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Enhanced Component Performance Study: Air-Operated Valves 1998–2013

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ABSTRACT

This report presents a performance evaluation of air-operated valves (AOVs) 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 2013 for the component reliability as reported in the Institute of Nuclear Power Operations (INPO) Consolidated Events Database (ICES). The AOV 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 or decreasing trends were identified in the AOV failure data.

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ACRONYMS

AFW	auxiliary feed water
AOV	air-operated valve
CCW	component cooling water
CRD	control rod drive
CSR	containment spray recirculation
EPIX	Equipment Performance and Information Exchange
FTOC	failure-to-open/close
FTOP	failure to operate or control
FY	fiscal year
HCI	high pressure cooling injection
HPI	high pressure injection
ICES	INPO Consolidated Events Database
INPO	Institute of Nuclear Power Operations
ISO	isolation condenser
LCS	low pressure core spray
MSPI	Mitigating Systems Performance Index
NPRDS	Nuclear Plant Reliability Data System
RCI	reactor core isolation cooling
RCS	reactor coolant system
RHR	residual heat removal
SO	spurious operation
SWN	service water – normally running
SWS	service water – normally in standby

Enhanced Component Performance Study: Air-Operated Valves 1998–2013

1. INTRODUCTION

This report presents a performance evaluation of air-operated valves (AOVs) at U.S. commercial nuclear power plants. This report does not estimate values for use in probabilistic risk assessments, but does evaluate component performance over time. The 2010 Component Reliability Update (Reference 1), which is an update to Industry-Average Performance for Components and Initiating Events at U.S Commercial Nuclear Power Plants (Reference 2), reports the current AOV unreliability estimates using Institute of Nuclear Power Operations (INPO) Consolidated Events Database (ICES) data from 1998 through 2010 for use in probabilistic risk assessments.

The data used in this study are based on the operating experience failure reports from fiscal year (FY)-98 through FY-13 for component reliability as reported in ICES. The AOV failure modes considered are failure-to-open/close (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, the Nuclear Plant Reliability Data System (NPRDS), and ICES. The ICES database, which includes the Mitigating Systems Performance Index (MSPI) designated devices as a subset, has matured to the point where component availability and reliability can be estimated with a higher degree of accuracy. In addition, the population of data in ICES has been growing and is much larger than the population used in the previous study.

The objective of the updated component performance studies is to obtain annual performance trends of failure rates and probabilities and to present an analysis of factors that could influence the component trends. Engineering analyses were performed with respect to time period and failure mode (Section 4.2). The factors analyzed are: sub-component, failure cause, detection method, recovery. 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.

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 or decreasing trends were identified in the AOV data.

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 AOVs have been calculated from the operating experience for the FTOC, FTOP, and SO failure modes. The AOV data set obtained from ICES was segregated to AOVs with ≤ 20 demands/year and AOVs with > 20 demands/year and includes AOVs in the systems listed in Table 1. Reference 1 lists the industry failure data for AOVs with ≤ 20 demands/year.

Table 2 shows industry-wide failure probability and failure rate results for AOVs with ≤ 20 demands/year from Reference 1, hence forth referred to as the 2010 Update results. No 2010 Update results are shown for > 20 demands/year AOVs because Reference 1 does not provide them.

The AOVs 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. Summary of AOV counts in the systems in which they are found.

System	Description	AOV Count		
		Total	≤20 demands/yr	>20 demands/yr
AFW	Auxiliary feedwater	360	194	166
CCW	Component cooling water	436	295	141
CRD	Control rod drive	117	66	51
CSR	Containment spray recirculation	30	28	2
HCI	High pressure coolant injection	14	7	7
HPI	High pressure injection	94	70	24
ISO	Isolation condenser	10	6	4
LCS	Low pressure core spray	12	10	2
RCI	Reactor core isolation	8	6	2
RCS	Reactor coolant	109	52	57
RHR	Residual heat removal	259	126	133
SWN	Normally running service water	511	296	215
SWS	Standby service water	55	20	35
	Total	2015	1176	839

Table 2. 2010 Update industry-wide distributions of p (failure probability) and λ (hourly rate) for AOVs with ≤ 20 demands/year (from Reference 1).

Failure Mode	5%	Median	Mean	95%	Distribution		
					Type	α	β
FTOC	6.27E−05	6.86E−04	9.51E−04	2.74E−03	Beta	1.11	1.168E+03
FTOP	2.66E−08	1.93E−07	2.49E−07	6.59E−07	Gamma	1.42	5.719E+06
SO	2.04E−09	7.46E−08	1.31E−07	4.49E−07	Gamma	0.68	5.211E+06

3.2 AOV 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.

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 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. The baseline industry values from the 2010 Update are also shown for comparison.

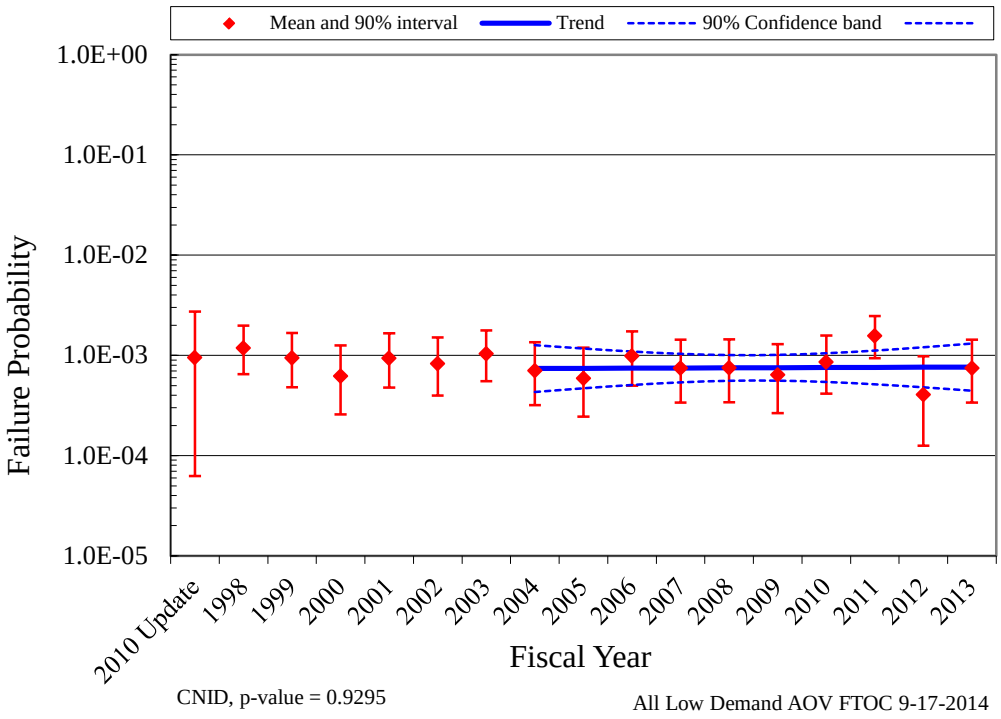

Figure 1. Failure probability estimate trend for AOV FTOC, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

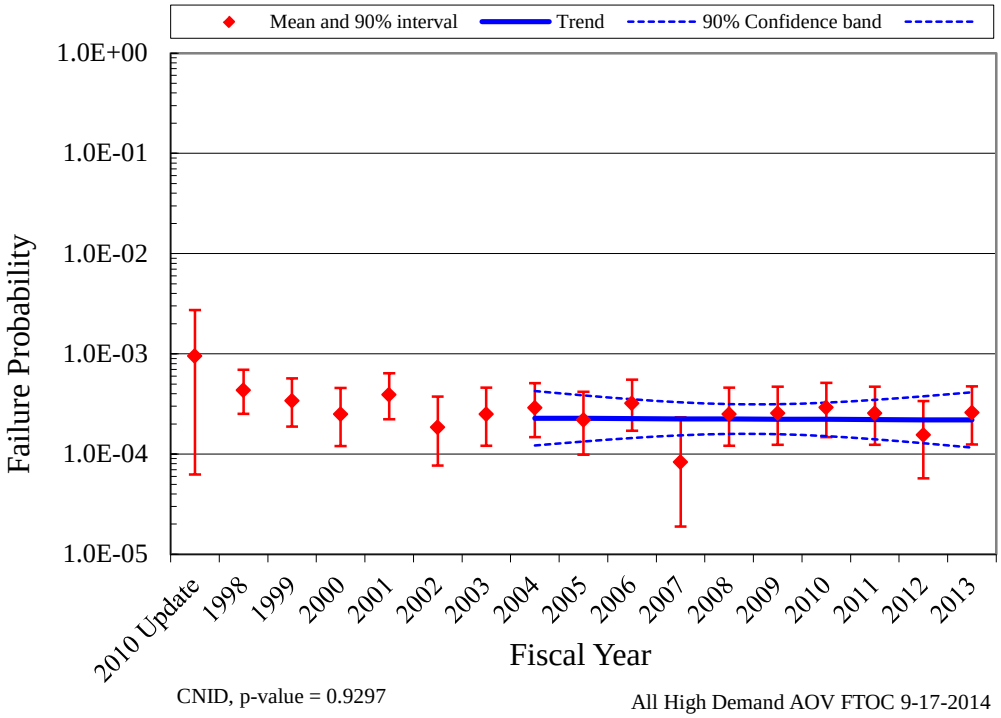

Figure 2. Failure probability estimate trend for AOV FTOC, all systems, industry-wide trend of AOVs with > 20 demands per year.

