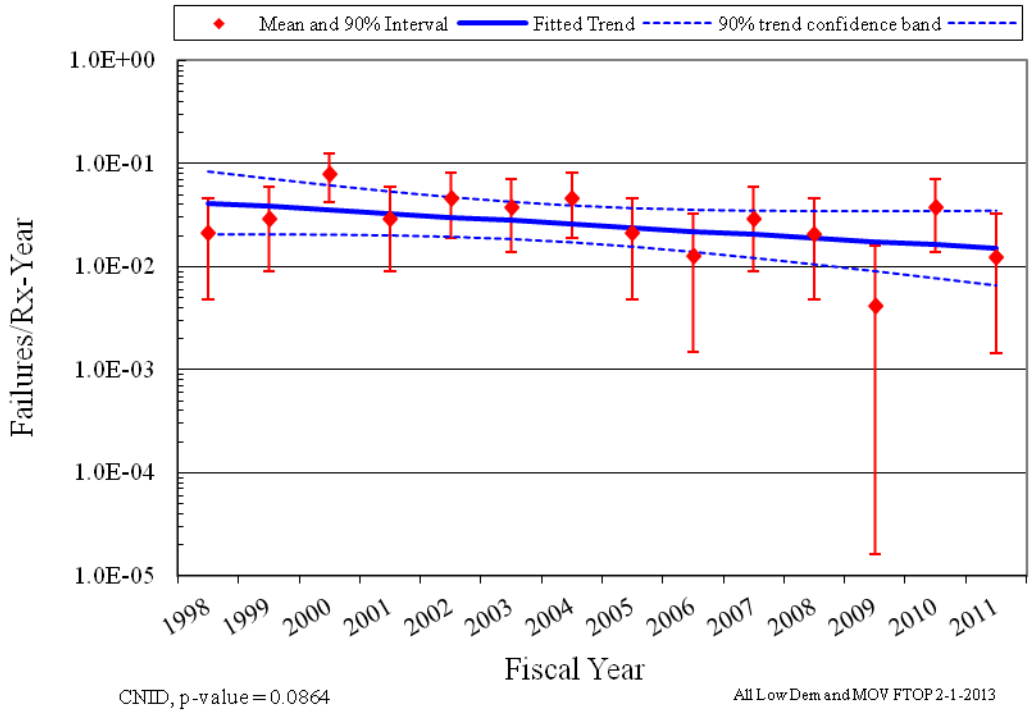

Figure 11. Frequency (failures per reactor year) of MOV FTOP events ≤ 20 demands per year.

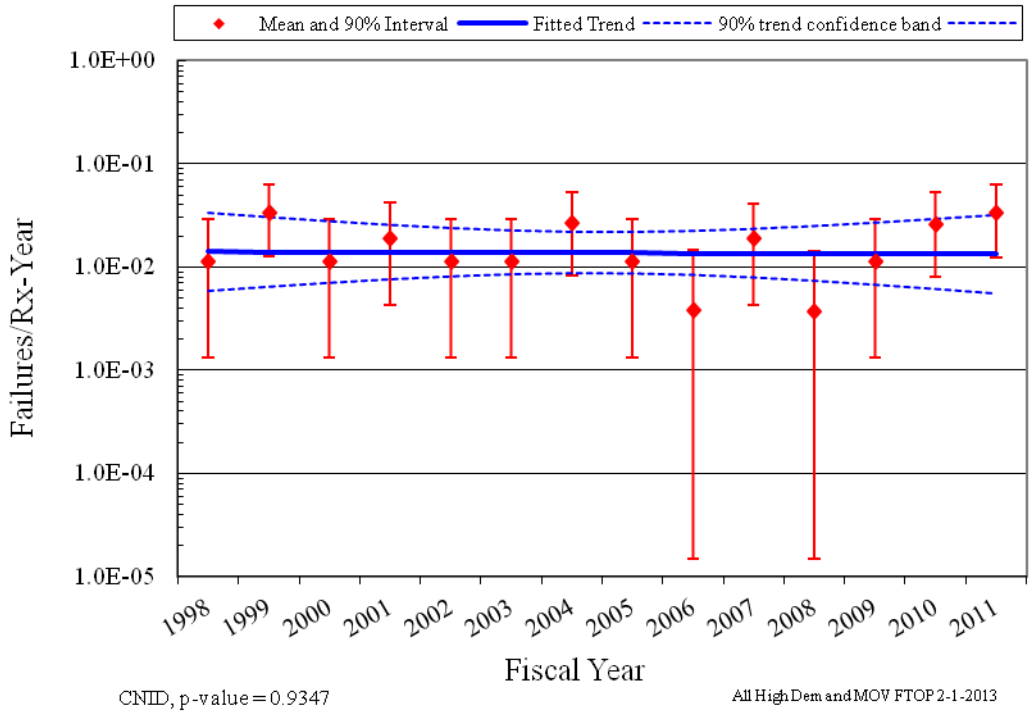

Figure 12. Frequency (failures per reactor year) of MOV FTOP events > 20 demands per year.

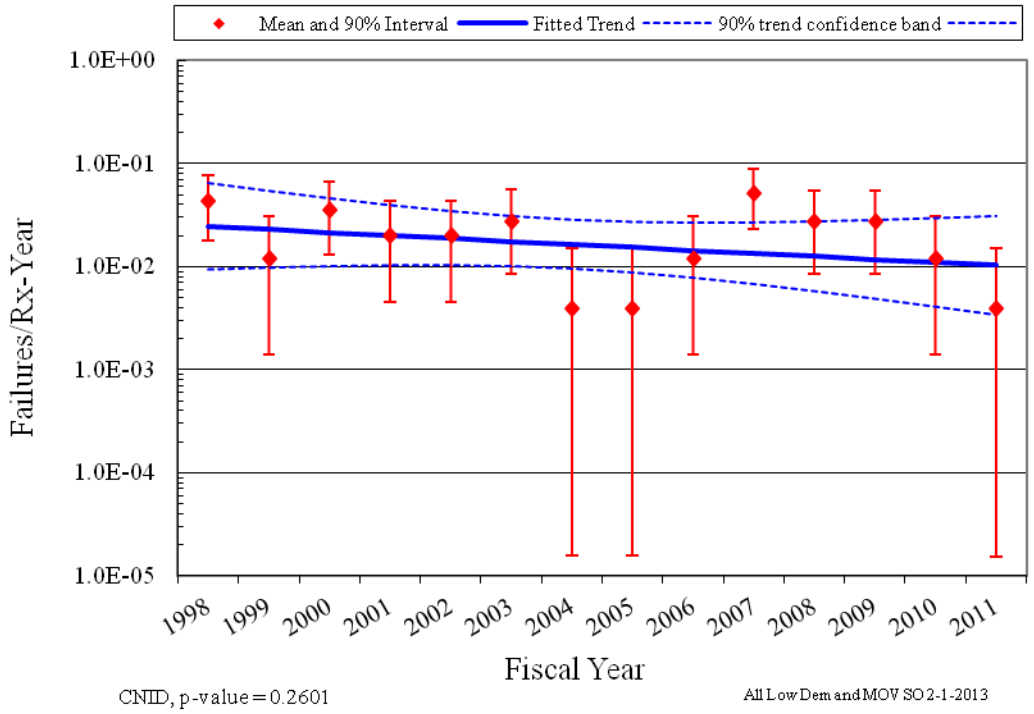

Figure 13. Frequency (failures per reactor year) of MOV SO events ≤ 20 demands per year.

