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Enhanced Component Performance Study: Motor-Operated Valves 1998–2012

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ABSTRACT

This report presents an enhanced performance evaluation of motor-operated valves (MOVs) at U.S. commercial nuclear power plants. The data used in this study are based on the operating experience failure reports from fiscal year 1998 through 2012 for the component reliability as reported in the Equipment Performance and Information Exchange (EPIX). The MOV failure modes considered are failure to open/close, failure to operate or control, and spurious operation. The component reliability estimates and the reliability data are trended for the most recent 10-year period while yearly estimates for reliability are provided for the entire active period. No statistically significant increasing trends were identified in the MOV results. Statistically significant decreasing trends were identified for failure to open/close and operation demands.

CONTENTS

FIGURES

TABLES

ACRONYMS

AFW	Auxiliary feedwater
CCW	component cooling water
CNID	constrained noninformative prior distribution
CRD	control rod drive
CSR	containment spray recirculation
CVC	chemical and volume control
EPIX	Equipment Performance and Information Exchange
EPS	emergency power supply
FTOC	failure-to-open/close (failure to operate)
FTOP	failure to operate or control
FY	fiscal year
HCI	high-pressure coolant injection
HCS	high-pressure core spray
HPI	high-pressure injection
ISO	isolation condenser
LCS	low-pressure core spray
MOV	motor-operated valve
MSPI	Mitigating Systems Performance Index
PRA	probabilistic risk assessment
RCI	reactor core isolation
RCS	reactor coolant
RHR	residual heat removal
SO	spurious operation
SWN	normally running service water
SWS	standby service water
TDP	turbine-driven pump
UA	unavailability
VSS	vapor suppression

Enhanced Component Performance Study: Motor-Operated Valves 1998–2012

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 the MOV unreliability estimates using Equipment Performance and Information Exchange (EPIX) data from 1998 through 2010 for use in PRAs.

The data used in this study are based on the operating experience failure reports from fiscal year (FY)-98 through FY-12 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). The component reliability estimates and the reliability data are trended for the most recent 10-year period while yearly estimates for reliability are provided for the entire active period.

Previously, the study relied on operating experience obtained from licensee event reports, Nuclear Plant Reliability Data System, 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, and 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[a] 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/yr (see Figure 2)
- Frequency (failures per reactor year) of MOV FTOC events > 20 demands/yr (see Figure 10)

and highly statistically significant decreasing trends were identified in the MOV results for

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

Considering the low-demand MOVs; Table 3 shows that 91% of the MOV FTOC failures occurred in eight systems. Table 4 shows that 88% of the MOV FTOP failures occurred in five systems. Similarly, Table 5 shows that 94% of the MOV SO failures occurred in seven systems.

Considering the high-demand MOVs; Table 6 shows that 84% of the MOV FTOC failures occurred in five systems. Table 7 shows that 90% of the MOV FTOP failures occurred in six systems. Similarly, Table 8 shows that all of the MOV SO failures occurred (or were identified) in three systems.

a. 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).

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 and MOVs with > 20 demands/yr and includes MOVs in the systems listed in Table 1. NUREG/CR-6928 lists the industry failure data for MOVs with ≤ 20 demands/yr. Table 2 shows industry-wide failure probability and failure rate results for the MOV with ≤ 20 demands/yr from Reference 1. No results are shown for > 20 demands/yr MOVs because Reference 1 does not present results for > 20 demands/yr.

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, engineered safety feature demands.

Table 1. MOV systems.

		MOV Component Count		
System	Description	Total	≤ 20 demands/yr	> 20 demands/yr
AFW	Auxiliary feedwater	581	445	136
CCW	Component cooling water	834	674	160
CRD	Control rod drive	25	10	15
CSR	Containment spray recirculation	345	324	21
CVC	Chemical and volume control	21	21	
HCI	High-pressure coolant injection	269	246	23
HCS	High-pressure core spray	47	28	19
HPI	High-pressure injection	1077	962	115
ISO	Isolation condenser	20	14	6
LCS	Low-pressure core spray	234	205	29
RCI	Reactor core isolation	335	303	32
RCS	Reactor coolant	108	101	7
RHR	Residual heat removal	2102	1803	299
SWN	Normally running service water	952	682	270
SWS	Standby service water	284	193	91
VSS	Vapor suppression	14	14	
	Total	7248	6025	1223

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

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 Figures 1–6. The data for the trend plots are contained in Tables 10–15, respectively.

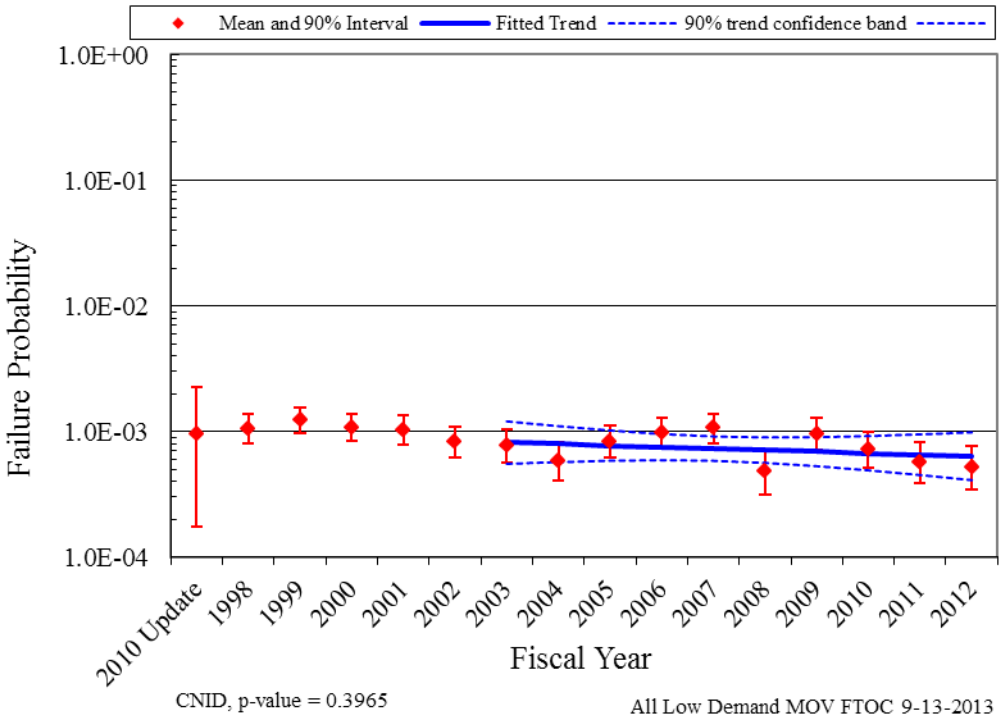

Figure 1. Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with ≤ 20 demands/yr.

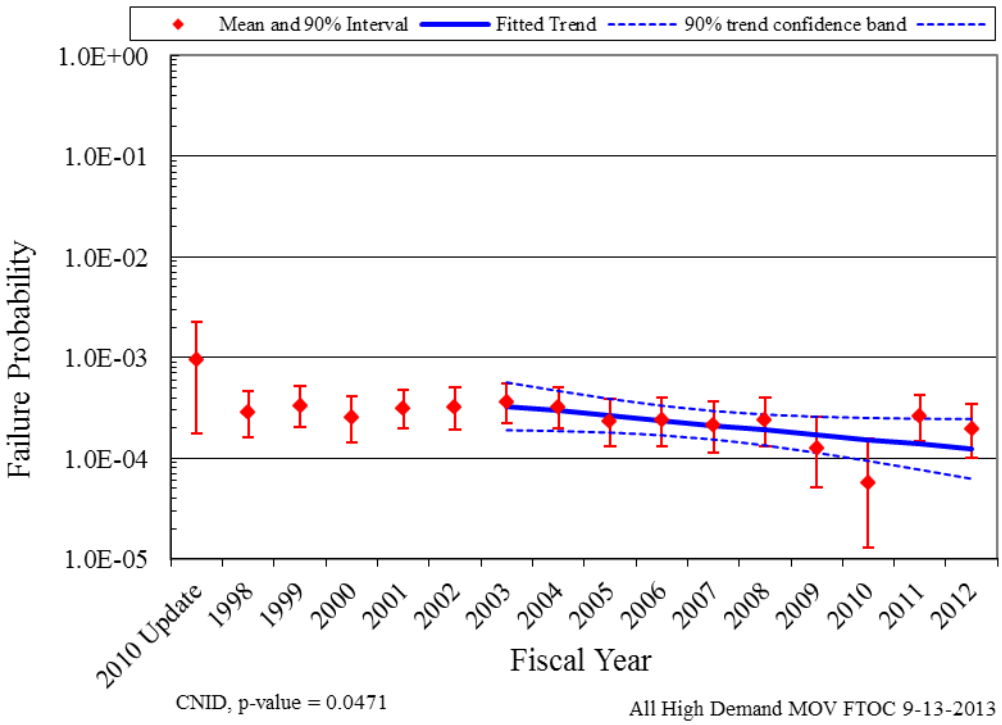

Figure 2. Failure probability estimate trend for MOV FTOC, all systems, industry-wide trend of MOVs with > 20 demands/yr.

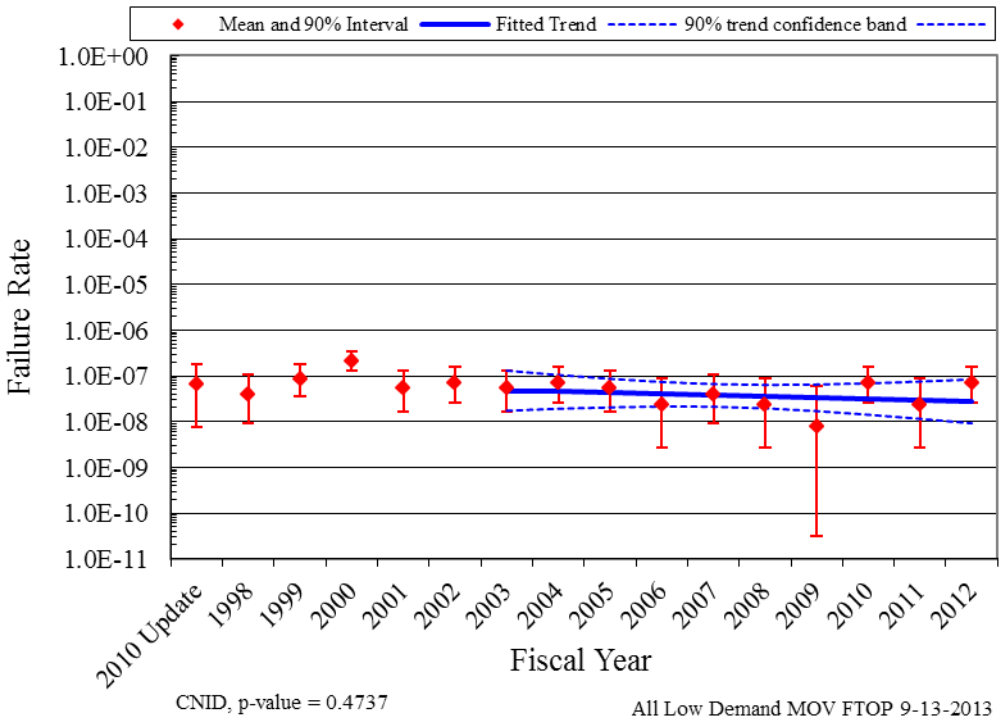

Figure 3. Failure rate estimate trend for MOV FTOP, all systems, industry-wide trend of MOVs with ≤ 20 demands/yr.