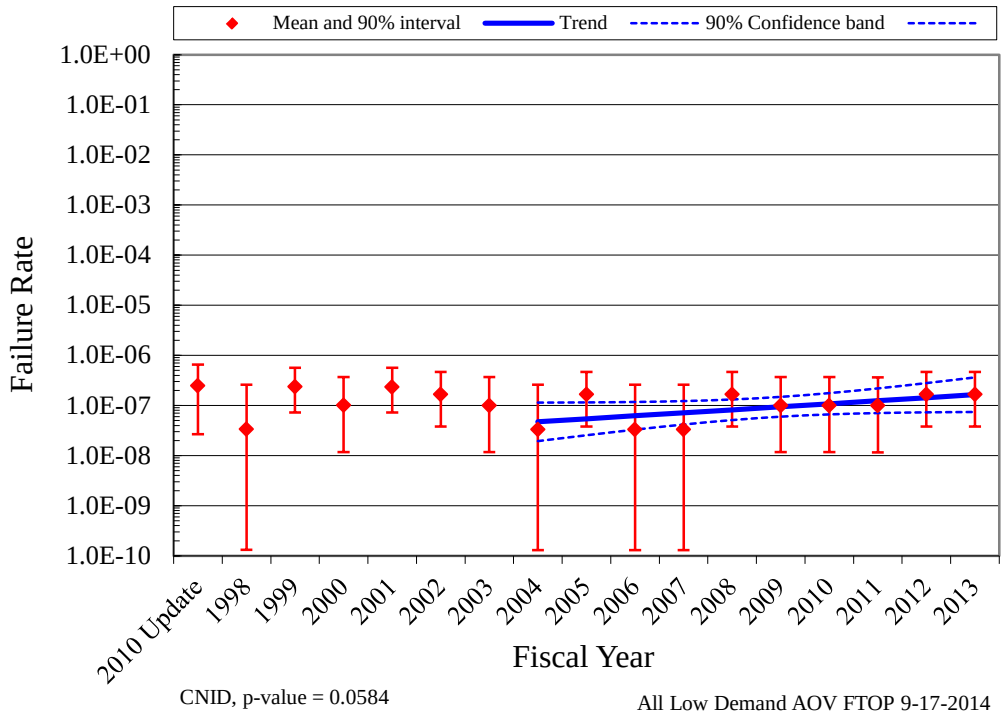

Figure 3. Failure rate estimate trend for AOV FTOP, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

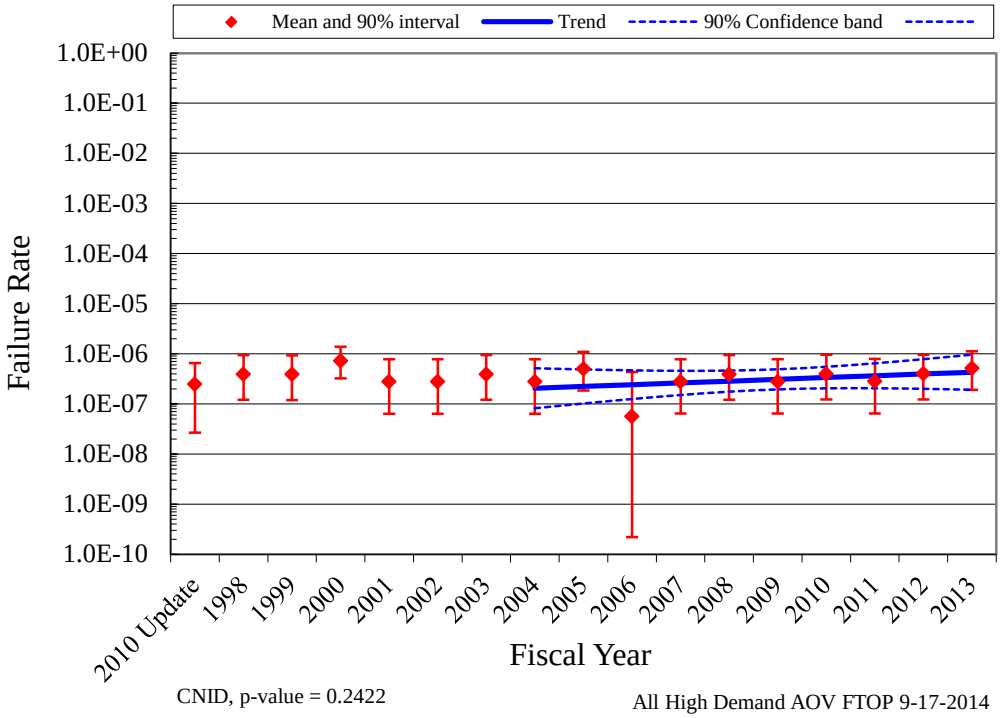

Figure 4. Failure rate estimate trend for AOV FTOP, all systems, industry-wide trend of AOVs with > 20 demands per year.

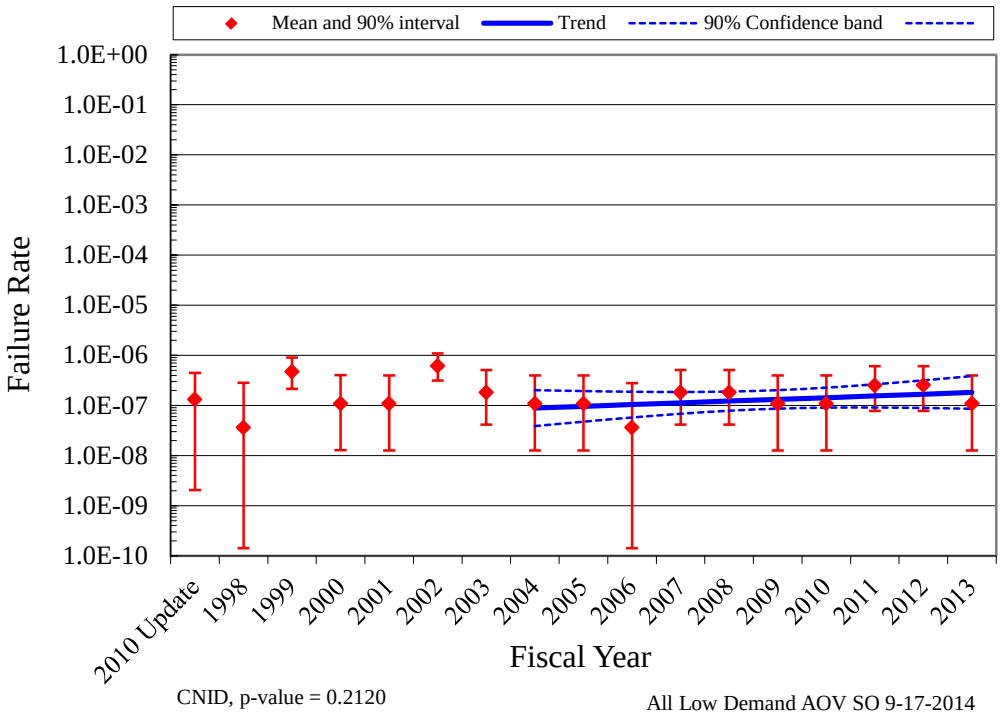

Figure 5. Failure rate estimate trend for AOV SO, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

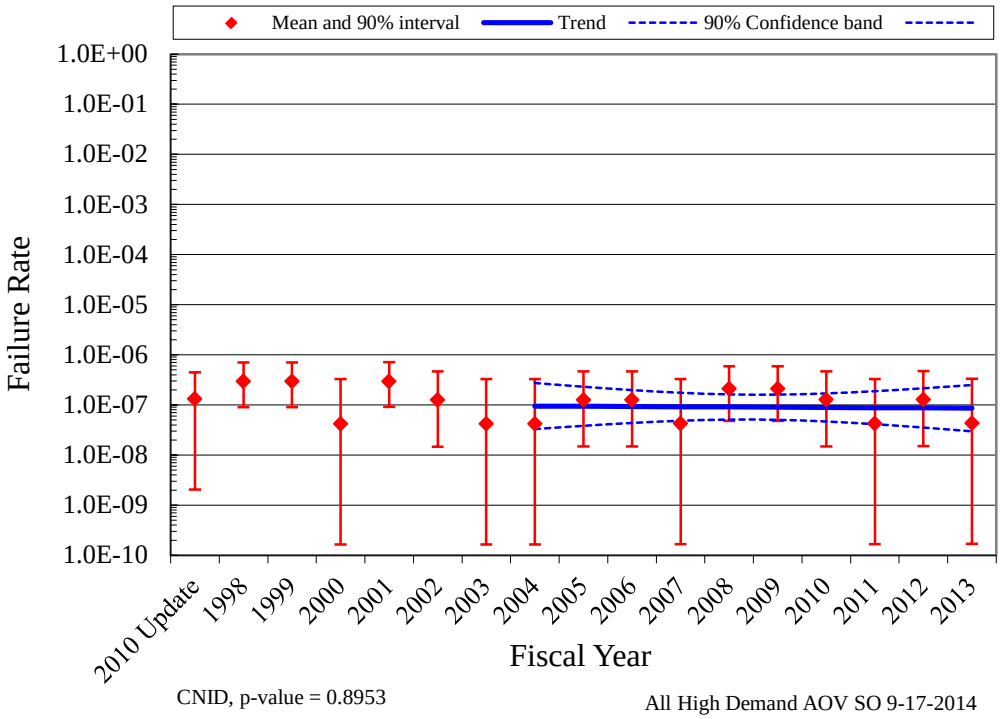

Figure 6. Failure rate estimate trend for AOV SO, all systems, industry-wide trend of AOVs with > 20 demands per year.

4. ENGINEERING TRENDS

4.1 Overview

This section presents frequency trends for AOV 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 AOV demands of ≤ 20 demands per reactor-year AOVs. Figure 9 shows the trend in failure events for FTOC mode for AOV ≤ 20 demands, and Figure 13 shows the trend for the SO failure events for AOV ≤ 20 demands.

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

Table 3 summarizes the failures by system, year, and the FTOC failure mode for AOV ≤ 20 demands. The systems contributing 50% or more (in bold) to the FTOC failure mode are AFW, CCW, HPI, RHR, SWN, and SWS. Table 4 summarizes the failures by system, year, and the FTOP failure mode for AOV ≤ 20 demands. The systems contributing 50% or more (in bold) to the FTOP failure mode are AFW, CCW, SWN, and SWS. Table 5 summarizes the failures by system, year, and the SO failure mode for AOV ≤ 20 demands. The systems together contributing 50% or more (in bold) to the SO failure mode are AFW, CCW, and CRD.

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

Tables 16–23 provide the plot data for frequency (per reactor year) of AOV 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.