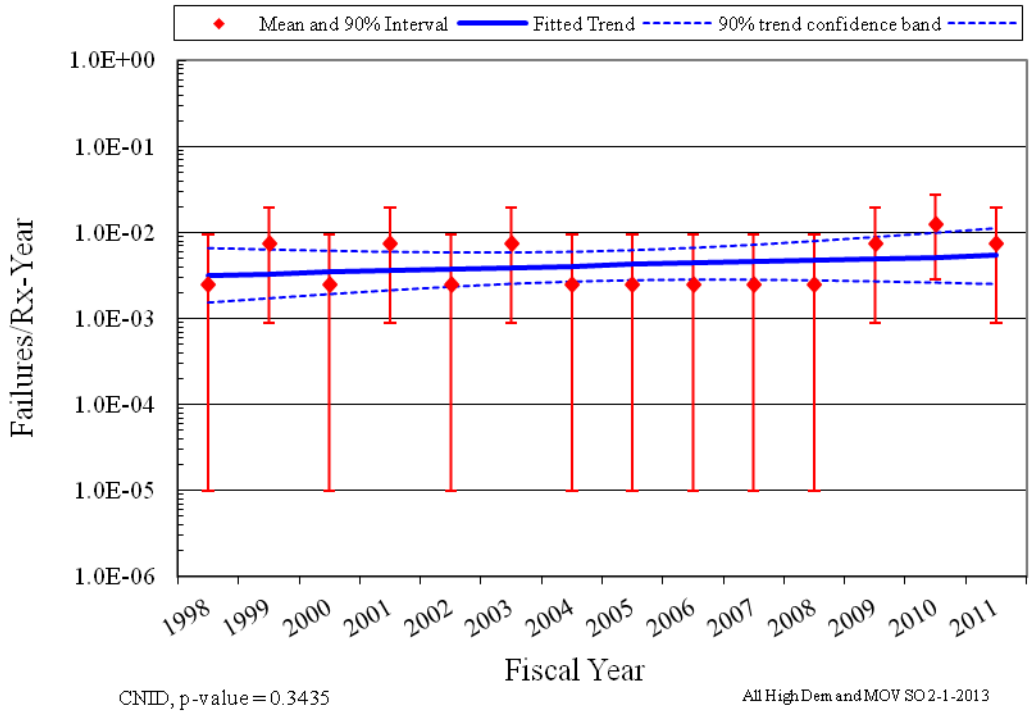

Figure 14. Frequency (failures per reactor year) of MOV SO events > 20 demands per year.

Table 3. Summary of MOV failure counts for the FTOC failure mode over time by system ≤ 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
AFW	444	6.2%	3	6	4	6	3			2		5	2	5	5	3	44	**7.9%**
CCW	674	9.5%	4	2	3	2	4	4	1		2	1		3	3	2	31	5.6%
CIS	19	0.3%											1				1	0.2%
CRD	10	0.1%		1													1	0.2%
CSR	328	4.6%	2	2	2		2	2	1				1	1		2	15	2.7%
CTS	6	0.1%		1													1	0.2%
CVC	539	7.6%	3	1	5		1	2			1	3	1	1			18	3.2%
HCI	246	3.5%	4	3	2	2	2	2	2	2	3	8		8	1		39	**7.0%**
HCS	28	0.4%		1	1												2	0.4%
HPI	965	13.5%	4	5	6	4	4	2	6	6	3	3	1	3	3	2	52	**9.4%**
HVC	23	0.3%	1	1													2	0.4%
ISO	14	0.2%		1	2	1			1	2						1	8	1.4%
LCS	205	2.9%	4	7	2	2	1	2			1	1				1	21	3.8%
MFW	286	4.0%	1					3	1	1	1	2	2	1	5		17	3.1%
MSS	159	2.2%		1	3	1	1	1	2	2		3	3	2	1	1	21	3.8%
RCI	304	4.3%	4	6	2	5	3	2	2	4	3	1	2	1	1	2	38	6.8%
RCS	160	2.2%				1		1	2		1						5	0.9%
RHR	1823	25.6%	18	13	16	10	12	10	8	13	16	10	8	8	13	3	158	**28.5%**
SWN	685	9.6%	4	4	6	11	2	7	1	1	6	1	4	4	2	3	56	**10.1%**
SWS	195	2.7%	14		1	1		1				1		1		2	21	3.8%
VSS	14	0.2%						2		1		1					4	0.7%
Total	7127	100.0%	66	55	55	46	35	41	27	34	37	40	25	38	34	22	555	100.0%

Table 4. Summary of MOV failure counts for the FTOP failure mode over time by system ≤ 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
AFW	444	6.6%			1		1	1	2				1		1		7	**15.9%**
CCW	674	10.1%			3	2				1							6	**13.6%**
CIS	19	0.3%											1				1	2.3%
CSR	328	4.9%							1								1	2.3%
CVC	539	8.1%						1									1	2.3%
HCI	246	3.7%										1					1	2.3%
HPI	965	14.4%					1								1	1	3	**6.8%**
HVC	23	0.3%					1										1	2.3%
MFW	286	4.3%				1			1			1					3	**6.8%**
MSS	159	2.4%					1										1	2.3%
RCI	304	4.5%		1													1	2.3%
RHR	1823	27.2%	1	2	3			2			1	1			2		12	**27.3%**
SWN	685	10.2%	1		2				1	1							5	**11.4%**
SWS	195	2.9%					1										1	2.3%
Total	6690	100.0%	2	3	9	3	5	4	5	2	1	3	2		4	1	44	100.0%

Table 5. Summary of MOV failure counts for the SO failure mode over time by system ≤ 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
AFW	444	8.2%	1		1												2	6.5%
CCW	674	12.4%					1	1					2	2			6	**19.4%**
CSR	328	6.0%				1											1	3.2%
CVC	539	9.9%			1												1	3.2%
HCI	246	4.5%				1						1			1		3	**9.7%**
LCS	205	3.8%		1							1	4					6	**19.4%**
RCI	304	5.6%			2								1	1			4	**12.9%**
RHR	1823	33.5%	3					1				1					5	**16.1%**
SWN	685	12.6%					1										1	3.2%
SWS	195	3.6%	1					1									2	6.5%
Total	5443	100.0%	5	1	4	2	2	3			1	6	3	3	1		31	100.0%

Table 6. Summary of MOV failure counts for the FTOC failure mode over time by system > 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
AFW	138	11.6%	2	1	3		4	7	3	2	2	1		1	1	1	28	**18.8%**
CCW	160	13.5%	1			1		2	2				1			1	8	**5.4%**
HCI	23	1.9%					1			1	1		1			1	5	3.4%
HCS	19	1.6%					1						1				2	1.3%
HPI	112	9.4%	2		1							1					4	2.7%
HVC	4	0.3%				1											1	0.7%
LCS	29	2.4%	1	1		1			1				1				5	3.4%
MSS	10	0.8%			1												1	0.7%
RCI	31	2.6%		1		1			1	2						1	6	4.0%
RCS	7	0.6%		1													1	0.7%
RHR	299	25.2%	3	7	5	4	2	3	2	4	2	7	3	3	1	6	52	**34.9%**
SWN	267	22.5%	2	4		4	1	1	5	1	3	1	1	1		1	25	**16.8%**
SWS	89	7.5%				3	2	2			1	1	1			1	11	**7.4%**
Total	1188	100.0%	11	15	10	15	11	15	14	10	9	11	9	5	2	12	149	100.0%

Table 7. Summary of MOV failure counts for the FTOP failure mode over time by system > 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
AFW	138	12.1%		1				1	1			1				1	5	**20.8%**
CCW	160	14.1%								1					1		2	**8.3%**
HCI	23	2.0%														1	1	4.2%
HPI	112	9.9%														1	1	4.2%
LCS	29	2.6%		1												1	2	**8.3%**
MFW	19	1.7%	1			2											3	**12.5%**
RHR	299	26.3%												1	1		2	**8.3%**
SWN	267	23.5%		2	1							1					4	**16.7%**
SWS	89	7.8%					1		2						1		4	**16.7%**
Total	1136	100.0%	1	4	1	2	1	1	3	1		2		1	3	4	24	100.0%

Table 8. Summary of MOV failure counts for the SO failure mode over time by system > 20 demands per year.