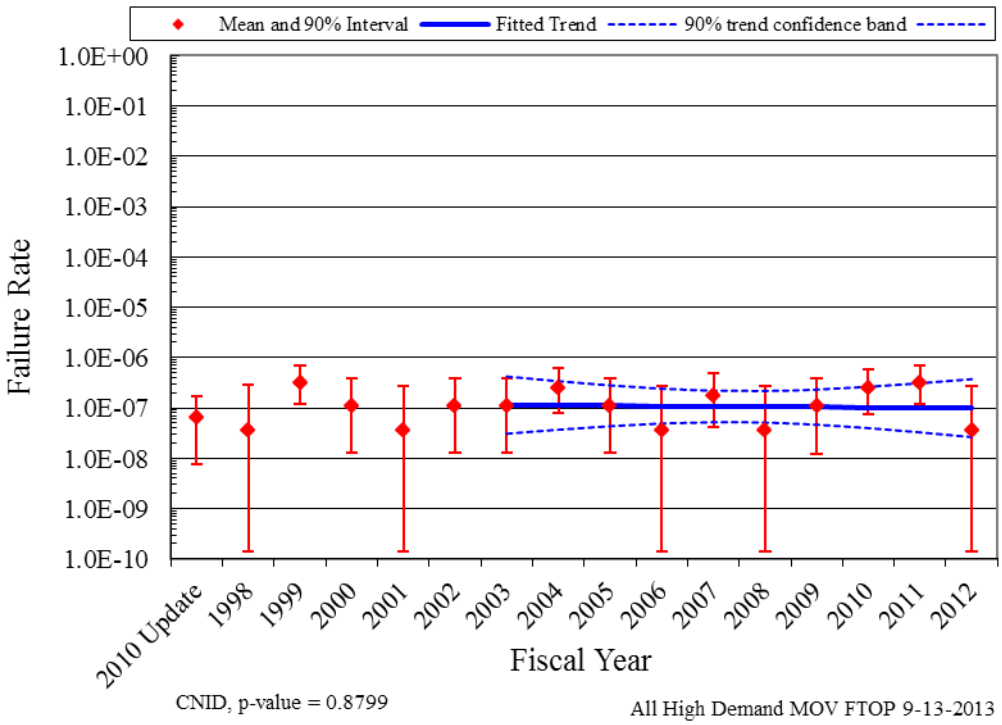

Figure 4. Failure rate estimate trend for MOV FTOP, all systems, industry-wide trend of MOVs with > 20 demands/yr.

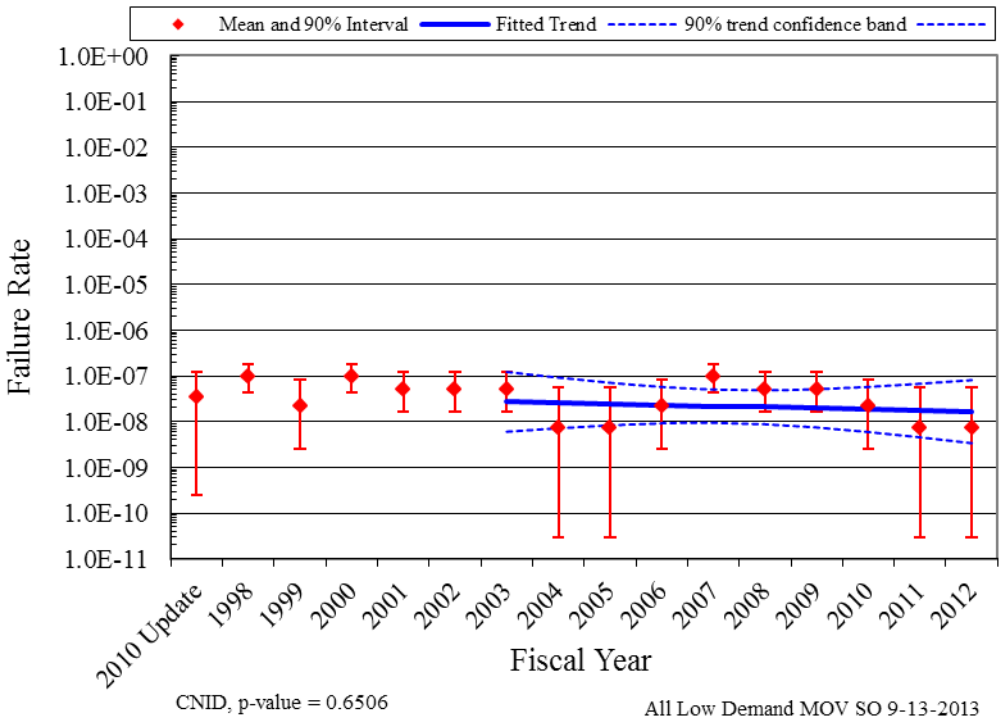

Figure 5. Failure rate estimate trend for MOV SO, all systems, industry-wide trend of MOVs with ≤ 20 demands/yr.

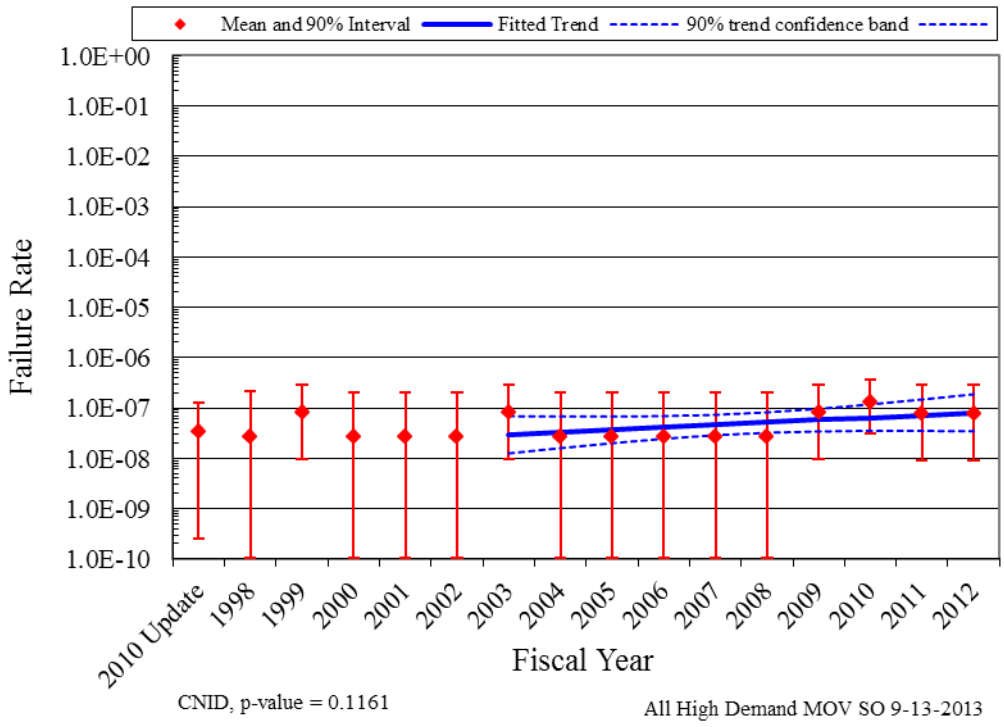

Figure 6. Failure rate estimate trend for MOV SO, all systems, industry-wide trend of MOVs with > 20 demands/yr.

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 systems contributing 50% or more (in bold) to the FTOC failure mode in Table 3 are AFW, CCW, HCI, HPI, LCS, RCI, RHR, and SWN. Table 4 summarizes the failures by system, year, and the FTOP failure mode of MOV ≤20 demands. The systems contributing 50% or more (in bold) to the FTOP failure mode in Table 4 are AFW, CCW, HPI, RHR, and SWN. Table 5 summarizes the failures by system, year, and the SO failure mode of MOV ≤20 demands. The systems contributing 50% or more (in bold) to the SO failure mode in Table 5**Error! Reference source not found.** are CCW, LCS, RCI, and RHR.

Table 6 summarizes the failures by system, year, and the FTOC failure mode of MOV > 20 demands. The systems contributing 50% or more (in bold) to the FTOC failure mode in Table 6 are AFW, CCW, RCI, RHR, SWN, and SWS. Table 7 summarizes the failures by system, year, and the FTOP failure mode of MOV > 20 demands. The systems contributing 50% or more (in bold) to the FTOP failure mode in Table 7 are AFW, CCW, LCS, RHR, SWN, and SWS. Table 8 summarizes the failures by system, year, and the SO failure mode of MOV > 20 demands. The contributing systems in Table 8 for the SO failure mode are RCI, RHR, and SWN.

Tables 16–23provide 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.

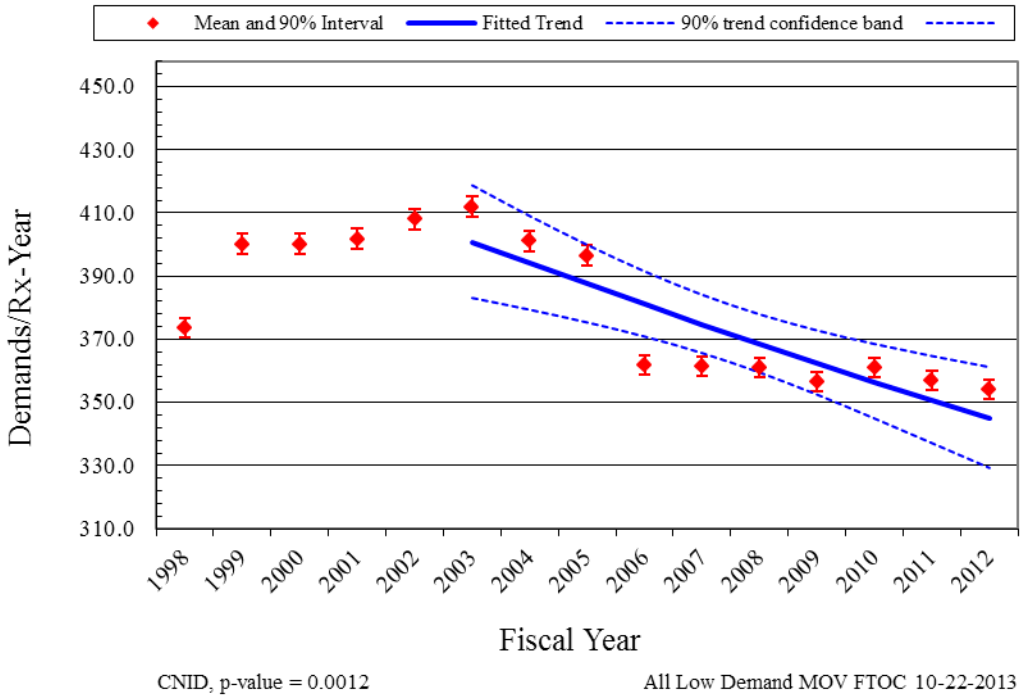

Figure 7. Frequency (demands per reactor year) of MOV operation demands, ≤ 20 demands/yr.