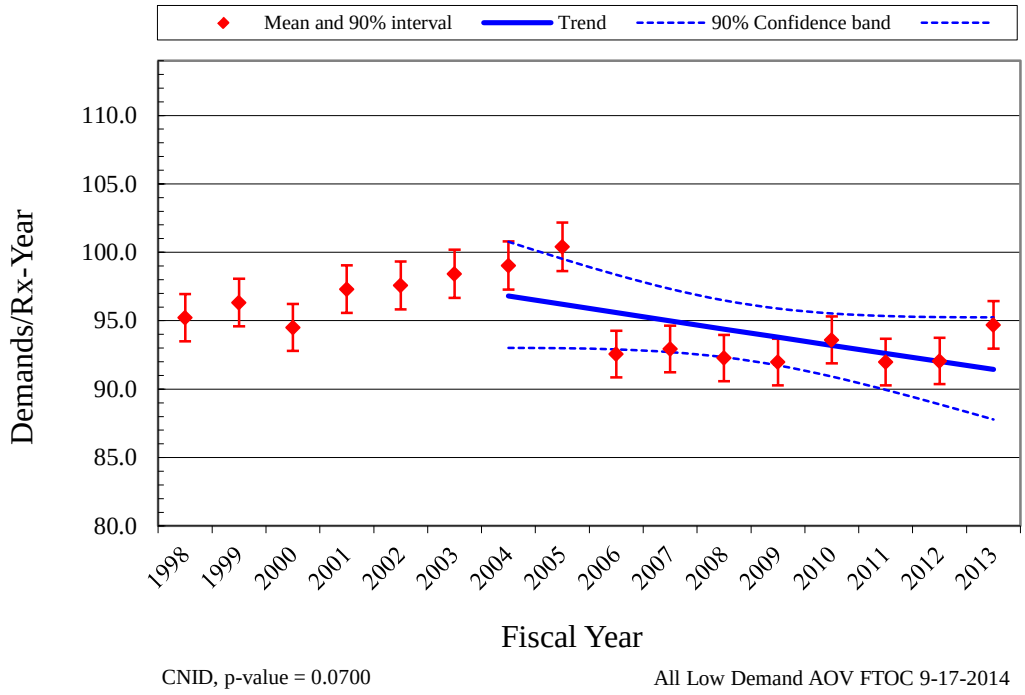

Figure 7. Frequency (demands per reactor year) of AOV FTOC demands, ≤ 20 demands per year.

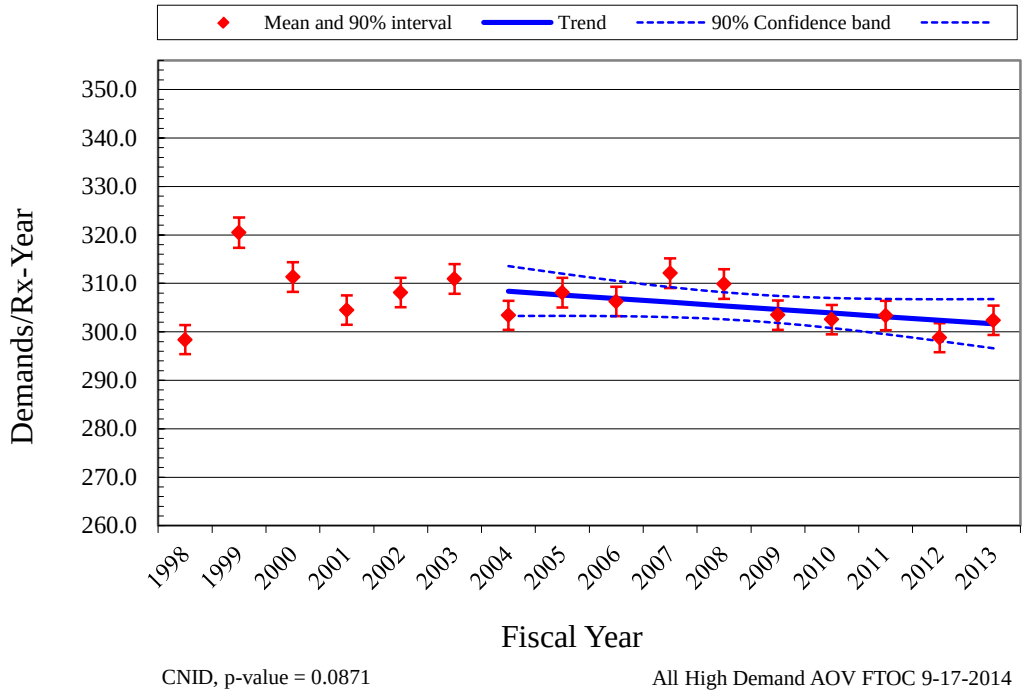

Figure 8. Frequency (demands per reactor year) of AOV FTOC demands, > 20 demands per year.

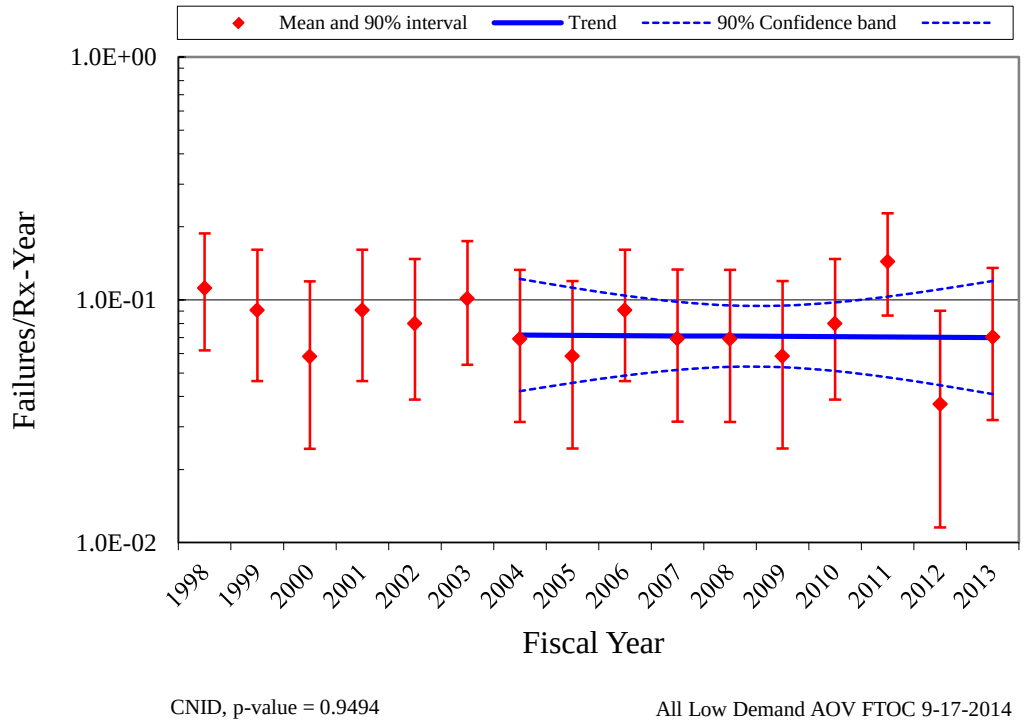

Figure 9. Frequency (failures per reactor year) of AOV FTOC events ≤ 20 demands per year.

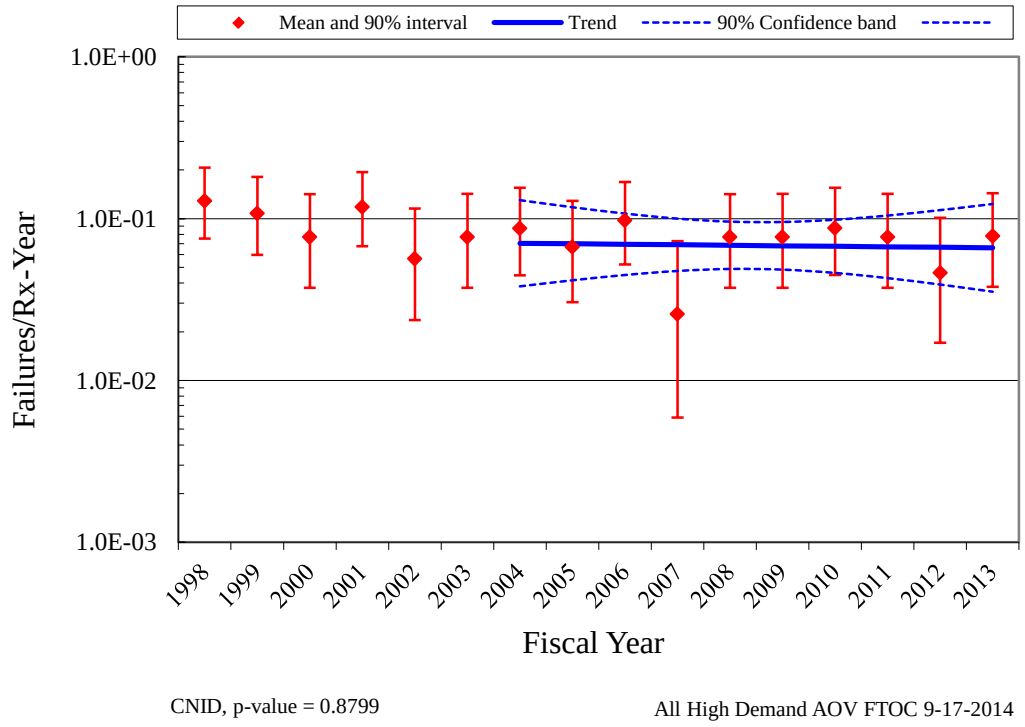

Figure 10. Frequency (failures per reactor year) of AOV FTOC events > 20 demands per year.

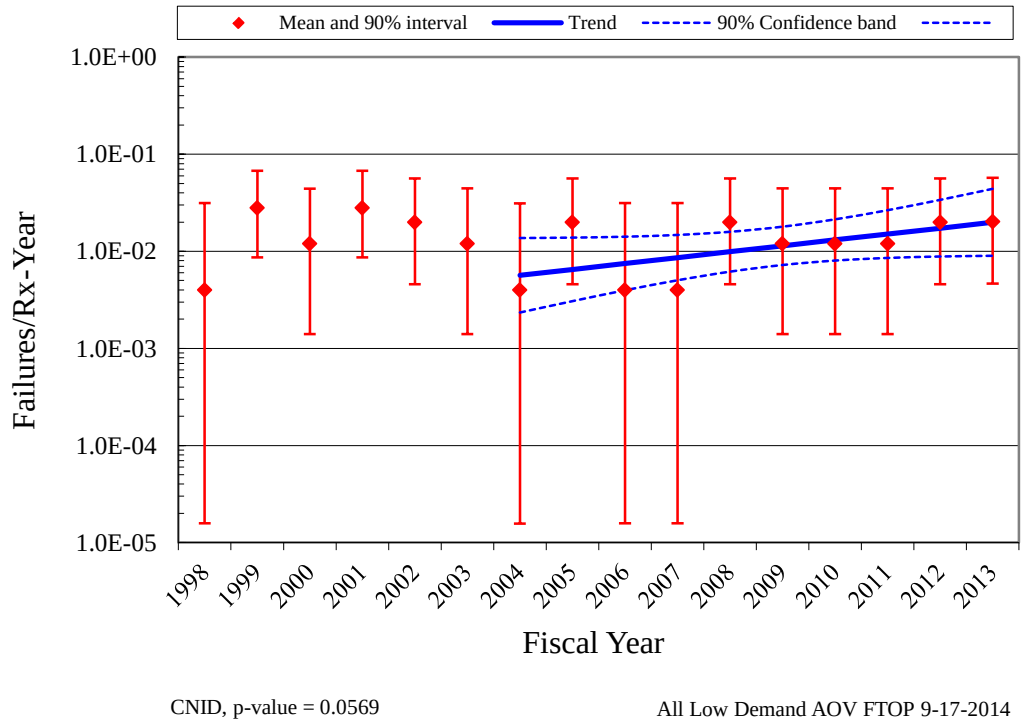

Figure 11. Frequency (failures per reactor year) of AOV FTOP events ≤ 20 demands per year.