System Code	Valve Count	Valve Percent	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	FY 10	FY 11	Total	Percent of Failures
MFW	19	3.1%				1											1	**14.3%**
RCI	31	5.0%													2		2	**28.6%**
RHR	299	48.5%												1		1	2	**28.6%**
SWN	267	43.3%		1				1									2	**28.6%**
Total	616	100.0%		1		1		1						1	2	1	7	100.0%

4.1 MOV Engineering Analysis by Failure Modes

The engineering analysis of MOV failure sub-components, causes, detection methods, and recovery are presented in this section. Each analysis divides the events into two periods: before July 2003 and after July 2003 (the start of the data begins in FY 1998 and the last date is FY 2011). This breakdown was chosen for two reasons: first, July 2003 represents a point in which the MSPI data collection attains a "higher level" of scrutiny; second, this date represents a point about half way through the full data period.

The second division of the events is by the failure mode determined after EPIX data review by the staff. See Section 5 for more description of failure modes.

MOV sub-component contributions to the three failure modes are presented in Figure 15. The sub-component contributions are similar to those used in the CCF database. For all three failure modes, the actuator is the largest contributor to the failure rates/probabilities. In the FTOP and SO failure modes, the valve was shown to have no contribution to the failure rates/probabilities.

MOV cause group contributions to the three failure modes are presented in Figure 16. The cause groups are similar to those used in the CCF database. Table 9 shows the breakdown of the cause groups with the specific causes that were coded during the data collection. The most likely cause for all three failure modes is grouped as Internal. Internal means that the cause was related to something within the MOV component such as a worn out part or the normal internal environment. Of particular interest is the Human cause group. The human cause group is primarily influenced by maintenance and operating procedures and practices.

MOV detection methods to the three failure modes are presented in Figure 17. The most likely detection method is a testing demand.

MOV recovery to the three failure modes are presented in Figure 18. The overall non-recovery to recovery ratio is approximately 14:1.

Table 9. Component failure cause groups.

Group	Specific Cause	Description
Design	Construction/installation error or inadequacy	Used when a construction or installation error is made during the original or modification installation. This includes specification of incorrect component or material.
Design	Design error or inadequacy	Used when a design error is made.
Design	Manufacturing error or inadequacy	Used when a manufacturing error is made during component manufacture.
External	State of other component	Used when the cause of a failure is the result of a component state that is not associated with the component that failed. An example would be the diesel failed due to no fuel in the fuel storage tanks.
External	Ambient environmental stress	Used when the cause of a failure is the result of an environmental condition from the location of the component.
Human	Accidental action (unintentional or undesired human errors)	Used when a human error (during the performance of an activity) results in an unintentional or undesired action.
Human	Human action procedure	Used when the procedure is not followed or the procedure is incorrect. For example: when a missed step or incorrect step in a surveillance procedure results in a component failure.
Human	Inadequate maintenance	Used when a human error (during the performance of maintenance) results in an unintentional or undesired action.
Internal	Internal to component, piece-part	Used when the cause of a failure is a non-specific result of a failure internal to the component that failed other than aging or wear.

Group	Specific Cause	Description
Internal	Internal environment	The internal environment led to the failure. Debris/Foreign material as well as an operating medium chemistry issue.
Internal	Setpoint drift	Used when the cause of a failure is the result of setpoint drift or adjustment.
Internal	Age/Wear	Used when the cause of the failure is a non-specific aging or wear issue.
Other	Unknown	Used when the cause of the failure is not known.
Other	Other (stated cause does not fit other categories)	Used when the cause of a failure is provided but it does not meet any one of the descriptions.
Procedure	Inadequate procedure	Used when the cause of a failure is the result of an inadequate procedure operating or maintenance.

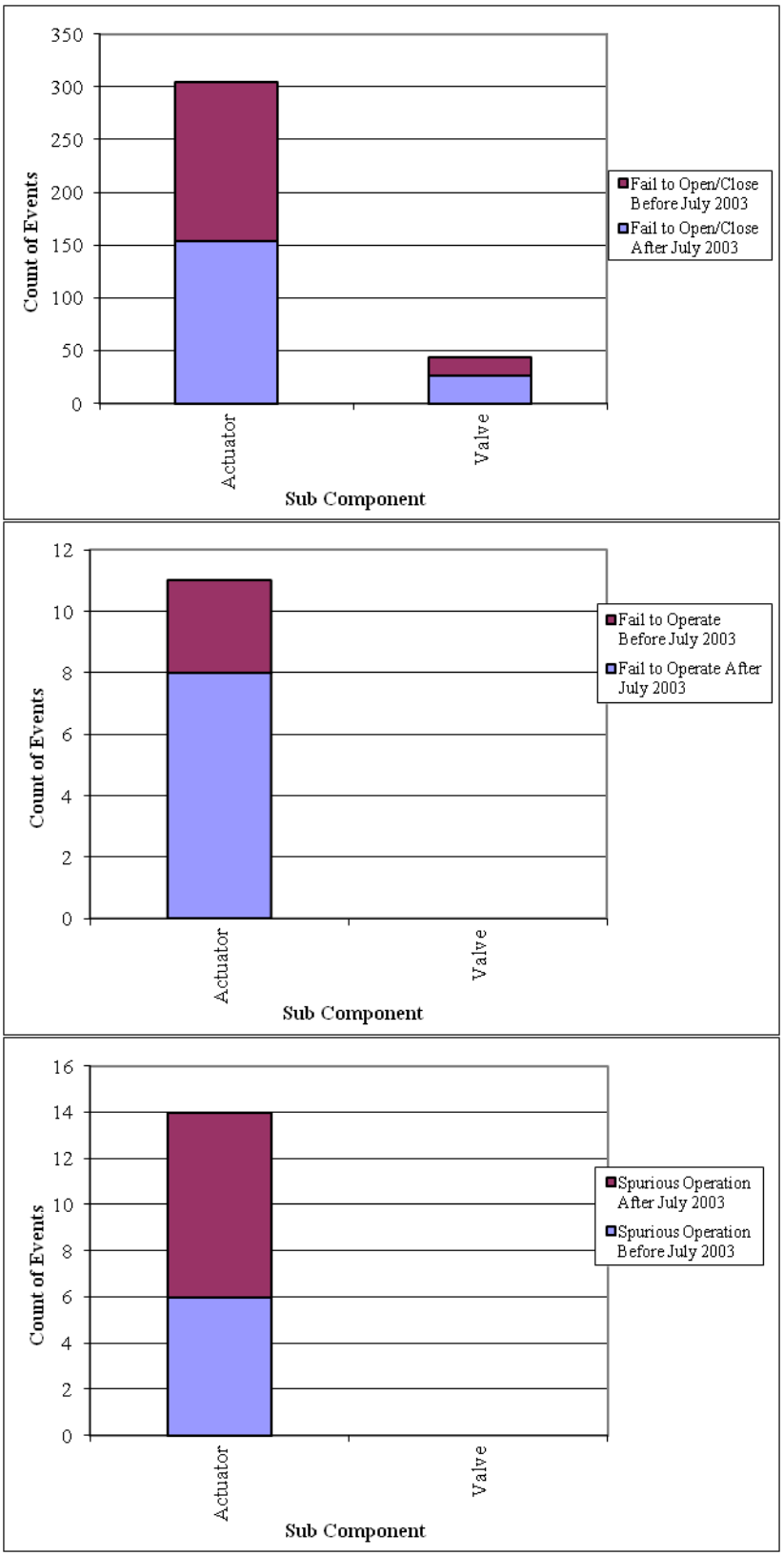

Figure 15. MOV failure breakdown by period, sub component, and failure mode.