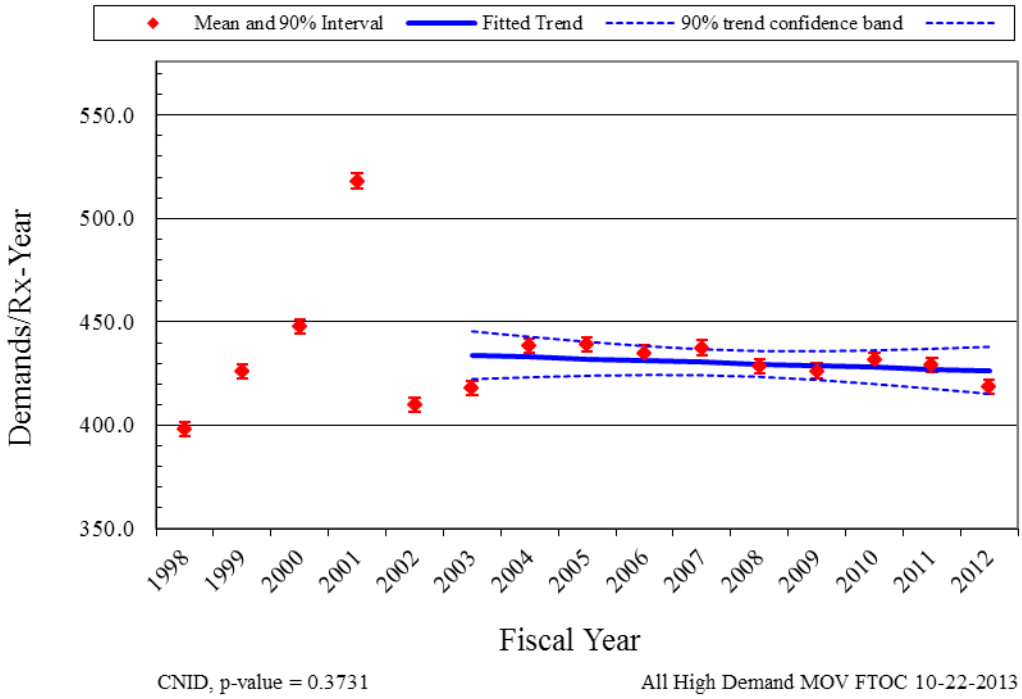

Figure 8. Frequency (demands per reactor year) of MOV operation demands, > 20 demands/yr.

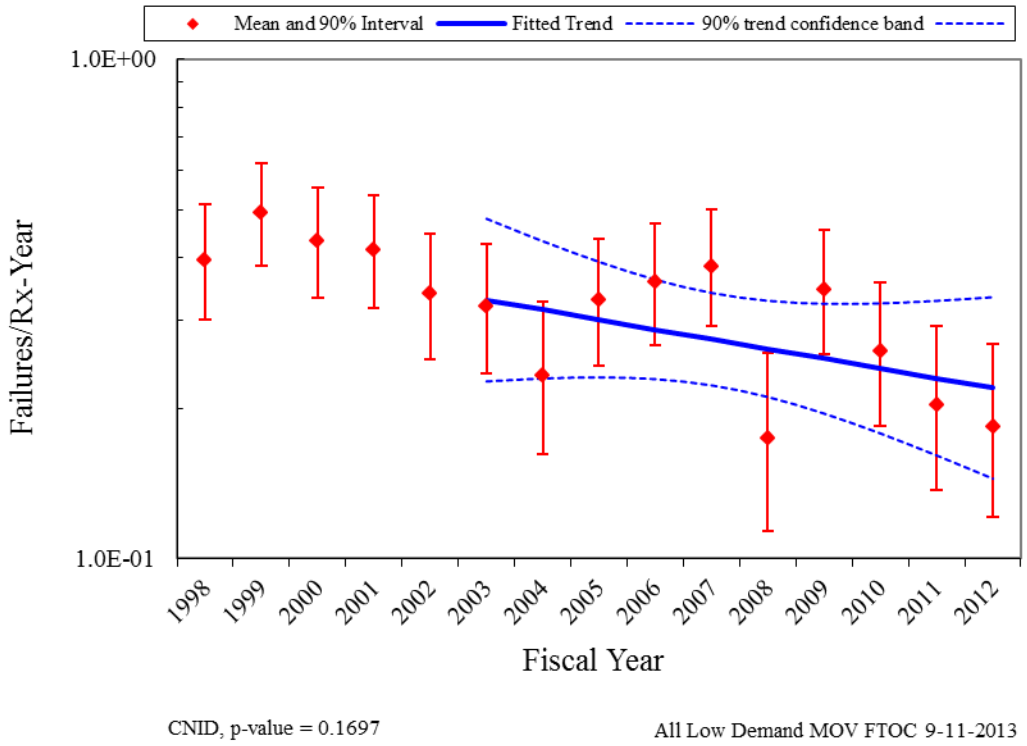

Figure 9. Frequency (failures per reactor year) of MOV FTOC events ≤ 20 demands/yr.

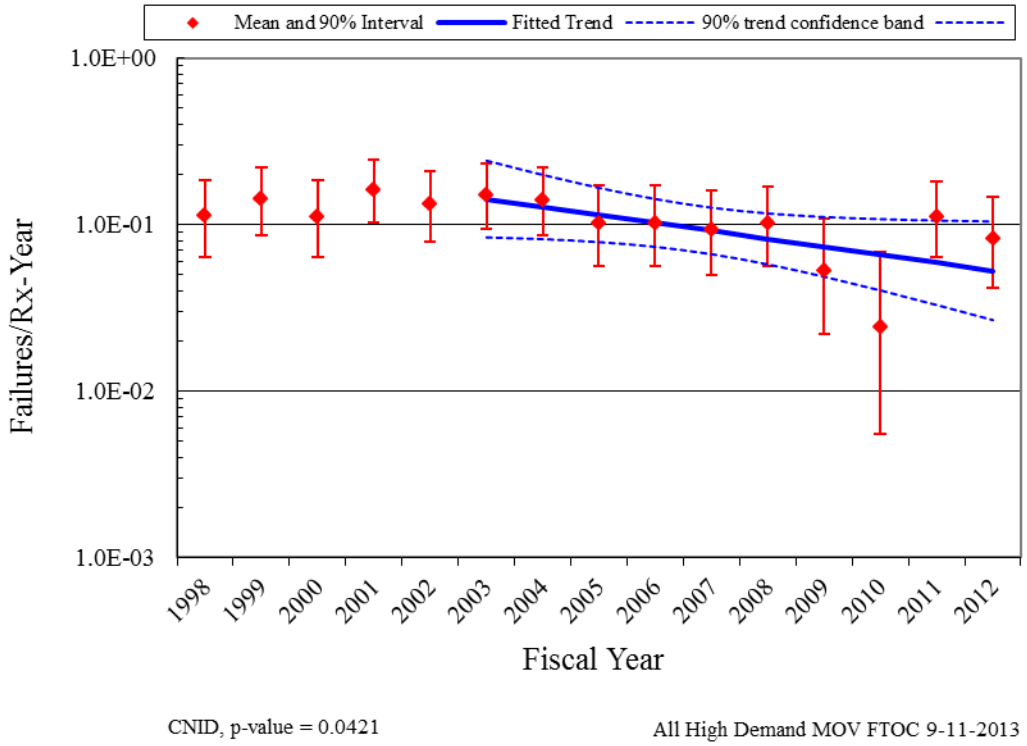

Figure 10. Frequency (failures per reactor year) of MOV FTOC events > 20 demands/yr.

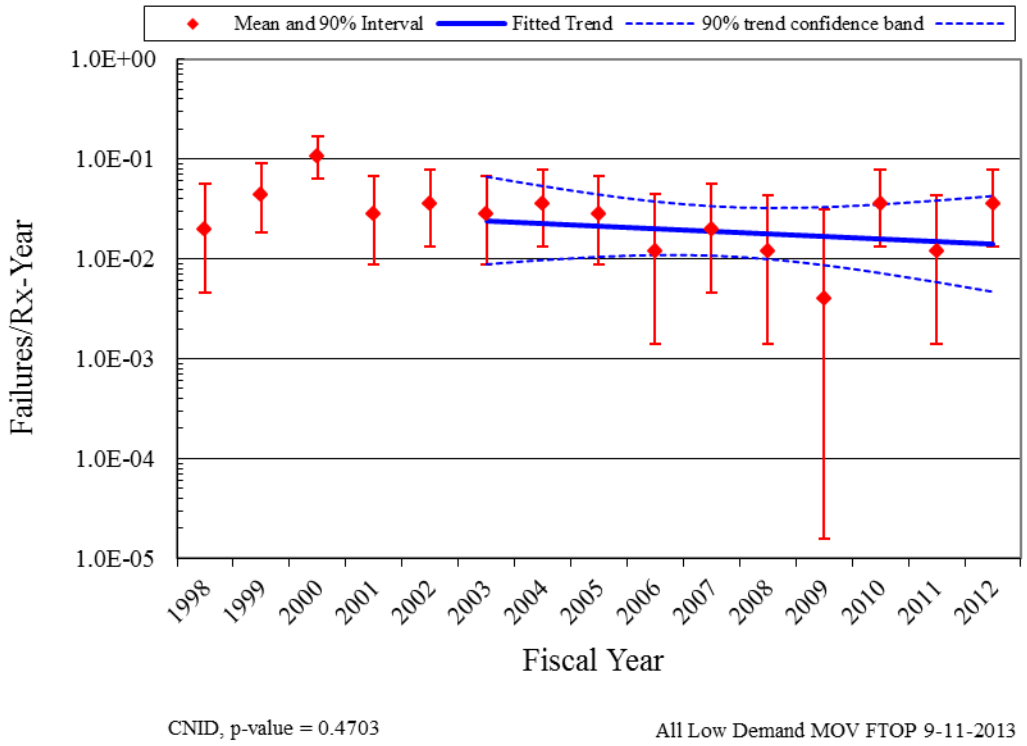

Figure 11. Frequency (failures per reactor year) of MOV FTOP events ≤ 20 demands/yr.