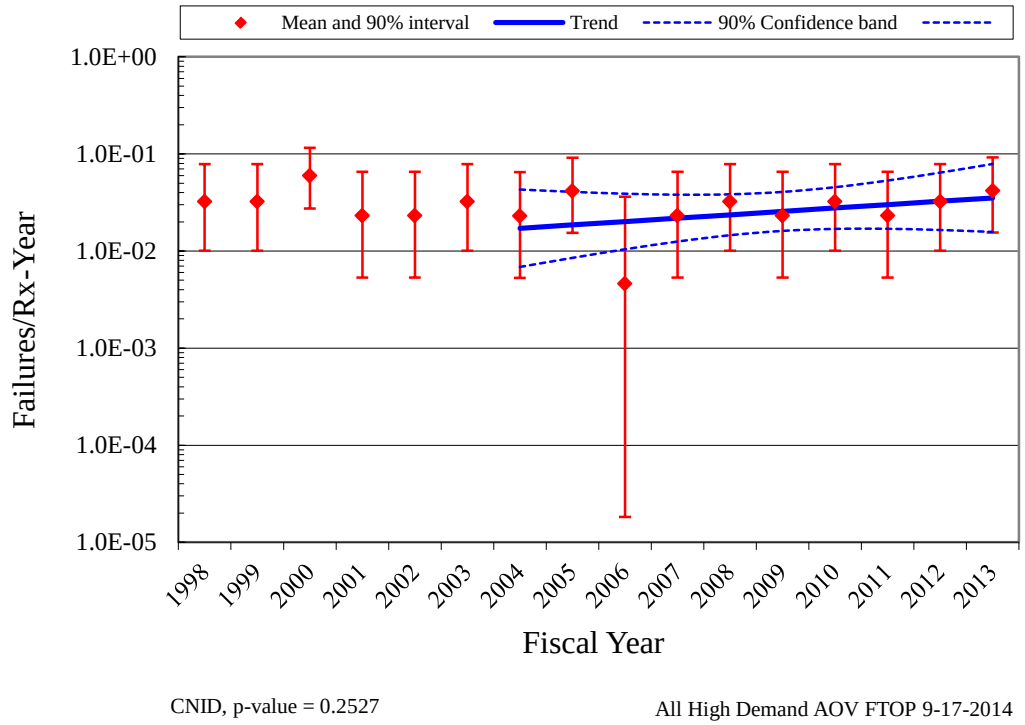

Figure 12. Frequency (failures per reactor year) of AOV FTOP events > 20 demands per year.

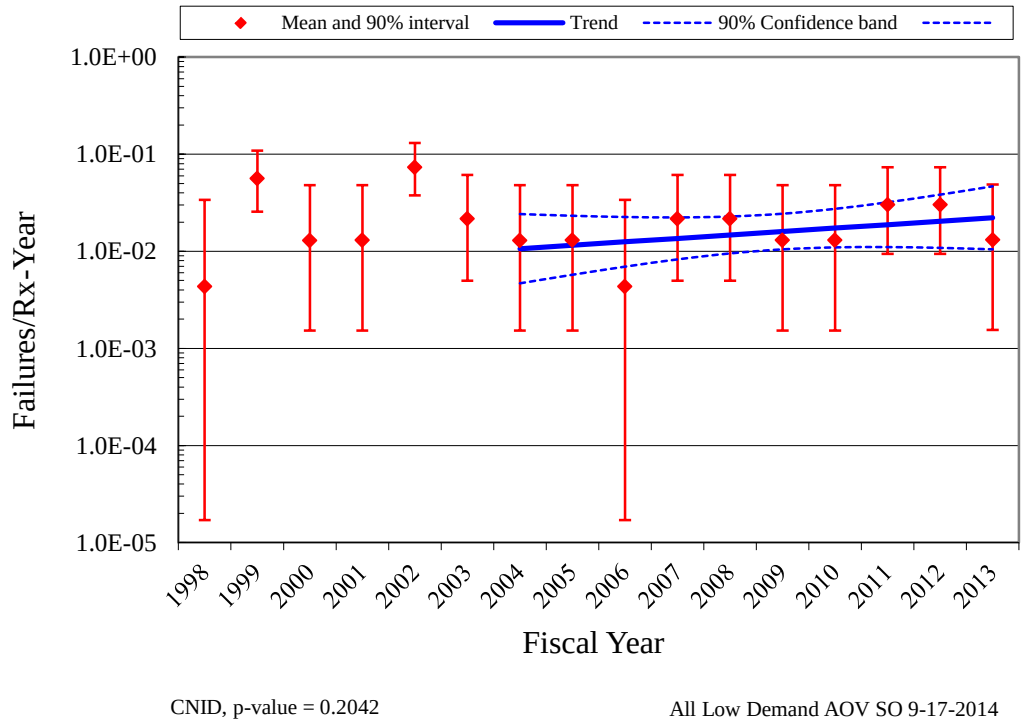

Figure 13. Frequency (failures per reactor year) of AOV SO events ≤ 20 demands per year.

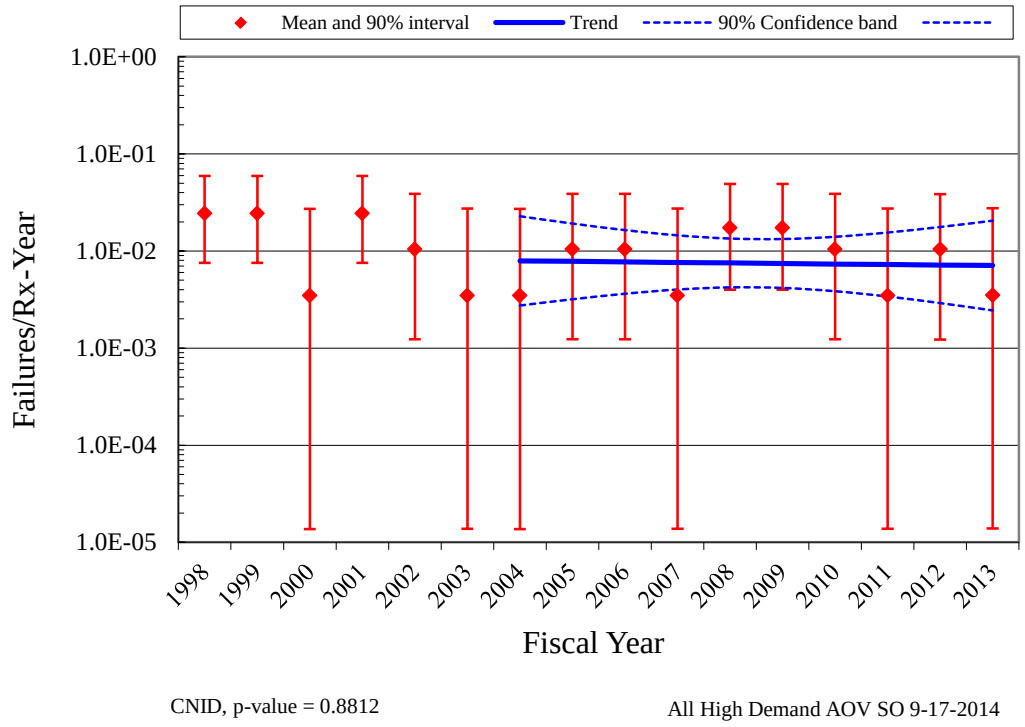

Figure 14. Frequency (failures per reactor year) of AOV SO events > 20 demands per year.

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	194	16.7%		2	2	1	1	1	3				10	**16.9%**
CCW	295	25.4%	1	1	2	2	1		1	3			11	**18.6%**
CRD	66	5.7%									1		1	1.7%
CSR	28	2.4%		1		1							2	3.4%
HPI	70	6.0%			1		1			3			5	**8.5%**
LCS	10	0.9%											0	0.0%
RCI	6	0.5%					1						1	1.7%
RCS	52	4.5%	1					1	1	1			4	6.8%
RHR	126	10.8%			2	1		1	1				5	**8.5%**
SWN	296	25.5%	4	1	1	1	2	2	1	4	1		17	**28.8%**
SWS	20	1.7%								2	1		3	5.1%
Total	1163	100%	6	5	8	6	6	5	7	13	3	0	59	100%

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	194	21.9%							1			2	3	**30.0%**
CCW	295	33.3%		1			1	1					3	**30.0%**
HPI	70	7.9%											0	0.0%
ISO	6	0.7%											0	0.0%
RCI	6	0.7%									1		1	10.0%
SWN	296	33.4%		1			1						2	**20.0%**
SWS	20	2.3%								1			1	10.0%
Total	887	100%	0	2	0	0	2	1	1	1	1	2	10	100%

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	194	23.6%	1	1		1	1	1		1			6	**42.9%**
CCW	295	35.8%				1			1	1	3		6	**42.9%**
CRD	66	8.0%											0	0.0%
HPI	70	8.5%											0	0.0%
RCS	52	6.3%											0	0.0%
RHR	126	15.3%					1						1	**7.1%**
SWS	20	2.4%								1			1	**7.1%**
Total	823	100%	1	1	0	2	2	1	1	3	3	0	14	100%

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	166	20.8%	5	3	3		2		1	2	3		14	**29.2%**
CCW	141	17.7%			1				1		1		3	6.3%
CRD	51	6.4%										1	1	2.1%
RCS	57	7.1%	2	1		1			1				3	6.3%
RHR	133	16.7%			1	1	1	2	2	2			9	**18.8%**
SWN	215	26.9%	1	2	2		4	5	2	3			18	**37.5%**
SWS	35	4.4%											0	0.0%
Total	798	100%	8	6	7	2	7	7	7	7	4	1	48	100%

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	166	23.5%			2	1				1			4	**19.0%**
CCW	141	20.0%					1						1	4.8%
CRD	51	7.2%							1				1	4.8%
RHR	133	18.8%					1				1		2	9.5%
SWN	215	30.5%	2	4		1	1	2	3	1	1		13	**61.9%**
Total	706	100%	2	4	2	2	3	2	4	2	2	0	21	100%

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

System Code	Valve Count	Valve Percent	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	Percent of Failures
AFW	166	25.3%		1					1				2	**25.0%**
CCW	141	21.5%									1		1	12.5%
RCI	2	0.3%					1						1	12.5%
RHR	133	20.2%					1						1	12.5%
SWN	215	32.7%			1			2					3	**37.5%**
Total	657	100%	0	1	1	0	2	2	1	0	1	0	8	100%

4.2 AOV Engineering Analysis by Failure Modes

The engineering analysis of AOV failure sub-components, causes, detection methods, and recoverability are presented in this section. Each analysis first divides the events into two categories: AOVs with ≤ 20 demands/year (low-demand) and AOVs with > 20 demands/year (high-demand).