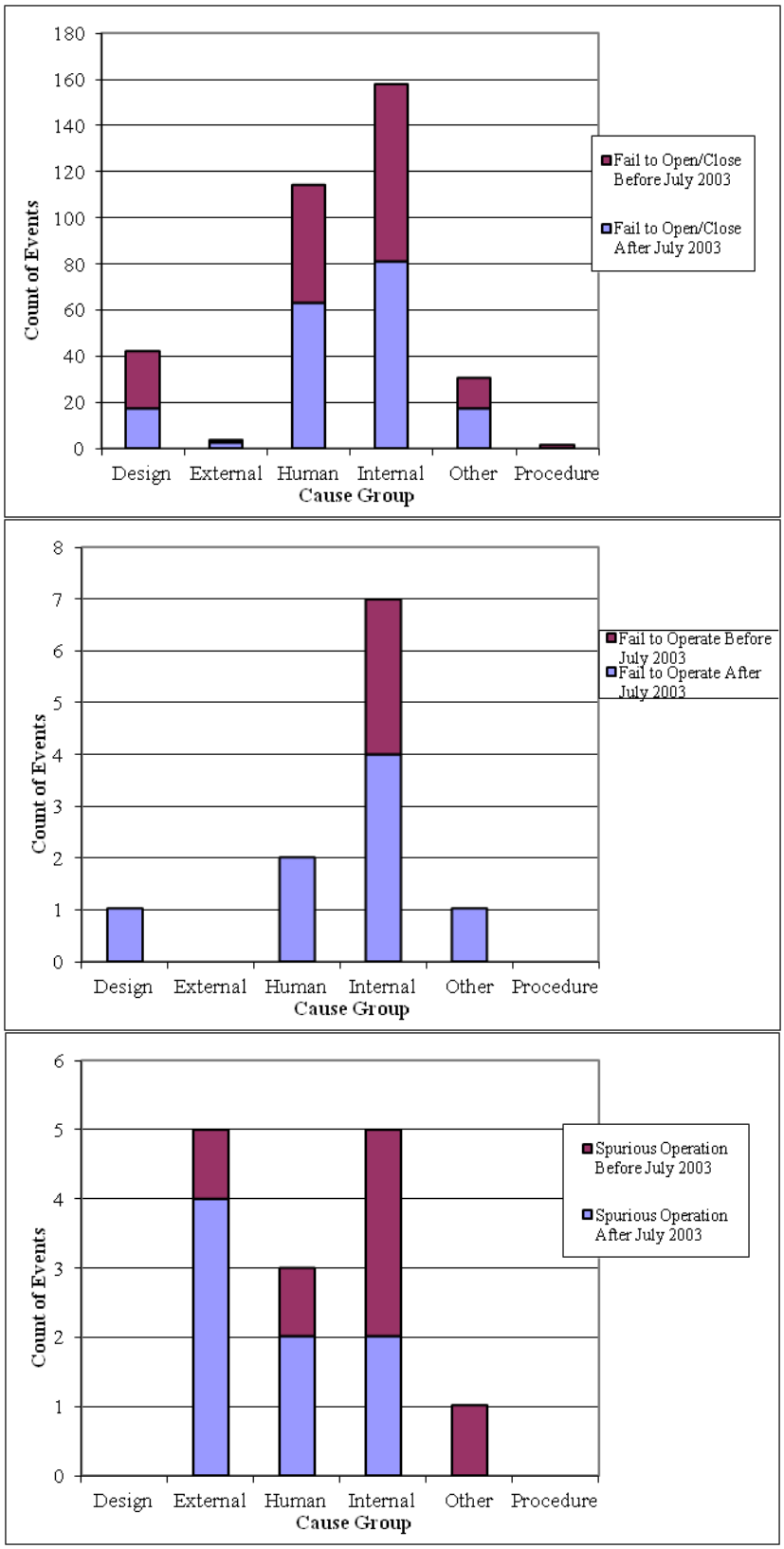

Figure 16. MOV breakdown by time period, cause group, and failure mode.

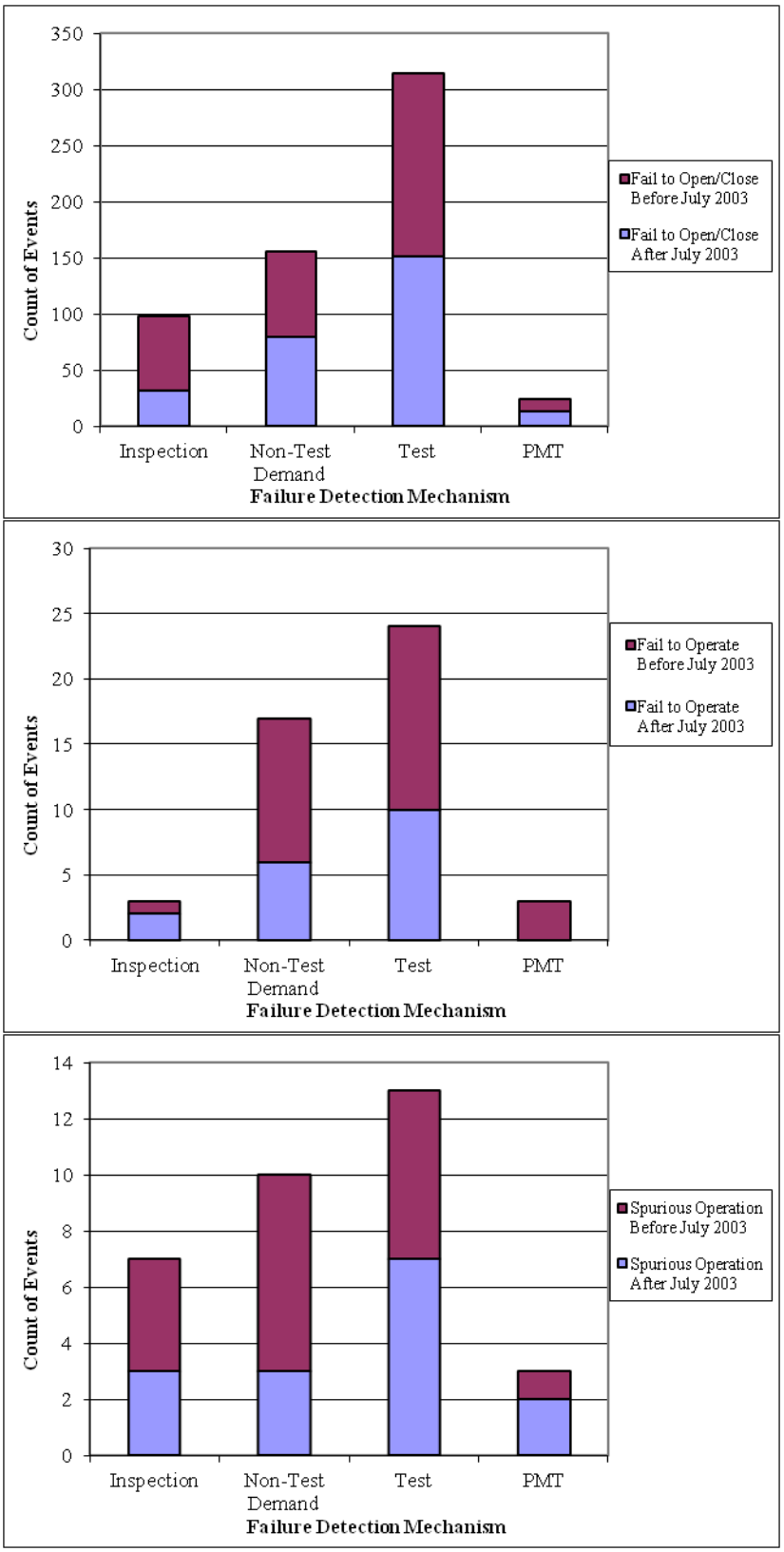

Figure 17. MOV component failure distribution by period, failure mode, and method of detection.