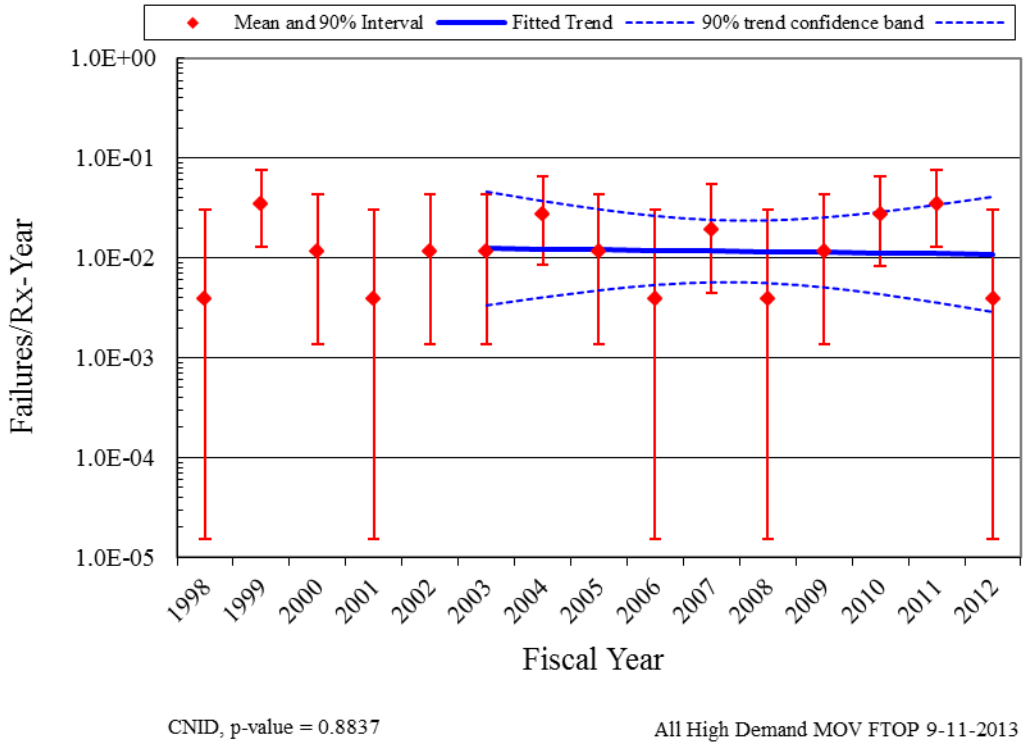

Figure 12. Frequency (failures per reactor year) of MOV FTOP events > 20 demands/yr.

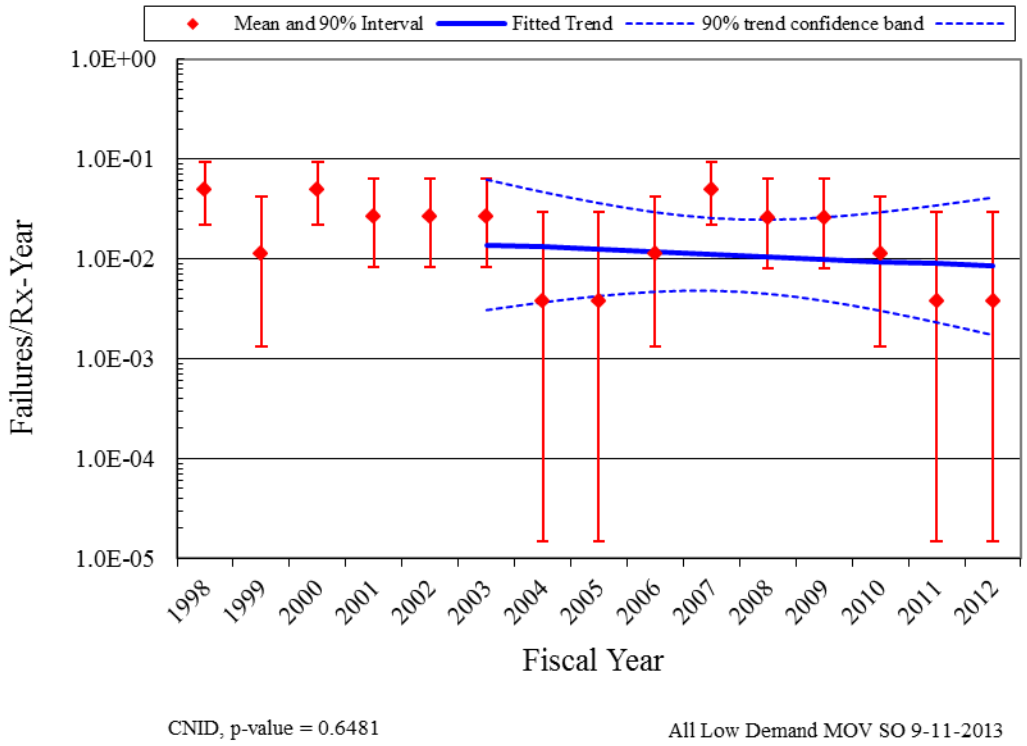

Figure 13. Frequency (failures per reactor year) of MOV SO events ≤ 20 demands/yr.

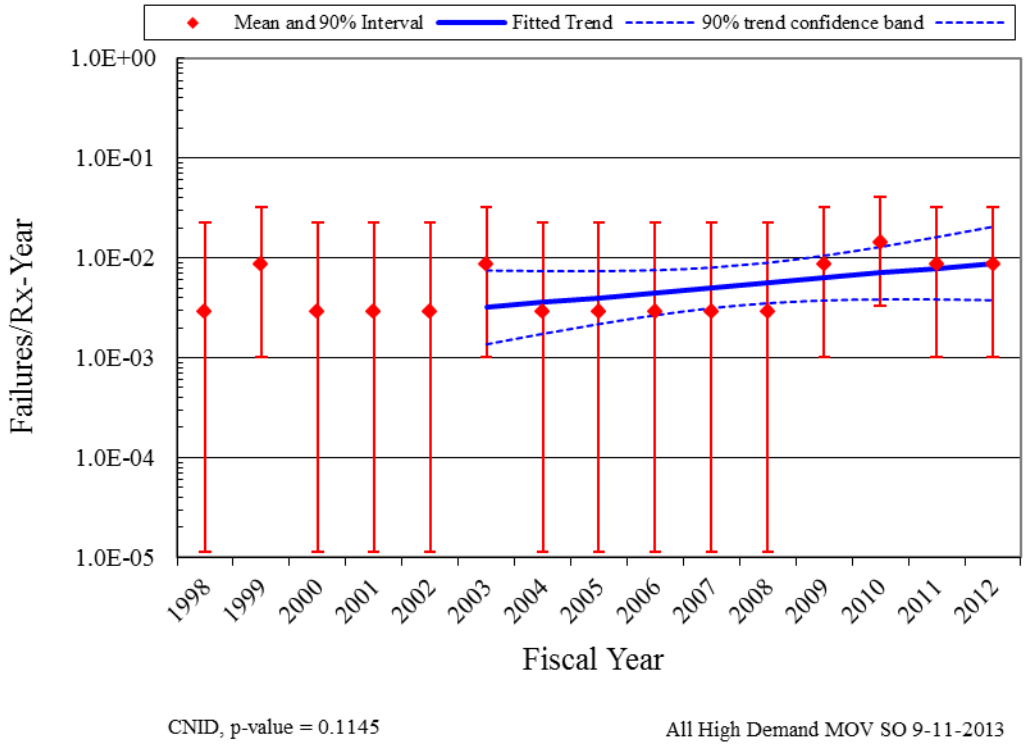

Figure 14. Frequency (failures per reactor year) of MOV SO events > 20 demands/yr.

Table 3. Summary of TDP failure counts for the FTS failure mode over time by system.

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	FY-12	Total	Percent of Failures
AFW	445	7.4%	3	5	4	6	3			3	1	5	2	5	5	3		45	8.9%
CCW	674	11.2%	4	2	3	2	4	4	1	2	2	1		3	3	2	1	34	6.7%
CRD	10	0.2%		1														1	0.2%
CSR	324	5.4%	1	2	2		2	3	1		1		1	1		2	2	18	3.6%
CVC	13	0.2%					1											1	0.2%
HCI	246	4.1%	4	2	2	3	2	2	2	2	3	8		8	1		1	40	7.9%
HCS	28	0.5%		1	1													2	0.4%
HPI	962	16.0%	4	5	6	4	3	2	6	5	3	3	1	3	3	2	1	51	10.1%
ISO	14	0.2%		1	2	1			1	2						1		8	1.6%
LCS	205	3.4%	4	8	2	3	1	2			1	1				1	4	27	5.4%
RCI	303	5.0%	3	7	4	5	3	2	2	4	3	3	2	2	1	2	3	46	9.1%
RCS	102	1.7%				1		1	2		1						1	6	1.2%
RHR	1803	30.0%	17	13	16	10	12	10	8	14	16	16	8	9	12	3	5	169	33.5%
SWN	682	11.3%	1	4	3	7	3	5	1	1	6	1	4	4	2	3	1	46	9.1%
SWS	193	3.2%				1						1		1		2		5	1.0%
VSS	14	0.2%					1	2		1		1						5	1.0%
Total	6018	100%	41	51	45	43	35	33	24	34	37	40	18	36	27	21	19	504	100%

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

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	FY-12	Total	Percent of Failures
AFW	445	7.8%			1		1	1	2				1		1		3	10	**20.0%**
CCW	674	11.8%			3	2				1								6	**12.0%**
CSR	324	5.7%							1									1	2.0%
HCI	246	4.3%										1						1	2.0%
HPI	962	16.8%					2								1	1		4	**8.0%**
RCI	303	5.3%		2														2	4.0%
RCS	102	1.8%								1								1	2.0%
RHR	1803	31.4%	1	3	7	1		2			1	1			2		1	19	**38.0%**
SWN	682	11.9%	1		2				1	1								5	**10.0%**
SWS	193	3.4%					1											1	2.0%
Total	5734	100%	2	5	13	3	4	3	4	3	1	2	1		4	1	4	50	100%

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

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	FY-12	Total	Percent of Failures
AFW	445	9.1%	1		1	1												3	8.3%
CCW	674	13.8%					1	1					2	2				6	**16.7%**
CSR	324	6.6%				1												1	2.8%
HCI	246	5.0%	1			1						1			1			4	11.1%
LCS	205	4.2%		1							1	4						6	**16.7%**
RCI	303	6.2%			3		1						1	1				6	**16.7%**
RHR	1803	37.0%	3		2			1				1						7	**19.4%**
SWN	682	14.0%					1											1	2.8%
SWS	193	4.0%	1					1										2	5.6%
Total	4875	100%	6	1	6	3	3	3			1	6	3	3	1			36	100%