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

AOV 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.

AOV 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 and FTOP failure modes is grouped as Internal. Internal means that the cause was related to something within the AOV component such as a worn out part or the normal internal environment. The second most likely cause for the FTOC and FTOP failure mode is grouped as Human, which includes human action, procedures and maintenance. The most likely cause for the SO failure mode is either Design or Internal, closely followed by Human

AOV detection methods to the three failure modes are presented in Figure 17. Note that there are differences between the low-demand and high-demand detection methods.

Low-Demand—the most likely detection method for FTOC is a testing demand. The most likely detection method for FTOP and SO is an actual demand.

High-Demand—the most likely detection method for FTOC is a non-test demand followed by testing. The most likely detection method for FTOP and SO is an actual demand.

AOV failure recoverability determination for three failure modes is presented in Figure 18. AOV failures are, by better than a 5:1 ratio, considered not recoverable.

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.

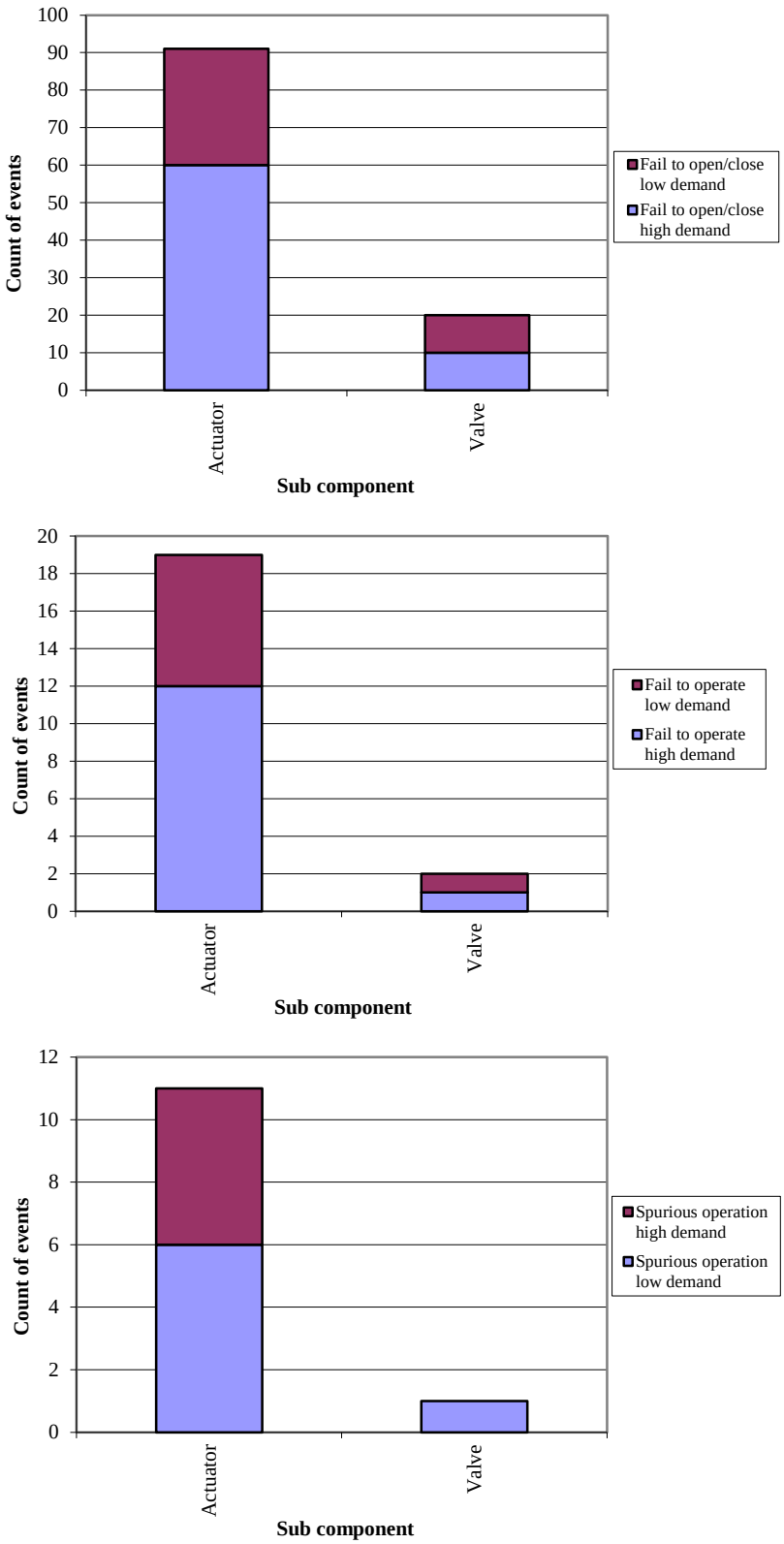

Figure 15. AOV failure event breakdown by subcomponent, failure mode, and demand rate

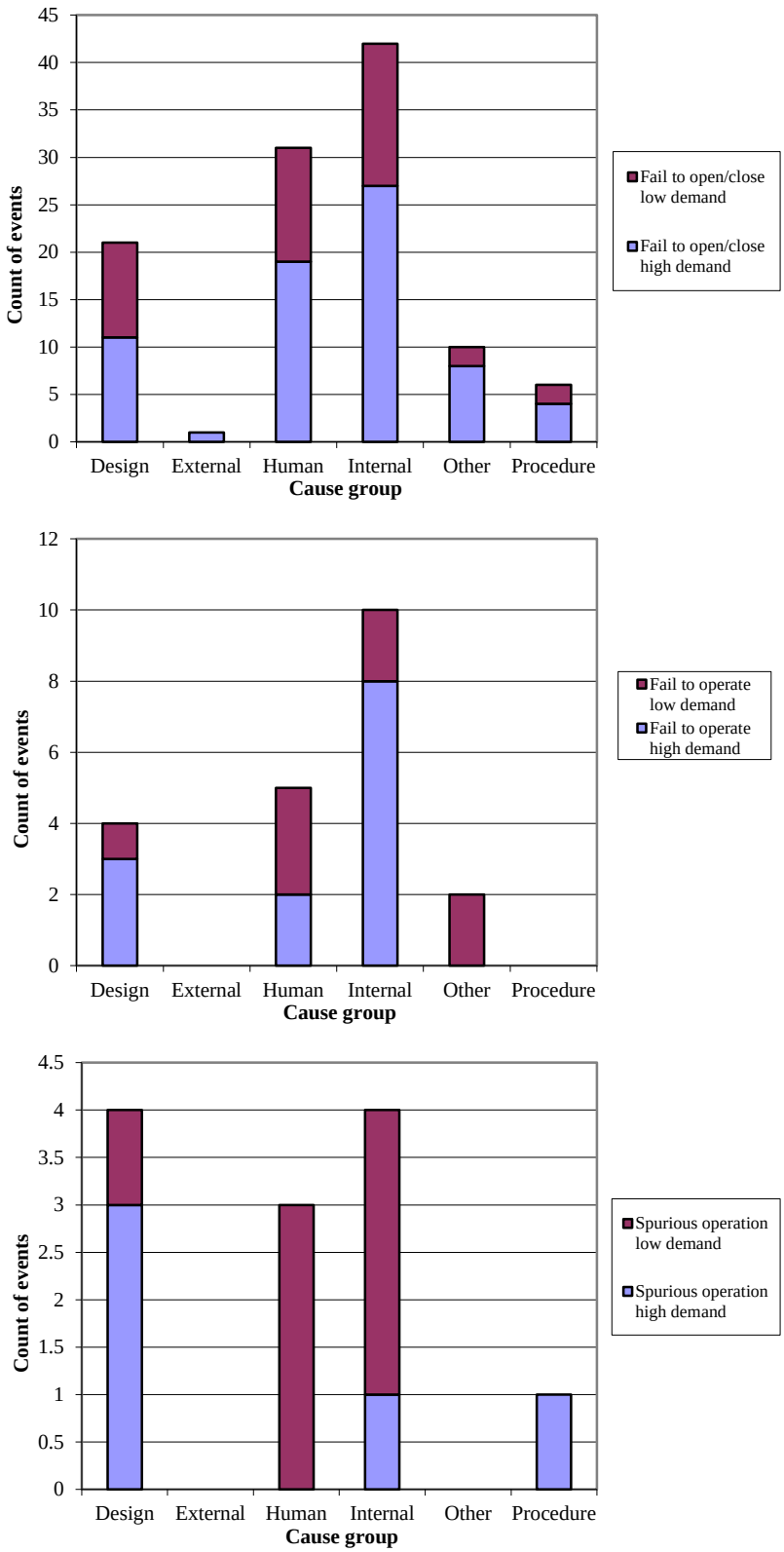

Figure 16. AOV failure event breakdown by cause group, failure mode, and demand rate