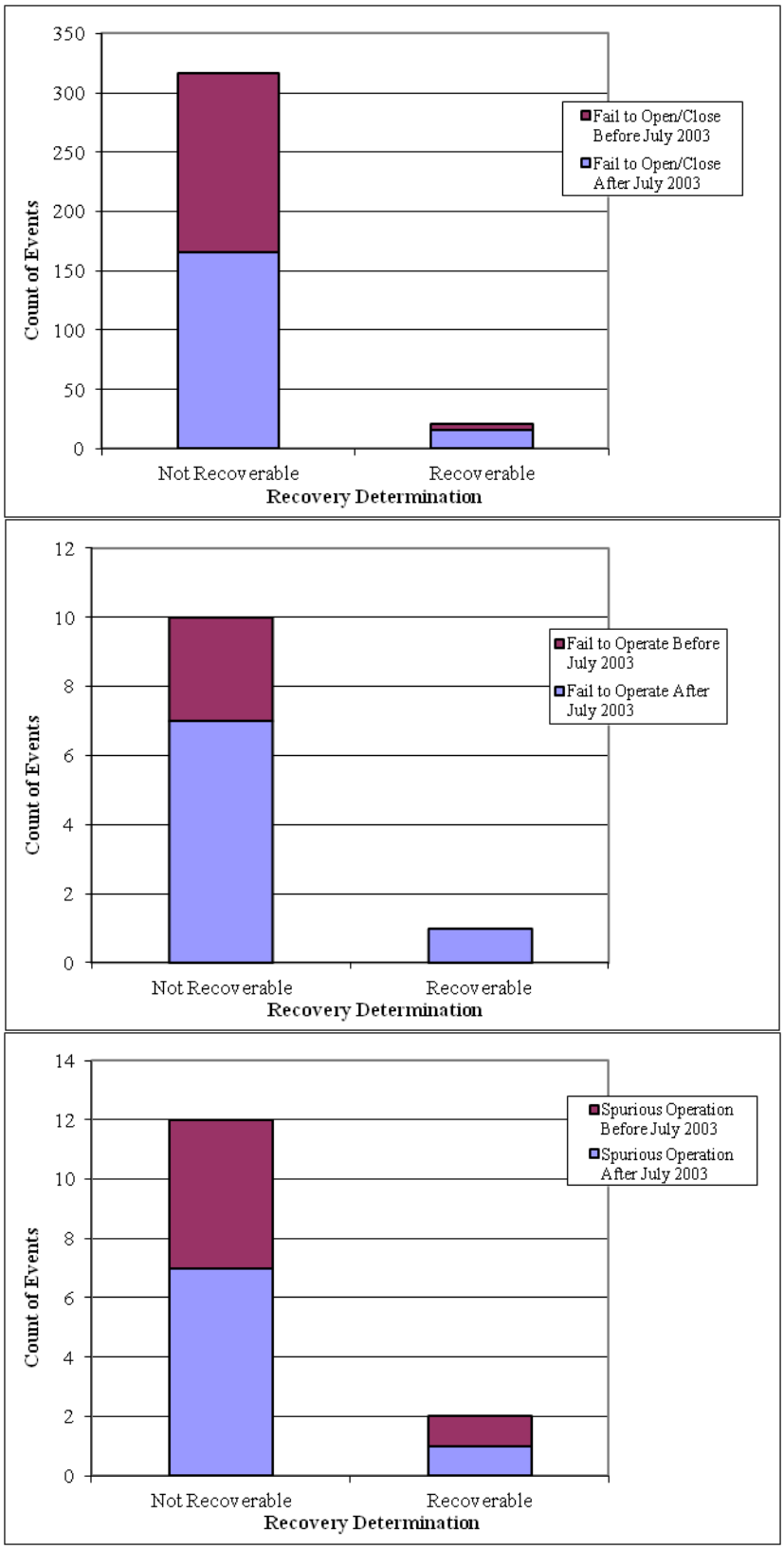

Figure 18. MOV component failure distribution by period, failure mode, and recovery.

5 MOV ASSEMBLY DESCRIPTION

A MOV assembly consists of a valve body and motor-operated sub-components (includes the circuit breaker). The valve body is generally a gate type. The motor-operator is generally a Limitorque or a Rotork ac or dc motor actuator.

The piece-parts of the valve body are the stem, packing, and internals. The motor-operator piece-parts include the torque switch, spring pack, limit switch, wiring/contacts, and motor internal and mechanical devices.

Failure modes for the MOV include Fail to Open/Close, which combines the Fail to Open and Fail to Close (FTOC) failure modes into a single category; Fail to Operate (FTOP), which is a rate-based failure mode that includes Fail to Control for a flow/temperature control device and any other rate-based failure modes not including spurious operation; and Spurious Operation (SO), which includes Spurious Opening and Spurious Closing.

6 DATA TABLES

Table 10. Plot data for industry-wide MOV FTOC trend with ≤ 20 demands per year. Figure 1

FY/ Source	Failures	Demands	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						1.76E-04	2.27E-03	9.63E-04
1998	66	42846	1.21E-03	9.56E-04	1.54E-03	1.24E-03	1.85E-03	1.53E-03
1999	55	45897	1.15E-03	9.30E-04	1.42E-03	9.43E-04	1.47E-03	1.19E-03
2000	55	46122	1.09E-03	9.04E-04	1.31E-03	9.38E-04	1.46E-03	1.19E-03
2001	46	46102	1.03E-03	8.75E-04	1.22E-03	7.68E-04	1.25E-03	9.97E-04
2002	35	46843	9.77E-04	8.42E-04	1.13E-03	5.54E-04	9.66E-04	7.49E-04
2003	41	46923	9.26E-04	8.05E-04	1.06E-03	6.63E-04	1.11E-03	8.74E-04
2004	27	46612	8.77E-04	7.63E-04	1.01E-03	4.13E-04	7.77E-04	5.83E-04
2005	34	45476	8.30E-04	7.18E-04	9.61E-04	5.52E-04	9.70E-04	7.49E-04
2006	37	41666	7.86E-04	6.70E-04	9.24E-04	6.63E-04	1.14E-03	8.88E-04
2007	40	41836	7.45E-04	6.21E-04	8.93E-04	7.22E-04	1.21E-03	9.55E-04
2008	25	42404	7.06E-04	5.74E-04	8.67E-04	4.14E-04	7.99E-04	5.94E-04
2009	38	41709	6.68E-04	5.29E-04	8.44E-04	6.83E-04	1.16E-03	9.11E-04
2010	34	42216	6.33E-04	4.87E-04	8.23E-04	5.94E-04	1.04E-03	8.07E-04
2011	22	42445	6.00E-04	4.47E-04	8.03E-04	3.56E-04	7.16E-04	5.23E-04

Table 11. Plot data for industry-wide MOV FTOC trend with > 20 demands per year. Figure 2

FY/ Source	Failures	Demands	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						1.76E-04	2.27E-03	9.63E-04
1998	11	40948	3.27E-04	2.18E-04	4.89E-04	1.52E-04	4.09E-04	2.67E-04
1999	15	43488	3.08E-04	2.15E-04	4.40E-04	2.11E-04	4.93E-04	3.40E-04
2000	10	45883	2.90E-04	2.11E-04	3.97E-04	1.21E-04	3.40E-04	2.19E-04
2001	15	52686	2.73E-04	2.06E-04	3.60E-04	1.76E-04	4.11E-04	2.83E-04
2002	11	42436	2.57E-04	2.00E-04	3.30E-04	1.47E-04	3.95E-04	2.58E-04
2003	15	42779	2.42E-04	1.91E-04	3.06E-04	2.15E-04	5.01E-04	3.45E-04
2004	14	44929	2.27E-04	1.80E-04	2.88E-04	1.88E-04	4.52E-04	3.08E-04
2005	10	44810	2.14E-04	1.67E-04	2.75E-04	1.24E-04	3.48E-04	2.24E-04
2006	9	44275	2.02E-04	1.53E-04	2.65E-04	1.09E-04	3.25E-04	2.05E-04
2007	11	44727	1.90E-04	1.39E-04	2.59E-04	1.40E-04	3.76E-04	2.46E-04
2008	9	44299	1.79E-04	1.25E-04	2.54E-04	1.09E-04	3.25E-04	2.05E-04
2009	5	43977	1.68E-04	1.13E-04	2.51E-04	4.97E-05	2.14E-04	1.19E-04
2010	2	44319	1.58E-04	1.01E-04	2.48E-04	1.23E-05	1.19E-04	5.39E-05
2011	12	43833	1.49E-04	9.03E-05	2.46E-04	1.59E-04	4.10E-04	2.72E-04