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

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	FY-12	Total	Percent of Failures
AFW	136	11.3%	2	1	4	1	4	7	3	2	2	1		1	1	1	2	32	**20.1%**
CCW	160	13.3%				1		2	2				1			1	1	8	**5.0%**
CSR	21	1.7%	1															1	0.6%
HCI	23	1.9%					1			1	1		1			1		5	3.1%
HCS	19	1.6%					1						1					2	1.3%
HPI	115	9.6%	2		1		1											4	2.5%
LCS	29	2.4%	1			1			1				1				1	5	3.1%
RCI	32	2.7%		1		1			1	2						1	1	7	**4.4%**
RCS	7	0.6%		1														1	0.6%
RHR	299	24.9%	3	7	6	4	2	3	2	4	3	7	3	3	1	6	2	56	**35.2%**
SWN	270	22.5%	2	4		5	2	1	5	1	3		2	1			1	27	**17.0%**
SWS	91	7.6%				3	2	2			1	1	1			1		11	**6.9%**
Total	1202	100%	11	14	11	16	13	15	14	10	10	9	10	5	2	11	8	159	100%

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

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	FY-12	Total	Percent of Failures
AFW	136	12.1%		1				1	1			1				1		5	23.8%
CCW	160	14.2%								1					1			2	9.5%
HCI	23	2.0%														1		1	4.8%
HPI	115	10.2%														1		1	4.8%
LCS	29	2.6%		1												1		2	9.5%
RHR	299	26.6%												1	1			2	9.5%
SWN	270	24.0%		2	1							1						4	19.0%
SWS	91	8.1%					1		2						1			4	19.0%
Total	1123	100%		4	1		1	1	3	1		2		1	3	4		21	100%

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

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	FY-12	Total	Percent of Failures
RCI	32	5.3%													2			2	28.6%
RHR	299	49.8%												1		1	1	3	**42.9%**
SWN	270	44.9%		1				1										2	28.6%
Total	601	100%		1				1						1	2	1	1	7	100%

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 first divides the events into two categories: MOVs with ≤ 20 demands/year [Low-Demands] and MOVs with > 20 demands/yr [High-Demands].

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 SO failure mode, the valve was shown to have no contribution to the failure rate.

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 the FTOC, FTOP, and SO 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. In addition, the External Cause group is increasing in importance for the SO failure mode.

MOV detection methods to the three failure modes are presented in Figure 17. The most likely detection method for the FTOC failure mode is a testing demand. The FTOP and SO detection modes are heavily influenced by testing and non-test demands.

MOV recovery to the three failure modes are presented in Figure 18. The overall non-recovery to recovery ratio is approximately 13:1.

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.
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.

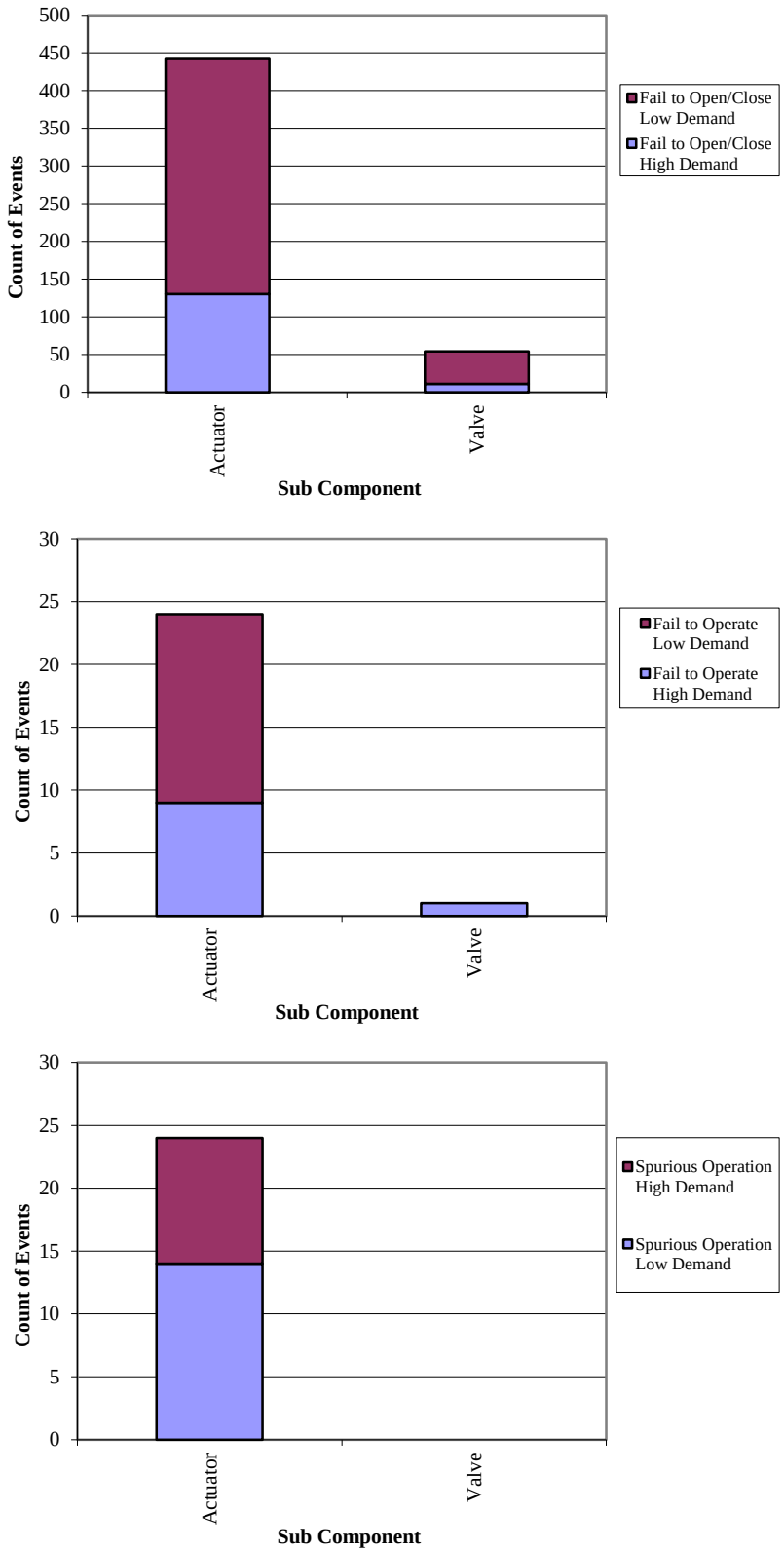

Figure 15. MOV failure breakdown by period, sub component, and failure mode.

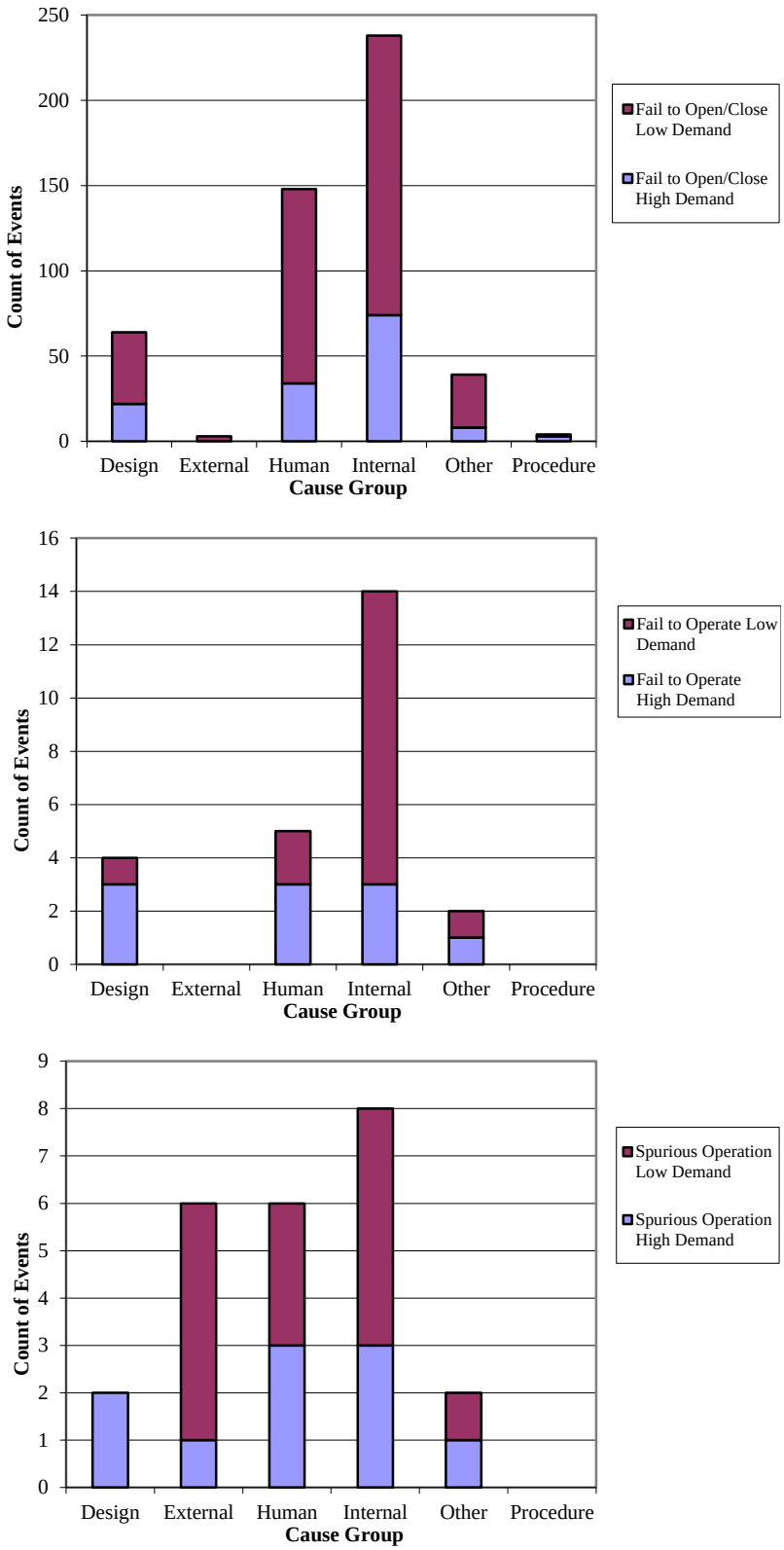

Figure 16. MOV breakdown by time period, cause group, and failure mode.