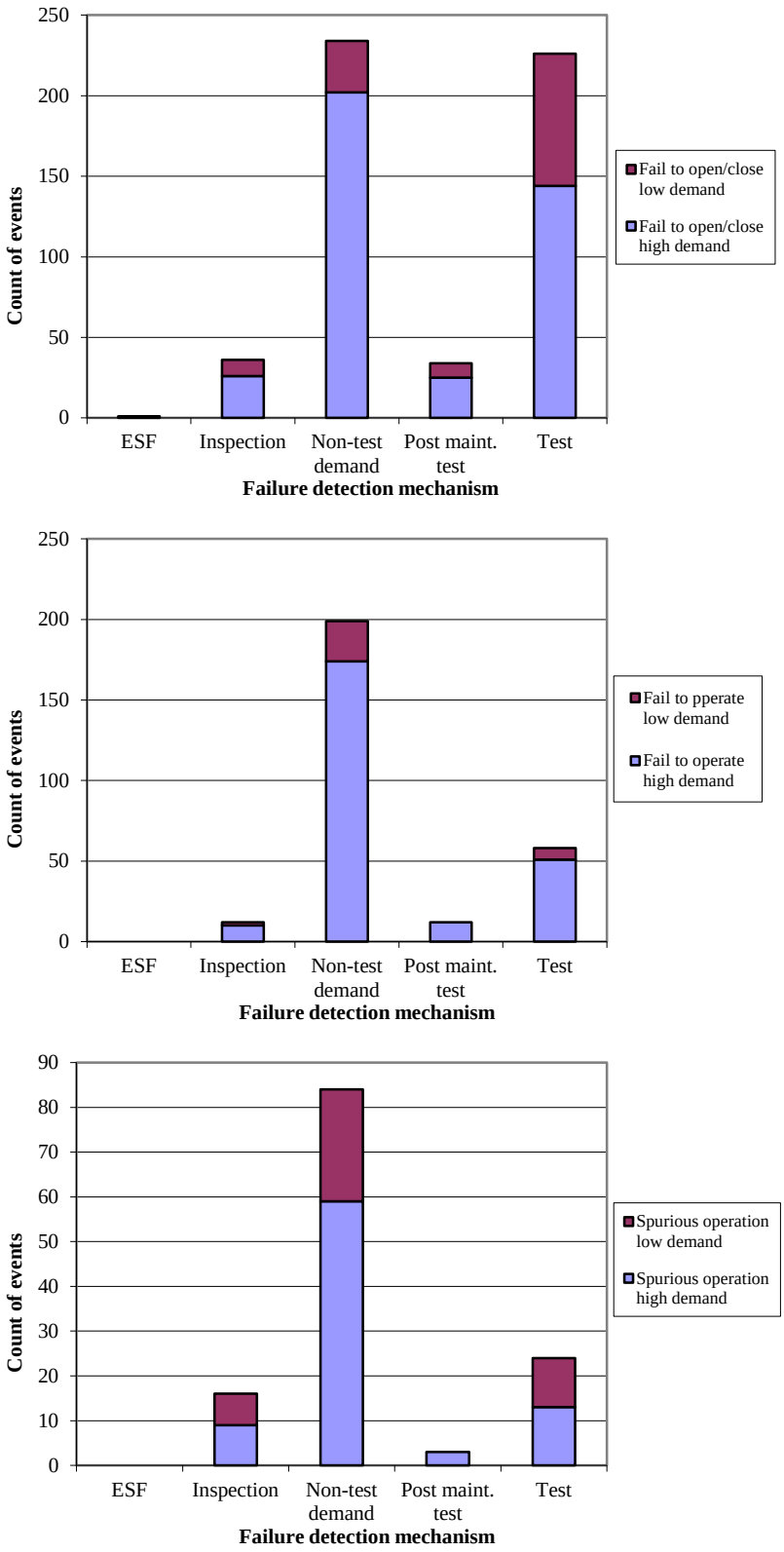

Figure 17. AOV failure event breakdown by method of detection, failure mode, and demand rate

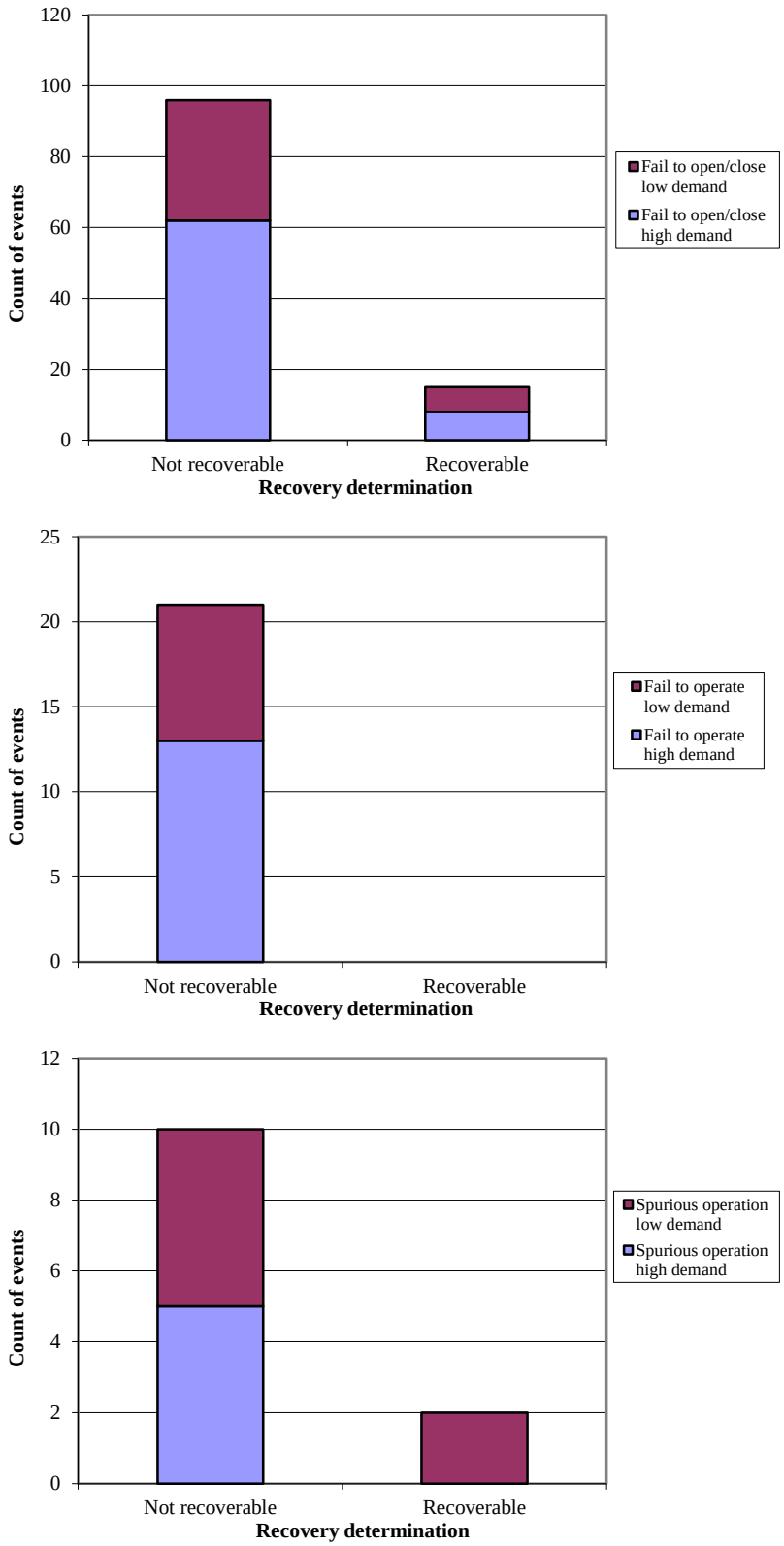

Figure 18. AOV failure event breakdown by recoverability, failure mode, and demand rate

5. AOV ASSEMBLY DESCRIPTION

An AOV assembly consists of a valve body and pneumatic operator sub-components. The valve body is generally a globe or butterfly type. The pneumatic operator is generally a piston or diaphragm type actuator. Main steam isolation valves and power operated relief valves are excluded from the AOV study even though pneumatically operated, as these are valves with different design and operating features.

The piece-parts of the valve body are the stem, packing, and internals. The pneumatic operator piece-parts may include piston internals/seals or diaphragm, positioner, mechanical linkage, volume booster, pilot valve, bolting, air regulator, airline, and wiring/contacts. Failures associated with instrument air systems that are not integral to the AOV assembly (e.g., contamination from the instrument air system that failed the AOV) are excluded in the AOV analysis.

Failure modes for the AOV include FTOC, which combines the fail to open and fail to close failure modes into a single category; 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 SO, which includes spurious opening and spurious closing.

6. DATA TABLES

Table 10. Plot data for Figure 1, failure probability estimate trend for AOV FTOC, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

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						6.27E−05	2.74E−03	9.51E−04
1998	10	8,284.2				6.52E−04	1.98E−03	1.18E−03
1999	8	8,379.4				4.82E-04	1.67E-03	9.44E-04
2000	5	8,243.6				2.58E-04	1.26E-03	6.20E-04
2001	8	8,464.6				4.77E-04	1.66E-03	9.35E-04
2002	7	8,487.4				3.98E-04	1.51E-03	8.23E-04
2003	9	8,562.0				5.51E-04	1.78E-03	1.03E-03
2004	6	8,638.2	7.38E-04	4.31E-04	1.26E-03	3.18E-04	1.35E-03	7.02E-04
2005	5	8,733.8	7.41E-04	4.69E-04	1.17E-03	2.44E-04	1.19E-03	5.88E-04
2006	8	8,051.5	7.44E-04	5.06E-04	1.09E-03	5.00E-04	1.74E-03	9.80E-04
2007	6	8,084.3	7.47E-04	5.38E-04	1.04E-03	3.38E-04	1.43E-03	7.46E-04
2008	6	8,048.6	7.49E-04	5.58E-04	1.01E-03	3.40E-04	1.44E-03	7.49E-04
2009	5	8,000.8	7.52E-04	5.59E-04	1.01E-03	2.65E-04	1.30E-03	6.38E-04
2010	7	8,141.6	7.55E-04	5.43E-04	1.05E-03	4.14E-04	1.57E-03	8.56E-04
2011	13	8,001.0	7.58E-04	5.14E-04	1.12E-03	9.37E-04	2.47E-03	1.57E-03
2012	3	8,029.8	7.61E-04	4.80E-04	1.20E-03	1.25E-04	9.77E-04	4.04E-04
2013	6	8,102.3	7.63E-04	4.44E-04	1.31E-03	3.38E-04	1.43E-03	7.45E-04
Total	112	132,251.7						

Table 11. Plot data for Figure 2, failure probability estimate trend for AOV FTOC, all systems, industry-wide trend of AOVs with > 20 demands per year.