Table 12. Plot data for industry-wide MOV FTOP trend with ≤ 20 demands per year. Figure 3

FY/ Source	Failures	Demands	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						7.40E-09	1.74E-07	6.62E-08
1998	2	62204760	6.88E-08	3.45E-08	1.37E-07	7.95E-09	7.68E-08	3.47E-08
1999	3	62353680	6.36E-08	3.45E-08	1.17E-07	1.50E-08	9.75E-08	4.85E-08
2000	9	62388720	5.88E-08	3.43E-08	1.01E-07	7.01E-08	2.09E-07	1.32E-07
2001	3	62371200	5.44E-08	3.37E-08	8.77E-08	1.50E-08	9.74E-08	4.85E-08
2002	5	62336160	5.03E-08	3.27E-08	7.74E-08	3.17E-08	1.36E-07	7.62E-08
2003	4	62379960	4.65E-08	3.11E-08	6.96E-08	2.30E-08	1.17E-07	6.23E-08
2004	5	62327400	4.30E-08	2.88E-08	6.41E-08	3.17E-08	1.36E-07	7.62E-08
2005	2	62362440	3.98E-08	2.61E-08	6.05E-08	7.93E-09	7.67E-08	3.46E-08
2006	1	62415000	3.68E-08	2.32E-08	5.83E-08	2.44E-09	5.41E-08	2.08E-08
2007	3	62379960	3.40E-08	2.02E-08	5.71E-08	1.50E-08	9.74E-08	4.85E-08
2008	2	62415000	3.14E-08	1.74E-08	5.66E-08	7.93E-09	7.66E-08	3.46E-08
2009	0	62476320	2.91E-08	1.49E-08	5.65E-08	2.72E-11	2.66E-08	6.92E-09
2010	4	62432520	2.69E-08	1.27E-08	5.67E-08	2.30E-08	1.17E-07	6.23E-08
2011	1	63203400	2.48E-08	1.08E-08	5.72E-08	2.41E-09	5.35E-08	2.05E-08

Table 13. Plot data for industry-wide MOV FTOP trend with > 20 demands per year. Figure 4

FY/ Source	Failures	Demands	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						7.40E-09	1.74E-07	6.62E-08
1998	1	10923720	1.31E-07	5.52E-08	3.11E-07	1.25E-08	2.77E-07	1.06E-07
1999	4	11090160	1.30E-07	6.04E-08	2.82E-07	1.16E-07	5.93E-07	3.15E-07
2000	1	11107680	1.30E-07	6.56E-08	2.57E-07	1.23E-08	2.73E-07	1.05E-07
2001	2	11090160	1.29E-07	7.07E-08	2.36E-07	4.01E-08	3.88E-07	1.75E-07
2002	1	11098920	1.29E-07	7.53E-08	2.20E-07	1.23E-08	2.74E-07	1.05E-07
2003	1	11107680	1.28E-07	7.87E-08	2.08E-07	1.23E-08	2.73E-07	1.05E-07
2004	3	11142720	1.27E-07	8.05E-08	2.02E-07	7.56E-08	4.91E-07	2.44E-07
2005	1	11151480	1.27E-07	8.00E-08	2.01E-07	1.23E-08	2.73E-07	1.05E-07
2006	0	11142720	1.26E-07	7.75E-08	2.06E-07	1.37E-10	1.34E-07	3.49E-08
2007	2	11160240	1.26E-07	7.33E-08	2.15E-07	3.99E-08	3.86E-07	1.74E-07
2008	0	11265360	1.25E-07	6.82E-08	2.29E-07	1.36E-10	1.33E-07	3.46E-08
2009	1	11212800	1.24E-07	6.26E-08	2.47E-07	1.22E-08	2.71E-07	1.04E-07
2010	3	11256600	1.24E-07	5.71E-08	2.69E-07	7.50E-08	4.87E-07	2.42E-07
2011	4	11230320	1.23E-07	5.17E-08	2.94E-07	1.15E-07	5.87E-07	3.12E-07

Table 14. Plot data for industry-wide MOV SO trend with ≤ 20 demands per year. Figure 5

FY/ Source	Failures	Hours	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						2.54E-10	1.24E-07	3.39E-08
1998	5	62204760	4.08E-08	1.55E-08	1.07E-07	3.01E-08	1.29E-07	7.23E-08
1999	1	62353680	3.81E-08	1.62E-08	8.99E-08	2.31E-09	5.13E-08	1.97E-08
2000	4	62388720	3.57E-08	1.67E-08	7.61E-08	2.18E-08	1.11E-07	5.90E-08
2001	2	62371200	3.34E-08	1.71E-08	6.52E-08	7.51E-09	7.26E-08	3.28E-08
2002	2	62336160	3.12E-08	1.71E-08	5.69E-08	7.52E-09	7.26E-08	3.28E-08
2003	3	62379960	2.92E-08	1.67E-08	5.09E-08	1.42E-08	9.22E-08	4.59E-08
2004	0	62327400	2.73E-08	1.59E-08	4.70E-08	2.58E-11	2.52E-08	6.56E-09
2005	0	62362440	2.55E-08	1.46E-08	4.48E-08	2.58E-11	2.52E-08	6.56E-09
2006	1	62415000	2.39E-08	1.30E-08	4.40E-08	2.31E-09	5.12E-08	1.97E-08
2007	6	62379960	2.23E-08	1.13E-08	4.42E-08	3.86E-08	1.47E-07	8.52E-08
2008	3	62415000	2.09E-08	9.65E-09	4.52E-08	1.42E-08	9.22E-08	4.59E-08
2009	3	62476320	1.95E-08	8.15E-09	4.68E-08	1.42E-08	9.21E-08	4.58E-08
2010	1	62432520	1.83E-08	6.84E-09	4.88E-08	2.31E-09	5.12E-08	1.97E-08
2011	0	63203400	1.71E-08	5.70E-09	5.12E-08	2.55E-11	2.49E-08	6.49E-09

Table 15. Plot data for industry-wide MOV SO trend, >20 demands per year. Figure 6

FY/ Source	Failures	Hours	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						2.54E-10	1.24E-07	3.39E-08
1998	0	10923720	2.98E-08	1.42E-08	6.24E-08	9.22E-11	9.01E-08	2.34E-08
1999	1	11090160	3.10E-08	1.60E-08	5.99E-08	8.19E-09	1.82E-07	6.98E-08
2000	0	11107680	3.22E-08	1.80E-08	5.78E-08	9.14E-11	8.93E-08	2.32E-08
2001	1	11090160	3.36E-08	2.00E-08	5.63E-08	8.19E-09	1.82E-07	6.98E-08
2002	0	11098920	3.49E-08	2.21E-08	5.53E-08	9.15E-11	8.93E-08	2.33E-08
2003	1	11107680	3.64E-08	2.39E-08	5.52E-08	8.18E-09	1.82E-07	6.97E-08
2004	0	11142720	3.78E-08	2.55E-08	5.62E-08	9.13E-11	8.92E-08	2.32E-08
2005	0	11151480	3.94E-08	2.65E-08	5.86E-08	9.12E-11	8.91E-08	2.32E-08
2006	0	11142720	4.10E-08	2.69E-08	6.25E-08	9.13E-11	8.92E-08	2.32E-08
2007	0	11160240	4.27E-08	2.68E-08	6.79E-08	9.12E-11	8.91E-08	2.32E-08
2008	0	11265360	4.44E-08	2.63E-08	7.50E-08	9.08E-11	8.87E-08	2.31E-08
2009	1	11212800	4.62E-08	2.56E-08	8.36E-08	8.14E-09	1.81E-07	6.94E-08
2010	2	11256600	4.81E-08	2.47E-08	9.39E-08	2.64E-08	2.56E-07	1.15E-07
2011	1	11230320	5.01E-08	2.37E-08	1.06E-07	8.13E-09	1.81E-07	6.94E-08