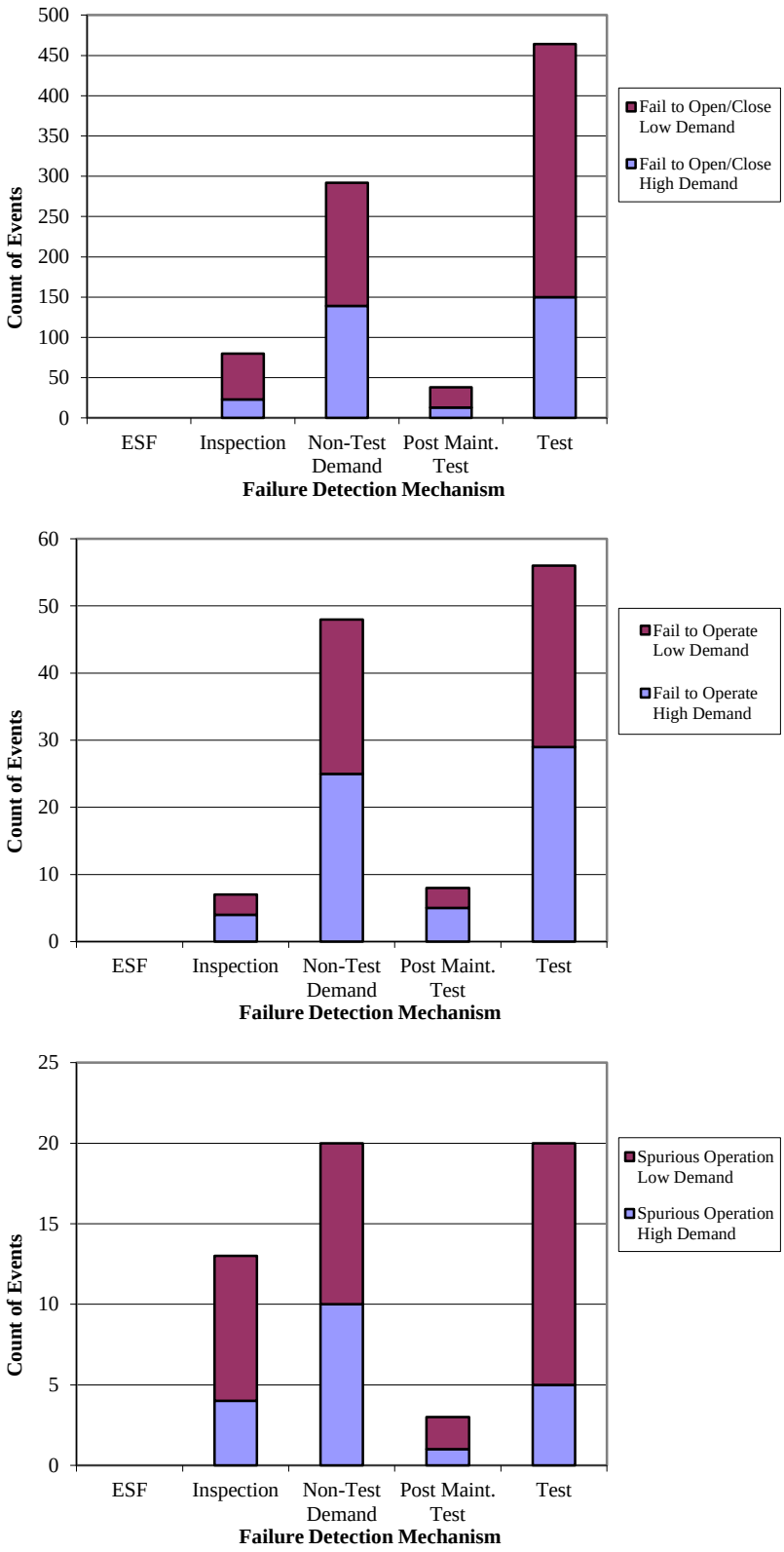

Figure 17. MOV component failure distribution by period, failure mode, and method of detection.

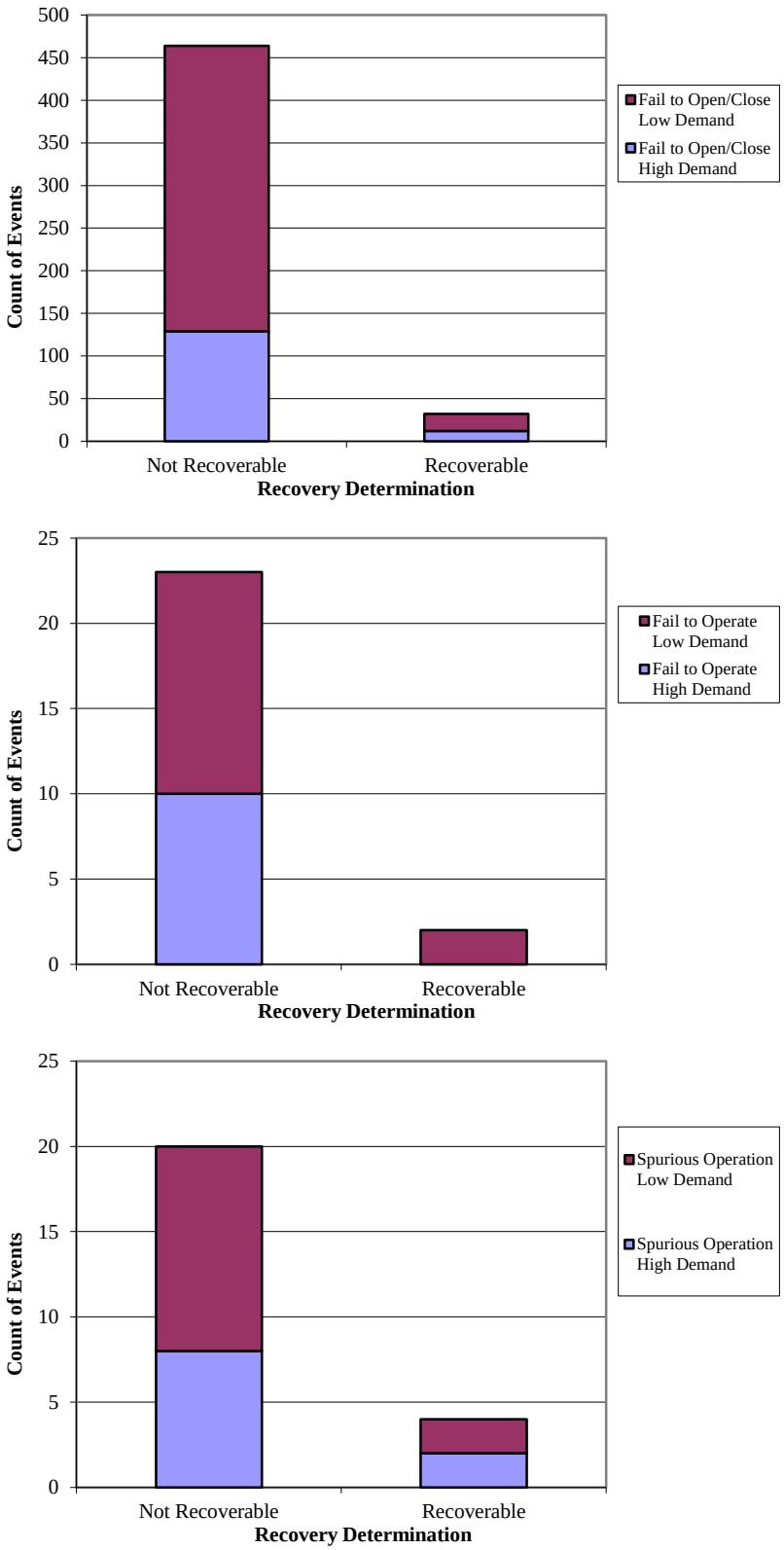

Figure 18. MOV component failure distribution by period, failure mode, and recovery.

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 FTOC failure modes into a single category; FTOP, which is a rate-based failure mode that includes FTC for a flow/temperature control device and any other rate-based failure modes not including spurious operation; and SO, which includes spurious opening and spurious closing.

6. DATA TABLES

Table 10. Plot data for industry-wide MOV FTOC trend with ≤ 20 demands/yr. 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	41	38,472.8				8.05E-04	1.37E-03	1.06E-03
1999	51	41,207.7				9.62E-04	1.55E-03	1.23E-03
2000	45	41,332.7				8.33E-04	1.39E-03	1.08E-03
2001	43	41,376.5				7.91E-04	1.33E-03	1.03E-03
2002	35	42,027.9				6.16E-04	1.10E-03	8.32E-04
2003	33	42,430.2	8.17E-04	5.54E-04	1.21E-03	5.70E-04	1.04E-03	7.77E-04
2004	24	41,431.9	7.95E-04	5.72E-04	1.10E-03	4.03E-04	8.15E-04	5.82E-04
2005	34	40,844.8	7.73E-04	5.86E-04	1.02E-03	6.13E-04	1.10E-03	8.31E-04
2006	37	37,259.3	7.52E-04	5.92E-04	9.55E-04	7.39E-04	1.30E-03	9.89E-04
2007	40	37,349.9	7.31E-04	5.85E-04	9.14E-04	8.06E-04	1.38E-03	1.07E-03
2008	18	37,627.8	7.11E-04	5.64E-04	8.98E-04	3.14E-04	7.12E-04	4.83E-04
2009	36	37,087.2	6.92E-04	5.30E-04	9.02E-04	7.20E-04	1.27E-03	9.67E-04
2010	27	37,561.9	6.73E-04	4.91E-04	9.21E-04	5.10E-04	9.89E-04	7.19E-04
2011	21	37,123.0	6.54E-04	4.51E-04	9.50E-04	3.83E-04	8.16E-04	5.69E-04
2012	19	36,918.4	6.37E-04	4.11E-04	9.86E-04	3.42E-04	7.57E-04	5.19E-04
Total	504	590,052.0						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY/ Source	Failures	Demands	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						1.76E-04	2.27E-03	9.63E-04
1998	11	38,628.1				1.60E-04	4.61E-04	2.82E-04
1999	14	41,300.8				2.03E-04	5.17E-04	3.33E-04
2000	11	43,550.0				1.43E-04	4.11E-04	2.51E-04
2001	16	50,246.5				1.99E-04	4.75E-04	3.14E-04
2002	13	39,778.1				1.92E-04	5.07E-04	3.21E-04
2003	15	40,534.0	3.29E-04	1.90E-04	5.67E-04	2.25E-04	5.54E-04	3.63E-04
2004	14	42,664.8	2.95E-04	1.86E-04	4.66E-04	1.97E-04	5.01E-04	3.23E-04
2005	10	42,596.1	2.64E-04	1.80E-04	3.89E-04	1.29E-04	3.92E-04	2.34E-04
2006	10	42,194.5	2.37E-04	1.69E-04	3.33E-04	1.30E-04	3.96E-04	2.36E-04
2007	9	42,598.0	2.13E-04	1.54E-04	2.95E-04	1.13E-04	3.64E-04	2.12E-04
2008	10	42,091.9	1.91E-04	1.34E-04	2.72E-04	1.31E-04	3.97E-04	2.37E-04
2009	5	41,783.3	1.71E-04	1.13E-04	2.59E-04	5.20E-05	2.54E-04	1.25E-04
2010	2	42,270.3	1.54E-04	9.40E-05	2.51E-04	1.29E-05	1.58E-04	5.62E-05
2011	11	42,054.5	1.38E-04	7.69E-05	2.47E-04	1.48E-04	4.25E-04	2.60E-04
2012	8	41,121.1	1.24E-04	6.25E-05	2.45E-04	1.00E-04	3.48E-04	1.96E-04
Total	159	633,412.1						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY/ Source	Failures	Demands	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						7.40E-09	1.74E-07	6.62E-08
1998	2	52,463,640.0				8.99E-09	1.10E-07	3.93E-08
1999	5	52,621,320.0				3.58E-08	1.75E-07	8.61E-08
2000	13	52,656,360.0				1.26E-07	3.33E-07	2.11E-07
2001	3	52,638,840.0				1.70E-08	1.32E-07	5.48E-08
2002	4	52,595,040.0				2.61E-08	1.54E-07	7.05E-08
2003	3	52,638,840.0	4.76E-08	1.74E-08	1.31E-07	1.70E-08	1.32E-07	5.48E-08
2004	4	52,586,280.0	4.49E-08	1.91E-08	1.05E-07	2.61E-08	1.54E-07	7.05E-08
2005	3	52,621,320.0	4.23E-08	2.06E-08	8.66E-08	1.70E-08	1.33E-07	5.48E-08
2006	1	52,665,120.0	3.98E-08	2.15E-08	7.38E-08	2.75E-09	8.66E-08	2.35E-08
2007	2	52,647,600.0	3.75E-08	2.12E-08	6.63E-08	8.97E-09	1.10E-07	3.91E-08
2008	1	52,682,640.0	3.53E-08	1.96E-08	6.37E-08	2.75E-09	8.66E-08	2.35E-08
2009	0	52,743,960.0	3.33E-08	1.71E-08	6.50E-08	3.07E-11	6.11E-08	7.82E-09
2010	4	52,717,680.0	3.14E-08	1.42E-08	6.92E-08	2.60E-08	1.54E-07	7.04E-08
2011	1	53,252,040.0	2.96E-08	1.16E-08	7.56E-08	2.73E-09	8.59E-08	2.33E-08
2012	4	52,866,600.0	2.79E-08	9.24E-09	8.40E-08	2.59E-08	1.54E-07	7.02E-08
Total	50	790,397,280.0						