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						6.27E−05	2.74E−03	9.51E−04
1998	12	26,852.8				2.52E-04	6.93E-04	4.32E-04
1999	10	28,841.8				1.87E-04	5.68E-04	3.39E-04
2000	7	28,093.3				1.20E-04	4.57E-04	2.48E-04
2001	11	27,403.1				2.22E-04	6.38E-04	3.90E-04
2002	5	27,730.1				7.67E-05	3.75E-04	1.84E-04
2003	7	27,982.5				1.21E-04	4.59E-04	2.49E-04
2004	8	27,381.1	2.28E-04	1.22E-04	4.25E-04	1.47E-04	5.11E-04	2.88E-04
2005	6	27,727.6	2.27E-04	1.33E-04	3.85E-04	9.88E-05	4.19E-04	2.18E-04
2006	9	27,561.4	2.26E-04	1.45E-04	3.52E-04	1.71E-04	5.51E-04	3.20E-04
2007	2	28,088.6	2.25E-04	1.54E-04	3.28E-04	1.90E-05	2.33E-04	8.28E-05
2008	7	27,961.5	2.24E-04	1.59E-04	3.15E-04	1.21E-04	4.59E-04	2.50E-04
2009	7	27,310.0	2.23E-04	1.58E-04	3.15E-04	1.23E-04	4.69E-04	2.55E-04
2010	8	27,227.0	2.22E-04	1.51E-04	3.26E-04	1.48E-04	5.14E-04	2.90E-04
2011	7	27,301.5	2.21E-04	1.40E-04	3.48E-04	1.24E-04	4.69E-04	2.55E-04
2012	4	26,966.8	2.20E-04	1.28E-04	3.77E-04	5.72E-05	3.38E-04	1.55E-04
2013	7	26,934.2	2.19E-04	1.16E-04	4.13E-04	1.25E-04	4.75E-04	2.58E-04
Total	117	441,363.3						

Table 12. Plot data for Figure 3, failure rate estimate trend for AOV FTOP, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

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						2.66E−08	6.59E−07	2.49E−07
1998	0	10,380,600.0				1.32E-10	2.62E-07	3.35E-08
1999	3	10,354,320.0				7.27E-08	5.67E-07	2.35E-07
2000	1	10,398,120.0				1.18E-08	3.70E-07	1.00E-07
2001	3	10,450,680.0				7.22E-08	5.64E-07	2.33E-07
2002	2	10,450,680.0				3.82E-08	4.69E-07	1.67E-07
2003	1	10,459,440.0				1.17E-08	3.69E-07	9.99E-08
2004	0	10,468,200.0	4.72E-08	1.95E-08	1.14E-07	1.31E-10	2.60E-07	3.33E-08
2005	2	10,468,200.0	5.42E-08	2.55E-08	1.15E-07	3.81E-08	4.68E-07	1.66E-07
2006	0	10,529,520.0	6.22E-08	3.29E-08	1.18E-07	1.30E-10	2.59E-07	3.31E-08
2007	0	10,459,440.0	7.15E-08	4.17E-08	1.23E-07	1.31E-10	2.60E-07	3.33E-08
2008	2	10,468,200.0	8.21E-08	5.12E-08	1.32E-07	3.81E-08	4.68E-07	1.66E-07
2009	1	10,450,680.0	9.43E-08	5.98E-08	1.49E-07	1.17E-08	3.69E-07	9.99E-08
2010	1	10,450,680.0	1.08E-07	6.64E-08	1.77E-07	1.17E-08	3.69E-07	9.99E-08
2011	1	10,573,320.0	1.24E-07	7.06E-08	2.19E-07	1.16E-08	3.66E-07	9.91E-08
2012	2	10,476,960.0	1.43E-07	7.30E-08	2.80E-07	3.81E-08	4.68E-07	1.66E-07
2013	2	10,494,480.0	1.64E-07	7.42E-08	3.64E-07	3.80E-08	4.67E-07	1.66E-07
Total	21	167,333,520.0						

Table 13. Plot data for Figure 4, failure rate estimate trend for AOV FTOP, all systems, industry-wide trend of AOVs with > 20 demands per year.

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						2.66E−08	6.59E−07	2.49E−07
1998	3	7,542,360.0				1.20E-07	9.40E-07	3.89E-07
1999	3	7,568,640.0				1.20E-07	9.37E-07	3.88E-07
2000	6	7,586,160.0				3.26E-07	1.38E-06	7.19E-07
2001	2	7,489,800.0				6.40E-08	7.86E-07	2.79E-07
2002	2	7,542,360.0				6.36E-08	7.81E-07	2.78E-07
2003	3	7,507,320.0				1.21E-07	9.43E-07	3.90E-07
2004	2	7,507,320.0	2.06E-07	8.22E-08	5.16E-07	6.39E-08	7.84E-07	2.79E-07
2005	4	7,516,080.0	2.23E-07	1.02E-07	4.89E-07	1.85E-07	1.10E-06	5.01E-07
2006	0	7,481,040.0	2.42E-07	1.25E-07	4.69E-07	2.20E-10	4.37E-07	5.59E-08
2007	2	7,481,040.0	2.63E-07	1.51E-07	4.59E-07	6.41E-08	7.87E-07	2.80E-07
2008	3	7,498,560.0	2.86E-07	1.76E-07	4.64E-07	1.21E-07	9.44E-07	3.91E-07
2009	2	7,481,040.0	3.10E-07	1.95E-07	4.92E-07	6.41E-08	7.87E-07	2.80E-07
2010	3	7,384,680.0	3.36E-07	2.05E-07	5.52E-07	1.23E-07	9.57E-07	3.96E-07
2011	2	7,437,240.0	3.65E-07	2.06E-07	6.47E-07	6.44E-08	7.91E-07	2.81E-07
2012	3	7,323,360.0	3.96E-07	2.00E-07	7.83E-07	1.23E-07	9.63E-07	3.99E-07
2013	4	7,305,840.0	4.30E-07	1.92E-07	9.63E-07	1.90E-07	1.12E-06	5.13E-07
Total	44	119,652,840.0						

Table 14. Plot data for Figure 5, failure rate estimate trend for AOV SO, all systems, industry-wide trend of AOVs with ≤ 20 demands per year.

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						2.04E−09	4.49E−07	1.31E−07
1998	0	10,380,600.0				1.43E-10	2.84E-07	3.63E-08
1999	6	10,354,320.0				2.14E-07	9.10E-07	4.73E-07
2000	1	10,398,120.0				1.28E-08	4.02E-07	1.09E-07
2001	1	10,450,680.0				1.27E-08	4.00E-07	1.08E-07
2002	8	10,450,680.0				3.13E-07	1.09E-06	6.14E-07
2003	2	10,459,440.0				4.14E-08	5.08E-07	1.81E-07
2004	1	10,468,200.0	8.86E-08	3.88E-08	2.02E-07	1.27E-08	4.00E-07	1.08E-07
2005	1	10,468,200.0	9.60E-08	4.75E-08	1.94E-07	1.27E-08	4.00E-07	1.08E-07
2006	0	10,529,520.0	1.04E-07	5.76E-08	1.88E-07	1.41E-10	2.81E-07	3.59E-08
2007	2	10,459,440.0	1.13E-07	6.84E-08	1.86E-07	4.14E-08	5.08E-07	1.81E-07
2008	2	10,468,200.0	1.22E-07	7.87E-08	1.90E-07	4.14E-08	5.08E-07	1.81E-07
2009	1	10,450,680.0	1.32E-07	8.65E-08	2.02E-07	1.27E-08	4.00E-07	1.08E-07
2010	1	10,450,680.0	1.43E-07	9.06E-08	2.27E-07	1.27E-08	4.00E-07	1.08E-07
2011	3	10,573,320.0	1.55E-07	9.11E-08	2.65E-07	7.77E-08	6.06E-07	2.51E-07
2012	3	10,476,960.0	1.68E-07	8.93E-08	3.17E-07	7.82E-08	6.10E-07	2.53E-07
2013	1	10,494,480.0	1.82E-07	8.61E-08	3.86E-07	1.27E-08	3.99E-07	1.08E-07
Total	33	167,333,520.0						

Table 15. Plot data for Figure 6, failure rate estimate trend for AOV SO, all systems, industry-wide trend of AOVs with > 20 demands per year.

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						2.04E−09	4.49E−07	1.31E−07
1998	3	7,542,360.0				9.09E-08	7.10E-07	2.94E-07
1999	3	7,568,640.0				9.07E-08	7.08E-07	2.93E-07
2000	0	7,586,160.0				1.64E-10	3.27E-07	4.18E-08
2001	3	7,489,800.0				9.13E-08	7.13E-07	2.95E-07
2002	1	7,542,360.0				1.48E-08	4.64E-07	1.26E-07
2003	0	7,507,320.0				1.65E-10	3.29E-07	4.21E-08
2004	0	7,507,320.0	9.51E-08	3.30E-08	2.74E-07	1.65E-10	3.29E-07	4.21E-08
2005	1	7,516,080.0	9.41E-08	3.83E-08	2.31E-07	1.48E-08	4.65E-07	1.26E-07
2006	1	7,481,040.0	9.31E-08	4.38E-08	1.98E-07	1.48E-08	4.67E-07	1.26E-07
2007	0	7,481,040.0	9.21E-08	4.84E-08	1.75E-07	1.66E-10	3.29E-07	4.22E-08
2008	2	7,498,560.0	9.11E-08	5.10E-08	1.62E-07	4.82E-08	5.92E-07	2.11E-07
2009	2	7,481,040.0	9.01E-08	5.04E-08	1.61E-07	4.83E-08	5.93E-07	2.11E-07
2010	1	7,384,680.0	8.91E-08	4.67E-08	1.70E-07	1.50E-08	4.71E-07	1.28E-07
2011	0	7,437,240.0	8.82E-08	4.13E-08	1.88E-07	1.66E-10	3.31E-07	4.23E-08
2012	1	7,323,360.0	8.72E-08	3.54E-08	2.15E-07	1.50E-08	4.73E-07	1.28E-07
2013	0	7,305,840.0	8.63E-08	2.98E-08	2.50E-07	1.68E-10	3.34E-07	4.28E-08
Total	18	119,652,840.0						