Table 16. Plot data for frequency (events per reactor year) of MOV operation demands with ≤ 20 demands per year. Figure 7

FY	Demands	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	42846	103.0	4.51E+02	4.30E+02	4.73E+02	4.13E+02	4.19E+02	4.16E+02
1999	45897	103.0	4.47E+02	4.29E+02	4.67E+02	4.42E+02	4.49E+02	4.46E+02
2000	46122	103.3	4.44E+02	4.27E+02	4.61E+02	4.43E+02	4.50E+02	4.47E+02
2001	46102	103.0	4.40E+02	4.26E+02	4.55E+02	4.44E+02	4.51E+02	4.48E+02
2002	46843	103.0	4.36E+02	4.24E+02	4.50E+02	4.51E+02	4.58E+02	4.55E+02
2003	46923	103.0	4.33E+02	4.21E+02	4.45E+02	4.52E+02	4.59E+02	4.56E+02
2004	46612	103.3	4.29E+02	4.18E+02	4.40E+02	4.48E+02	4.55E+02	4.51E+02
2005	45476	103.0	4.26E+02	4.15E+02	4.37E+02	4.38E+02	4.45E+02	4.42E+02
2006	41666	103.0	4.22E+02	4.10E+02	4.34E+02	4.01E+02	4.08E+02	4.05E+02
2007	41836	103.4	4.18E+02	4.06E+02	4.31E+02	4.02E+02	4.08E+02	4.05E+02
2008	42404	104.3	4.15E+02	4.01E+02	4.29E+02	4.03E+02	4.10E+02	4.07E+02
2009	41709	104.0	4.11E+02	3.96E+02	4.28E+02	3.98E+02	4.04E+02	4.01E+02
2010	42216	104.0	4.08E+02	3.91E+02	4.26E+02	4.03E+02	4.09E+02	4.06E+02
2011	42445	104.0	4.05E+02	3.85E+02	4.25E+02	4.05E+02	4.11E+02	4.08E+02

Table 17. Plot data for frequency (events per reactor year) of MOV operation demands with > 20 demands per year. Figure 8

FY	Demands	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	40948	103.0	4.33E+02	4.04E+02	4.65E+02	3.94E+02	4.01E+02	3.98E+02
1999	43488	103.0	4.33E+02	4.06E+02	4.61E+02	4.19E+02	4.26E+02	4.22E+02
2000	45883	103.3	4.32E+02	4.09E+02	4.57E+02	4.41E+02	4.48E+02	4.44E+02
2001	52686	103.0	4.32E+02	4.11E+02	4.54E+02	5.08E+02	5.15E+02	5.12E+02
2002	42436	103.0	4.31E+02	4.13E+02	4.51E+02	4.09E+02	4.15E+02	4.12E+02
2003	42779	103.0	4.31E+02	4.14E+02	4.48E+02	4.12E+02	4.19E+02	4.15E+02
2004	44929	103.3	4.30E+02	4.14E+02	4.47E+02	4.32E+02	4.38E+02	4.35E+02
2005	44810	103.0	4.30E+02	4.14E+02	4.46E+02	4.32E+02	4.38E+02	4.35E+02
2006	44275	103.0	4.29E+02	4.13E+02	4.47E+02	4.27E+02	4.33E+02	4.30E+02
2007	44727	103.4	4.29E+02	4.10E+02	4.48E+02	4.29E+02	4.36E+02	4.33E+02
2008	44299	104.3	4.28E+02	4.08E+02	4.50E+02	4.21E+02	4.28E+02	4.25E+02
2009	43977	104.0	4.28E+02	4.05E+02	4.52E+02	4.20E+02	4.26E+02	4.23E+02
2010	44319	104.0	4.27E+02	4.01E+02	4.55E+02	4.23E+02	4.29E+02	4.26E+02
2011	43833	104.0	4.27E+02	3.98E+02	4.58E+02	4.18E+02	4.25E+02	4.21E+02

Table 18. Plot data for frequency (events per reactor year) of MOV FTOC events with ≤ 20 demands per year. Figure 9

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	66	103.0	5.50E-01	4.48E-01	6.74E-01	5.15E-01	7.71E-01	6.38E-01
1999	55	103.0	5.16E-01	4.31E-01	6.18E-01	4.20E-01	6.55E-01	5.32E-01
2000	55	103.3	4.85E-01	4.14E-01	5.69E-01	4.19E-01	6.53E-01	5.31E-01
2001	46	103.0	4.56E-01	3.96E-01	5.25E-01	3.44E-01	5.59E-01	4.46E-01
2002	35	103.0	4.28E-01	3.77E-01	4.86E-01	2.52E-01	4.39E-01	3.40E-01
2003	41	103.0	4.03E-01	3.57E-01	4.54E-01	3.02E-01	5.05E-01	3.98E-01
2004	27	103.3	3.78E-01	3.36E-01	4.26E-01	1.86E-01	3.51E-01	2.63E-01
2005	34	103.0	3.55E-01	3.13E-01	4.03E-01	2.44E-01	4.29E-01	3.31E-01
2006	37	103.0	3.34E-01	2.90E-01	3.84E-01	2.69E-01	4.61E-01	3.60E-01
2007	40	103.4	3.14E-01	2.68E-01	3.67E-01	2.93E-01	4.92E-01	3.87E-01
2008	25	104.3	2.95E-01	2.47E-01	3.52E-01	1.69E-01	3.25E-01	2.42E-01
2009	38	104.0	2.77E-01	2.26E-01	3.39E-01	2.74E-01	4.68E-01	3.66E-01
2010	34	104.0	2.60E-01	2.08E-01	3.26E-01	2.42E-01	4.24E-01	3.28E-01
2011	22	104.0	2.45E-01	1.90E-01	3.15E-01	1.45E-01	2.93E-01	2.14E-01

Table 19. Plot data for frequency (events per reactor year) of MOV FTOC events with > 20 demands per year. Figure 10

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	11	103.0	1.41E-01	9.31E-02	2.14E-01	6.07E-02	1.63E-01	1.07E-01
1999	15	103.0	1.33E-01	9.18E-02	1.92E-01	8.94E-02	2.09E-01	1.44E-01
2000	10	103.3	1.25E-01	9.02E-02	1.73E-01	5.36E-02	1.51E-01	9.71E-02
2001	15	103.0	1.17E-01	8.81E-02	1.57E-01	8.94E-02	2.09E-01	1.44E-01
2002	11	103.0	1.10E-01	8.53E-02	1.43E-01	6.07E-02	1.63E-01	1.07E-01
2003	15	103.0	1.04E-01	8.15E-02	1.33E-01	8.94E-02	2.09E-01	1.44E-01
2004	14	103.3	9.78E-02	7.69E-02	1.24E-01	8.19E-02	1.97E-01	1.34E-01
2005	10	103.0	9.20E-02	7.14E-02	1.19E-01	5.37E-02	1.51E-01	9.74E-02
2006	9	103.0	8.66E-02	6.55E-02	1.14E-01	4.69E-02	1.40E-01	8.81E-02
2007	11	103.4	8.15E-02	5.95E-02	1.12E-01	6.05E-02	1.63E-01	1.06E-01
2008	9	104.3	7.67E-02	5.37E-02	1.09E-01	4.64E-02	1.38E-01	8.71E-02
2009	5	104.0	7.21E-02	4.82E-02	1.08E-01	2.10E-02	9.04E-02	5.05E-02
2010	2	104.0	6.79E-02	4.32E-02	1.07E-01	5.26E-03	5.09E-02	2.30E-02
2011	12	104.0	6.39E-02	3.85E-02	1.06E-01	6.71E-02	1.73E-01	1.15E-01