Table 13. Plot data for industry-wide MOV FTOP trend with > 20 demands/yr. 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	0	10,380,600.0				1.42E-10	2.83E-07	3.62E-08
1999	4	10,547,040.0				1.19E-07	7.03E-07	3.22E-07
2000	1	10,564,560.0				1.26E-08	3.95E-07	1.07E-07
2001	0	10,547,040.0				1.41E-10	2.79E-07	3.57E-08
2002	1	10,555,800.0				1.26E-08	3.95E-07	1.07E-07
2003	1	10,564,560.0	1.14E-07	3.08E-08	4.22E-07	1.26E-08	3.95E-07	1.07E-07
2004	3	10,599,600.0	1.12E-07	3.70E-08	3.41E-07	7.72E-08	6.02E-07	2.49E-07
2005	1	10,608,360.0	1.11E-07	4.35E-08	2.81E-07	1.25E-08	3.94E-07	1.07E-07
2006	0	10,599,600.0	1.09E-07	4.92E-08	2.41E-07	1.40E-10	2.78E-07	3.56E-08
2007	2	10,617,120.0	1.07E-07	5.23E-08	2.20E-07	4.07E-08	5.00E-07	1.78E-07
2008	0	10,722,240.0	1.06E-07	5.13E-08	2.17E-07	1.39E-10	2.76E-07	3.53E-08
2009	1	10,669,680.0	1.04E-07	4.65E-08	2.32E-07	1.25E-08	3.92E-07	1.06E-07
2010	3	10,713,480.0	1.02E-07	3.97E-08	2.64E-07	7.66E-08	5.98E-07	2.47E-07
2011	4	10,879,920.0	1.01E-07	3.27E-08	3.11E-07	1.16E-07	6.87E-07	3.14E-07
2012	0	10,757,280.0	9.93E-08	2.64E-08	3.74E-07	1.38E-10	2.75E-07	3.52E-08
Total	21	159,326,880.0						

Table 14. Plot data for industry-wide MOV SO trend with ≤ 20 demands/yr. 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	6	52,463,640.0				4.36E-08	1.85E-07	9.62E-08
1999	1	52,621,320.0				2.60E-09	8.18E-08	2.22E-08
2000	6	52,656,360.0				4.35E-08	1.85E-07	9.60E-08
2001	3	52,638,840.0				1.60E-08	1.25E-07	5.17E-08
2002	3	52,595,040.0				1.60E-08	1.25E-07	5.17E-08
2003	3	52,638,840.0	2.72E-08	6.03E-09	1.22E-07	1.60E-08	1.25E-07	5.17E-08
2004	0	52,586,280.0	2.57E-08	7.19E-09	9.19E-08	2.91E-11	5.78E-08	7.39E-09
2005	0	52,621,320.0	2.44E-08	8.34E-09	7.11E-08	2.90E-11	5.77E-08	7.39E-09
2006	1	52,665,120.0	2.31E-08	9.21E-09	5.77E-08	2.60E-09	8.17E-08	2.21E-08
2007	6	52,647,600.0	2.18E-08	9.44E-09	5.05E-08	4.35E-08	1.85E-07	9.60E-08
2008	3	52,682,640.0	2.07E-08	8.79E-09	4.86E-08	1.60E-08	1.25E-07	5.17E-08
2009	3	52,743,960.0	1.96E-08	7.47E-09	5.13E-08	1.60E-08	1.25E-07	5.16E-08
2010	1	52,717,680.0	1.85E-08	5.95E-09	5.77E-08	2.60E-09	8.17E-08	2.21E-08
2011	0	53,252,040.0	1.76E-08	4.55E-09	6.77E-08	2.88E-11	5.72E-08	7.32E-09
2012	0	52,866,600.0	1.66E-08	3.40E-09	8.13E-08	2.89E-11	5.75E-08	7.36E-09
Total	36	790,397,280.0						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY/ Source	Failures	Hours	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
2010 Update						2.54E-10	1.24E-07	3.39E-08
1998	0	10,380,600.0				1.06E-10	2.10E-07	2.69E-08
1999	1	10,547,040.0				9.38E-09	2.95E-07	8.00E-08
2000	0	10,564,560.0				1.05E-10	2.08E-07	2.66E-08
2001	0	10,547,040.0				1.05E-10	2.08E-07	2.67E-08
2002	0	10,555,800.0				1.05E-10	2.08E-07	2.66E-08
2003	1	10,564,560.0	2.94E-08	1.25E-08	6.88E-08	9.37E-09	2.95E-07	7.99E-08
2004	0	10,599,600.0	3.28E-08	1.59E-08	6.77E-08	1.05E-10	2.08E-07	2.66E-08
2005	0	10,608,360.0	3.67E-08	2.00E-08	6.75E-08	1.04E-10	2.08E-07	2.66E-08
2006	0	10,599,600.0	4.11E-08	2.44E-08	6.90E-08	1.05E-10	2.08E-07	2.66E-08
2007	0	10,617,120.0	4.59E-08	2.88E-08	7.33E-08	1.04E-10	2.08E-07	2.66E-08
2008	0	10,722,240.0	5.14E-08	3.22E-08	8.19E-08	1.04E-10	2.06E-07	2.64E-08
2009	1	10,669,680.0	5.75E-08	3.43E-08	9.63E-08	9.32E-09	2.93E-07	7.94E-08
2010	2	10,713,480.0	6.43E-08	3.51E-08	1.18E-07	3.03E-08	3.72E-07	1.32E-07
2011	1	10,879,920.0	7.19E-08	3.50E-08	1.48E-07	9.22E-09	2.90E-07	7.86E-08
2012	1	10,757,280.0	8.04E-08	3.45E-08	1.87E-07	9.27E-09	2.92E-07	7.91E-08
Total	7	159,326,880.0						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Demands	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	38,468	103.0				3.70E+02	3.77E+02	3.73E+02
1999	41,230	103.0				3.97E+02	4.04E+02	4.00E+02
2000	41,357	103.3				3.97E+02	4.04E+02	4.00E+02
2001	41,400	103.0				3.99E+02	4.05E+02	4.02E+02
2002	42,033	103.0	3.91E+02	3.79E+02	4.03E+02	4.05E+02	4.11E+02	4.08E+02
2003	42,440	103.0	3.87E+02	3.77E+02	3.98E+02	4.09E+02	4.15E+02	4.12E+02
2004	41,435	103.3	3.84E+02	3.74E+02	3.94E+02	3.98E+02	4.04E+02	4.01E+02
2005	40,817	103.0	3.80E+02	3.70E+02	3.90E+02	3.93E+02	4.00E+02	3.96E+02
2006	37,269	103.0	3.76E+02	3.66E+02	3.87E+02	3.59E+02	3.65E+02	3.62E+02
2007	37,400	103.4	3.73E+02	3.61E+02	3.85E+02	3.59E+02	3.65E+02	3.62E+02
2008	37,664	104.3	3.69E+02	3.56E+02	3.82E+02	3.58E+02	3.64E+02	3.61E+02
2009	37,120	104.0	3.65E+02	3.51E+02	3.80E+02	3.54E+02	3.60E+02	3.57E+02
2010	37,538	104.0	3.62E+02	3.46E+02	3.79E+02	3.58E+02	3.64E+02	3.61E+02
2011	37,116	104.0	3.58E+02	3.41E+02	3.77E+02	3.54E+02	3.60E+02	3.57E+02
Total	553,286	1,447.2						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Demands	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	38,473	103.0				3.70E+02	3.77E+02	3.74E+02
1999	41,208	103.0				3.97E+02	4.03E+02	4.00E+02
2000	41,333	103.3				3.97E+02	4.03E+02	4.00E+02
2001	41,376	103.0				3.98E+02	4.05E+02	4.02E+02
2002	42,028	103.0				4.05E+02	4.11E+02	4.08E+02
2003	42,430	103.0	4.01E+02	3.83E+02	4.19E+02	4.09E+02	4.15E+02	4.12E+02
2004	41,432	103.3	3.94E+02	3.79E+02	4.09E+02	3.98E+02	4.04E+02	4.01E+02
2005	40,845	103.0	3.87E+02	3.75E+02	4.00E+02	3.93E+02	4.00E+02	3.97E+02
2006	37,259	103.0	3.81E+02	3.71E+02	3.92E+02	3.59E+02	3.65E+02	3.62E+02
2007	37,350	103.4	3.75E+02	3.66E+02	3.84E+02	3.58E+02	3.64E+02	3.61E+02
2008	37,628	104.3	3.69E+02	3.60E+02	3.78E+02	3.58E+02	3.64E+02	3.61E+02
2009	37,087	104.0	3.63E+02	3.52E+02	3.73E+02	3.54E+02	3.60E+02	3.57E+02
2010	37,562	104.0	3.57E+02	3.45E+02	3.69E+02	3.58E+02	3.64E+02	3.61E+02
2011	37,123	104.0	3.51E+02	3.37E+02	3.65E+02	3.54E+02	3.60E+02	3.57E+02
2012	36,918	104.3	3.45E+02	3.29E+02	3.61E+02	3.51E+02	3.57E+02	3.54E+02
Total	590,052	1,551.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	41	103.0				3.01E-01	5.13E-01	3.96E-01
1999	51	103.0				3.85E-01	6.20E-01	4.91E-01
2000	45	103.3				3.33E-01	5.54E-01	4.33E-01
2001	43	103.0				3.17E-01	5.35E-01	4.15E-01
2002	35	103.0				2.51E-01	4.48E-01	3.39E-01
2003	33	103.0	3.29E-01	2.26E-01	4.79E-01	2.35E-01	4.27E-01	3.20E-01
2004	24	103.3	3.15E-01	2.29E-01	4.32E-01	1.61E-01	3.27E-01	2.33E-01
2005	34	103.0	3.01E-01	2.31E-01	3.93E-01	2.43E-01	4.37E-01	3.29E-01
2006	37	103.0	2.88E-01	2.29E-01	3.62E-01	2.67E-01	4.70E-01	3.58E-01
2007	40	103.4	2.75E-01	2.22E-01	3.40E-01	2.91E-01	5.01E-01	3.85E-01
2008	18	104.3	2.63E-01	2.11E-01	3.28E-01	1.13E-01	2.57E-01	1.74E-01
2009	36	104.0	2.51E-01	1.95E-01	3.24E-01	2.57E-01	4.55E-01	3.45E-01
2010	27	104.0	2.40E-01	1.78E-01	3.24E-01	1.84E-01	3.57E-01	2.60E-01
2011	21	104.0	2.30E-01	1.61E-01	3.28E-01	1.37E-01	2.91E-01	2.03E-01
2012	19	104.3	2.20E-01	1.45E-01	3.34E-01	1.21E-01	2.68E-01	1.84E-01
Total	504	1,551.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	11	97.0				6.41E-02	1.84E-01	1.13E-01
1999	14	97.0				8.67E-02	2.20E-01	1.42E-01
2000	11	97.3				6.39E-02	1.84E-01	1.12E-01
2001	16	97.0				1.02E-01	2.44E-01	1.62E-01
2002	13	97.0				7.90E-02	2.08E-01	1.32E-01
2003	15	97.0	1.43E-01	8.39E-02	2.42E-01	9.44E-02	2.32E-01	1.52E-01
2004	14	97.3	1.28E-01	8.18E-02	1.99E-01	8.64E-02	2.20E-01	1.42E-01
2005	10	97.0	1.14E-01	7.86E-02	1.66E-01	5.67E-02	1.72E-01	1.03E-01
2006	10	97.0	1.02E-01	7.36E-02	1.43E-01	5.67E-02	1.72E-01	1.03E-01
2007	9	97.4	9.17E-02	6.65E-02	1.27E-01	4.93E-02	1.59E-01	9.27E-02
2008	10	98.3	8.22E-02	5.78E-02	1.17E-01	5.60E-02	1.70E-01	1.02E-01
2009	5	98.0	7.36E-02	4.87E-02	1.11E-01	2.22E-02	1.08E-01	5.33E-02
2010	2	98.0	6.59E-02	4.03E-02	1.08E-01	5.55E-03	6.82E-02	2.42E-02
2011	11	98.0	5.90E-02	3.29E-02	1.06E-01	6.34E-02	1.82E-01	1.11E-01
2012	8	98.3	5.29E-02	2.67E-02	1.05E-01	4.19E-02	1.46E-01	8.22E-02
Total	159	1,461.4						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	2	103.0				4.58E-03	5.62E-02	2.00E-02
1999	5	103.0				1.83E-02	8.94E-02	4.40E-02
2000	13	103.3				6.44E-02	1.70E-01	1.08E-01
2001	3	103.0				8.67E-03	6.76E-02	2.80E-02
2002	4	103.0				1.33E-02	7.87E-02	3.60E-02
2003	3	103.0	2.43E-02	8.85E-03	6.67E-02	8.67E-03	6.76E-02	2.80E-02
2004	4	103.3	2.29E-02	9.75E-03	5.37E-02	1.33E-02	7.85E-02	3.59E-02
2005	3	103.0	2.15E-02	1.05E-02	4.42E-02	8.67E-03	6.76E-02	2.80E-02
2006	1	103.0	2.03E-02	1.09E-02	3.76E-02	1.41E-03	4.43E-02	1.20E-02
2007	2	103.4	1.91E-02	1.08E-02	3.38E-02	4.57E-03	5.61E-02	1.99E-02
2008	1	104.3	1.80E-02	9.98E-03	3.24E-02	1.39E-03	4.38E-02	1.19E-02
2009	0	104.0	1.69E-02	8.68E-03	3.31E-02	1.56E-05	3.10E-02	3.97E-03
2010	4	104.0	1.60E-02	7.23E-03	3.52E-02	1.32E-02	7.80E-02	3.57E-02
2011	1	104.0	1.50E-02	5.87E-03	3.84E-02	1.40E-03	4.39E-02	1.19E-02
2012	4	104.3	1.41E-02	4.69E-03	4.27E-02	1.32E-02	7.79E-02	3.56E-02
Total	50	1,551.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	0	97.0				1.53E-05	3.04E-02	3.89E-03
1999	4	97.0				1.29E-02	7.66E-02	3.50E-02
2000	1	97.3				1.37E-03	4.30E-02	1.17E-02
2001	0	97.0				1.53E-05	3.04E-02	3.89E-03
2002	1	97.0				1.37E-03	4.31E-02	1.17E-02
2003	1	97.0	1.24E-02	3.35E-03	4.61E-02	1.37E-03	4.31E-02	1.17E-02
2004	3	97.3	1.23E-02	4.03E-03	3.72E-02	8.42E-03	6.57E-02	2.72E-02
2005	1	97.0	1.21E-02	4.74E-03	3.07E-02	1.37E-03	4.31E-02	1.17E-02
2006	0	97.0	1.19E-02	5.36E-03	2.64E-02	1.53E-05	3.04E-02	3.89E-03
2007	2	97.4	1.17E-02	5.71E-03	2.40E-02	4.45E-03	5.46E-02	1.94E-02
2008	0	98.3	1.15E-02	5.60E-03	2.38E-02	1.52E-05	3.01E-02	3.85E-03
2009	1	98.0	1.14E-02	5.08E-03	2.54E-02	1.36E-03	4.27E-02	1.16E-02
2010	3	98.0	1.12E-02	4.34E-03	2.89E-02	8.37E-03	6.53E-02	2.70E-02
2011	4	98.0	1.10E-02	3.57E-03	3.41E-02	1.28E-02	7.60E-02	3.48E-02
2012	0	98.3	1.09E-02	2.88E-03	4.10E-02	1.52E-05	3.01E-02	3.85E-03
Total	21	1,461.4						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	6	103.0				2.22E-02	9.42E-02	4.90E-02
1999	1	103.0				1.33E-03	4.17E-02	1.13E-02
2000	6	103.3				2.22E-02	9.40E-02	4.89E-02
2001	3	103.0				8.17E-03	6.38E-02	2.64E-02
2002	3	103.0				8.17E-03	6.38E-02	2.64E-02
2003	3	103.0	1.39E-02	3.08E-03	6.23E-02	8.17E-03	6.38E-02	2.64E-02
2004	0	103.3	1.31E-02	3.67E-03	4.68E-02	1.48E-05	2.94E-02	3.76E-03
2005	0	103.0	1.24E-02	4.26E-03	3.62E-02	1.48E-05	2.95E-02	3.77E-03
2006	1	103.0	1.17E-02	4.70E-03	2.94E-02	1.33E-03	4.17E-02	1.13E-02
2007	6	103.4	1.11E-02	4.82E-03	2.57E-02	2.22E-02	9.40E-02	4.89E-02
2008	3	104.3	1.05E-02	4.48E-03	2.47E-02	8.09E-03	6.32E-02	2.61E-02
2009	3	104.0	9.96E-03	3.81E-03	2.61E-02	8.11E-03	6.33E-02	2.62E-02
2010	1	104.0	9.43E-03	3.03E-03	2.93E-02	1.32E-03	4.14E-02	1.12E-02
2011	0	104.0	8.93E-03	2.32E-03	3.44E-02	1.47E-05	2.92E-02	3.74E-03
2012	0	104.3	8.45E-03	1.73E-03	4.13E-02	1.47E-05	2.92E-02	3.73E-03
Total	36	1,551.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	0	97.0				1.14E-05	2.27E-02	2.91E-03
1999	1	97.0				1.02E-03	3.22E-02	8.72E-03
2000	0	97.3				1.14E-05	2.27E-02	2.90E-03
2001	0	97.0				1.14E-05	2.27E-02	2.91E-03
2002	0	97.0				1.14E-05	2.27E-02	2.91E-03
2003	1	97.0	3.20E-03	1.37E-03	7.50E-03	1.02E-03	3.22E-02	8.72E-03
2004	0	97.3	3.58E-03	1.74E-03	7.38E-03	1.14E-05	2.27E-02	2.90E-03
2005	0	97.0	4.01E-03	2.18E-03	7.37E-03	1.14E-05	2.27E-02	2.91E-03
2006	0	97.0	4.49E-03	2.67E-03	7.54E-03	1.14E-05	2.27E-02	2.91E-03
2007	0	97.4	5.02E-03	3.15E-03	8.01E-03	1.14E-05	2.27E-02	2.90E-03
2008	0	98.3	5.62E-03	3.53E-03	8.96E-03	1.13E-05	2.25E-02	2.88E-03
2009	1	98.0	6.29E-03	3.75E-03	1.05E-02	1.02E-03	3.20E-02	8.67E-03
2010	2	98.0	7.04E-03	3.84E-03	1.29E-02	3.31E-03	4.06E-02	1.44E-02
2011	1	98.0	7.88E-03	3.84E-03	1.62E-02	1.02E-03	3.20E-02	8.67E-03
2012	1	98.3	8.82E-03	3.78E-03	2.06E-02	1.01E-03	3.19E-02	8.65E-03
Total	7	1,461.4						

7. REFERENCES

1. Nuclear Regulatory Commission, *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*, NUREG/CR-6928, Nuclear Regulatory Commission, February 2007.