Table 20. Plot data for frequency (events per reactor year) of MOV FTOP events with ≤ 20 demands per year. Figure 11

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	2	103.0	4.16E-02	2.09E-02	8.29E-02	4.80E-03	4.64E-02	2.10E-02
1999	3	103.0	3.85E-02	2.09E-02	7.09E-02	9.09E-03	5.90E-02	2.93E-02
2000	9	103.3	3.56E-02	2.07E-02	6.10E-02	4.23E-02	1.26E-01	7.95E-02
2001	3	103.0	3.29E-02	2.04E-02	5.30E-02	9.09E-03	5.90E-02	2.93E-02
2002	5	103.0	3.04E-02	1.97E-02	4.68E-02	1.92E-02	8.25E-02	4.61E-02
2003	4	103.0	2.81E-02	1.88E-02	4.21E-02	1.39E-02	7.09E-02	3.77E-02
2004	5	103.3	2.60E-02	1.74E-02	3.87E-02	1.91E-02	8.23E-02	4.60E-02
2005	2	103.0	2.40E-02	1.58E-02	3.66E-02	4.80E-03	4.64E-02	2.10E-02
2006	1	103.0	2.22E-02	1.40E-02	3.52E-02	1.48E-03	3.28E-02	1.26E-02
2007	3	103.4	2.05E-02	1.22E-02	3.45E-02	9.06E-03	5.88E-02	2.93E-02
2008	2	104.3	1.90E-02	1.05E-02	3.42E-02	4.75E-03	4.59E-02	2.07E-02
2009	0	104.0	1.75E-02	9.01E-03	3.41E-02	1.63E-05	1.60E-02	4.16E-03
2010	4	104.0	1.62E-02	7.67E-03	3.42E-02	1.38E-02	7.03E-02	3.74E-02
2011	1	104.0	1.50E-02	6.51E-03	3.45E-02	1.46E-03	3.25E-02	1.25E-02

Table 21. Plot data for frequency (events per reactor year) of MOV FTOP events with > 20 demands per year. Figure 12

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	1	103.0	1.41E-02	5.93E-03	3.34E-02	1.33E-03	2.95E-02	1.13E-02
1999	4	103.0	1.40E-02	6.48E-03	3.03E-02	1.25E-02	6.38E-02	3.40E-02
2000	1	103.3	1.40E-02	7.05E-03	2.76E-02	1.32E-03	2.94E-02	1.13E-02
2001	2	103.0	1.39E-02	7.60E-03	2.54E-02	4.32E-03	4.18E-02	1.89E-02
2002	1	103.0	1.38E-02	8.10E-03	2.37E-02	1.33E-03	2.95E-02	1.13E-02
2003	1	103.0	1.38E-02	8.48E-03	2.24E-02	1.33E-03	2.95E-02	1.13E-02
2004	3	103.3	1.37E-02	8.67E-03	2.17E-02	8.16E-03	5.30E-02	2.64E-02
2005	1	103.0	1.37E-02	8.63E-03	2.17E-02	1.33E-03	2.95E-02	1.13E-02
2006	0	103.0	1.36E-02	8.36E-03	2.22E-02	1.48E-05	1.45E-02	3.77E-03
2007	2	103.4	1.36E-02	7.92E-03	2.33E-02	4.31E-03	4.17E-02	1.88E-02
2008	0	104.3	1.35E-02	7.37E-03	2.48E-02	1.47E-05	1.44E-02	3.74E-03
2009	1	104.0	1.35E-02	6.78E-03	2.67E-02	1.32E-03	2.93E-02	1.12E-02
2010	3	104.0	1.34E-02	6.18E-03	2.91E-02	8.12E-03	5.27E-02	2.62E-02
2011	4	104.0	1.34E-02	5.60E-03	3.18E-02	1.25E-02	6.34E-02	3.37E-02

Table 22. Plot data for frequency (events per reactor year) of MOV SO events ≤ 20 demands per year. Figure 13

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	5	62204760	4.08E-08	1.55E-08	1.07E-07	3.01E-08	1.29E-07	7.23E-08
1999	1	62353680	3.81E-08	1.62E-08	8.99E-08	2.31E-09	5.13E-08	1.97E-08
2000	4	62388720	3.57E-08	1.67E-08	7.61E-08	2.18E-08	1.11E-07	5.90E-08
2001	2	62371200	3.34E-08	1.71E-08	6.52E-08	7.51E-09	7.26E-08	3.28E-08
2002	2	62336160	3.12E-08	1.71E-08	5.69E-08	7.52E-09	7.26E-08	3.28E-08
2003	3	62379960	2.92E-08	1.67E-08	5.09E-08	1.42E-08	9.22E-08	4.59E-08
2004	0	62327400	2.73E-08	1.59E-08	4.70E-08	2.58E-11	2.52E-08	6.56E-09
2005	0	62362440	2.55E-08	1.46E-08	4.48E-08	2.58E-11	2.52E-08	6.56E-09
2006	1	62415000	2.39E-08	1.30E-08	4.40E-08	2.31E-09	5.12E-08	1.97E-08
2007	6	62379960	2.23E-08	1.13E-08	4.42E-08	3.86E-08	1.47E-07	8.52E-08
2008	3	62415000	2.09E-08	9.65E-09	4.52E-08	1.42E-08	9.22E-08	4.59E-08
2009	3	62476320	1.95E-08	8.15E-09	4.68E-08	1.42E-08	9.21E-08	4.58E-08
2010	1	62432520	1.83E-08	6.84E-09	4.88E-08	2.31E-09	5.12E-08	1.97E-08
2011	0	63203400	1.71E-08	5.70E-09	5.12E-08	2.55E-11	2.49E-08	6.49E-09

Table 23. Plot data for frequency (events per reactor year) of MOV SO events > 20 demands per year. Figure 14

FY	Failures	Reactor Years	Regression Curve Data Points			Plot Trend Error Bar Points		
			Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	0	103.0	3.20E-03	1.53E-03	6.71E-03	9.86E-06	9.63E-03	2.51E-03
1999	1	103.0	3.33E-03	1.72E-03	6.44E-03	8.82E-04	1.96E-02	7.52E-03
2000	0	103.3	3.47E-03	1.93E-03	6.22E-03	9.84E-06	9.62E-03	2.50E-03
2001	1	103.0	3.61E-03	2.15E-03	6.06E-03	8.82E-04	1.96E-02	7.52E-03
2002	0	103.0	3.76E-03	2.37E-03	5.96E-03	9.86E-06	9.63E-03	2.51E-03
2003	1	103.0	3.92E-03	2.58E-03	5.95E-03	8.82E-04	1.96E-02	7.52E-03
2004	0	103.3	4.08E-03	2.75E-03	6.06E-03	9.84E-06	9.62E-03	2.50E-03
2005	0	103.0	4.25E-03	2.86E-03	6.31E-03	9.86E-06	9.63E-03	2.51E-03
2006	0	103.0	4.42E-03	2.90E-03	6.74E-03	9.86E-06	9.63E-03	2.51E-03
2007	0	103.4	4.60E-03	2.89E-03	7.33E-03	9.84E-06	9.61E-03	2.50E-03
2008	0	104.3	4.80E-03	2.84E-03	8.09E-03	9.79E-06	9.57E-03	2.49E-03
2009	1	104.0	4.99E-03	2.76E-03	9.03E-03	8.77E-04	1.95E-02	7.48E-03
2010	2	104.0	5.20E-03	2.67E-03	1.01E-02	2.86E-03	2.76E-02	1.25E-02
2011	1	104.0	5.41E-03	2.56E-03	1.14E-02	8.77E-04	1.95E-02	7.48E-03

7 REFERENCES

1. U.S. NRC, *Component Reliability Data Sheets Update 2010*, January 2012, http://nrcoe.inl.gov/resultsdb/publicdocs/AvgPerf/ComponentReliabilityDataSheets2010.pdf

2. S.A. Eide, et al, *Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, NUREG/CR-6928, February 2007.