Table 16. Plot data for Figure 7, frequency (demands per reactor year) of AOV FTOC demands, ≤ 20 demands per year

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Demands	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	8,283	87.0				9.35E+01	9.69E+01	9.52E+01
1999	8,379	87.0				9.46E+01	9.81E+01	9.63E+01
2000	8,244	87.2				9.28E+01	9.62E+01	9.45E+01
2001	8,465	87.0				9.56E+01	9.91E+01	9.73E+01
2002	8,487	87.0				9.58E+01	9.93E+01	9.76E+01
2003	8,562	87.0				9.67E+01	1.00E+02	9.84E+01
2004	8,638	87.2	9.68E+01	9.30E+01	1.01E+02	9.73E+01	1.01E+02	9.90E+01
2005	8,734	87.0	9.62E+01	9.30E+01	9.95E+01	9.86E+01	1.02E+02	1.00E+02
2006	8,051	87.0	9.56E+01	9.29E+01	9.84E+01	9.09E+01	9.43E+01	9.25E+01
2007	8,084	87.0	9.50E+01	9.27E+01	9.73E+01	9.12E+01	9.46E+01	9.29E+01
2008	8,049	87.2	9.44E+01	9.23E+01	9.65E+01	9.06E+01	9.40E+01	9.23E+01
2009	8,001	87.0	9.38E+01	9.17E+01	9.59E+01	9.03E+01	9.37E+01	9.20E+01
2010	8,142	87.0	9.32E+01	9.09E+01	9.55E+01	9.19E+01	9.53E+01	9.36E+01
2011	8,001	87.0	9.26E+01	8.99E+01	9.53E+01	9.03E+01	9.37E+01	9.20E+01
2012	8,030	87.2	9.20E+01	8.89E+01	9.53E+01	9.04E+01	9.38E+01	9.20E+01
2013	8,102	85.6	9.14E+01	8.78E+01	9.52E+01	9.30E+01	9.64E+01	9.47E+01
Total	132,252	1,391.5						

Table 17. Plot data for Figure 8, frequency (demands per reactor year) of AOV FTOC demands, > 20 demands per year.

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Demands	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	26,853	90.0				2.95E+02	3.01E+02	2.98E+02
1999	28,842	90.0				3.17E+02	3.24E+02	3.20E+02
2000	28,093	90.2				3.08E+02	3.14E+02	3.11E+02
2001	27,403	90.0				3.01E+02	3.08E+02	3.04E+02
2002	27,730	90.0				3.05E+02	3.11E+02	3.08E+02
2003	27,983	90.0				3.08E+02	3.14E+02	3.11E+02
2004	27,381	90.2	3.08E+02	3.03E+02	3.14E+02	3.00E+02	3.06E+02	3.03E+02
2005	27,728	90.0	3.08E+02	3.03E+02	3.12E+02	3.05E+02	3.11E+02	3.08E+02
2006	27,561	90.0	3.07E+02	3.03E+02	3.11E+02	3.03E+02	3.09E+02	3.06E+02
2007	28,089	90.0	3.06E+02	3.03E+02	3.09E+02	3.09E+02	3.15E+02	3.12E+02
2008	27,962	90.2	3.05E+02	3.03E+02	3.08E+02	3.07E+02	3.13E+02	3.10E+02
2009	27,310	90.0	3.05E+02	3.02E+02	3.07E+02	3.00E+02	3.06E+02	3.03E+02
2010	27,227	90.0	3.04E+02	3.01E+02	3.07E+02	3.00E+02	3.06E+02	3.03E+02
2011	27,301	90.0	3.03E+02	3.00E+02	3.07E+02	3.00E+02	3.06E+02	3.03E+02
2012	26,967	90.2	3.02E+02	2.98E+02	3.07E+02	2.96E+02	3.02E+02	2.99E+02
2013	26,934	89.1	3.02E+02	2.97E+02	3.07E+02	2.99E+02	3.05E+02	3.02E+02
Total	441,363	1,440.1						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	10	87.0				6.19E-02	1.88E-01	1.12E-01
1999	8	87.0				4.63E-02	1.61E-01	9.08E-02
2000	5	87.2				2.44E-02	1.19E-01	5.86E-02
2001	8	87.0				4.63E-02	1.61E-01	9.08E-02
2002	7	87.0				3.88E-02	1.47E-01	8.01E-02
2003	9	87.0				5.40E-02	1.74E-01	1.01E-01
2004	6	87.2	7.16E-02	4.21E-02	1.22E-01	3.14E-02	1.33E-01	6.92E-02
2005	5	87.0	7.14E-02	4.55E-02	1.12E-01	2.44E-02	1.19E-01	5.87E-02
2006	8	87.0	7.13E-02	4.88E-02	1.04E-01	4.63E-02	1.61E-01	9.08E-02
2007	6	87.0	7.11E-02	5.14E-02	9.82E-02	3.15E-02	1.33E-01	6.94E-02
2008	6	87.2	7.09E-02	5.30E-02	9.48E-02	3.14E-02	1.33E-01	6.92E-02
2009	5	87.0	7.07E-02	5.28E-02	9.47E-02	2.44E-02	1.19E-01	5.87E-02
2010	7	87.0	7.05E-02	5.09E-02	9.76E-02	3.88E-02	1.47E-01	8.01E-02
2011	13	87.0	7.03E-02	4.80E-02	1.03E-01	8.62E-02	2.27E-01	1.44E-01
2012	3	87.2	7.01E-02	4.45E-02	1.11E-01	1.15E-02	9.01E-02	3.73E-02
2013	6	85.6	7.00E-02	4.09E-02	1.20E-01	3.19E-02	1.36E-01	7.05E-02
Total	112	1,391.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	12	90.0				7.54E-02	2.07E-01	1.29E-01
1999	10	90.0				5.98E-02	1.82E-01	1.08E-01
2000	7	90.2				3.74E-02	1.42E-01	7.72E-02
2001	11	90.0				6.76E-02	1.94E-01	1.19E-01
2002	5	90.0				2.36E-02	1.15E-01	5.68E-02
2003	7	90.0				3.75E-02	1.42E-01	7.74E-02
2004	8	90.2	7.05E-02	3.82E-02	1.30E-01	4.46E-02	1.55E-01	8.75E-02
2005	6	90.0	7.00E-02	4.16E-02	1.18E-01	3.04E-02	1.29E-01	6.71E-02
2006	9	90.0	6.95E-02	4.49E-02	1.08E-01	5.22E-02	1.69E-01	9.81E-02
2007	2	90.0	6.90E-02	4.75E-02	1.00E-01	5.91E-03	7.26E-02	2.58E-02
2008	7	90.2	6.85E-02	4.89E-02	9.59E-02	3.74E-02	1.42E-01	7.72E-02
2009	7	90.0	6.80E-02	4.84E-02	9.54E-02	3.75E-02	1.42E-01	7.74E-02
2010	8	90.0	6.75E-02	4.62E-02	9.85E-02	4.48E-02	1.56E-01	8.77E-02
2011	7	90.0	6.70E-02	4.29E-02	1.05E-01	3.75E-02	1.42E-01	7.74E-02
2012	4	90.2	6.65E-02	3.92E-02	1.13E-01	1.71E-02	1.01E-01	4.63E-02
2013	7	89.1	6.60E-02	3.54E-02	1.23E-01	3.78E-02	1.44E-01	7.82E-02
Total	117	1,440.1						

Table 20. Plot data for Figure 11, frequency (failures per reactor year) of AOV FTOP events ≤ 20 demands per year.

			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	87.0				1.58E-05	3.13E-02	4.01E-03
1999	3	87.0				8.68E-03	6.78E-02	2.80E-02
2000	1	87.2				1.41E-03	4.43E-02	1.20E-02
2001	3	87.0				8.68E-03	6.78E-02	2.80E-02
2002	2	87.0				4.59E-03	5.64E-02	2.00E-02
2003	1	87.0				1.41E-03	4.44E-02	1.20E-02
2004	0	87.2	5.67E-03	2.34E-03	1.37E-02	1.57E-05	3.12E-02	4.00E-03
2005	2	87.0	6.51E-03	3.07E-03	1.38E-02	4.59E-03	5.64E-02	2.00E-02
2006	0	87.0	7.49E-03	3.97E-03	1.41E-02	1.58E-05	3.13E-02	4.01E-03
2007	0	87.0	8.61E-03	5.03E-03	1.47E-02	1.58E-05	3.13E-02	4.01E-03
2008	2	87.2	9.90E-03	6.17E-03	1.59E-02	4.58E-03	5.63E-02	2.00E-02
2009	1	87.0	1.14E-02	7.23E-03	1.79E-02	1.41E-03	4.44E-02	1.20E-02
2010	1	87.0	1.31E-02	8.03E-03	2.13E-02	1.41E-03	4.44E-02	1.20E-02
2011	1	87.0	1.51E-02	8.54E-03	2.65E-02	1.41E-03	4.44E-02	1.20E-02
2012	2	87.2	1.73E-02	8.84E-03	3.39E-02	4.58E-03	5.63E-02	2.00E-02
2013	2	85.6	1.99E-02	8.99E-03	4.40E-02	4.64E-03	5.70E-02	2.03E-02
Total	21	1,391.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	3	90.0				1.01E-02	7.86E-02	3.25E-02
1999	3	90.0				1.01E-02	7.86E-02	3.25E-02
2000	6	90.2				2.73E-02	1.16E-01	6.02E-02
2001	2	90.0				5.32E-03	6.53E-02	2.32E-02
2002	2	90.0				5.32E-03	6.53E-02	2.32E-02
2003	3	90.0				1.01E-02	7.86E-02	3.25E-02
2004	2	90.2	1.72E-02	6.86E-03	4.30E-02	5.31E-03	6.52E-02	2.32E-02
2005	4	90.0	1.86E-02	8.51E-03	4.07E-02	1.54E-02	9.14E-02	4.18E-02
2006	0	90.0	2.02E-02	1.04E-02	3.90E-02	1.83E-05	3.63E-02	4.64E-03
2007	2	90.0	2.18E-02	1.25E-02	3.80E-02	5.32E-03	6.53E-02	2.32E-02
2008	3	90.2	2.36E-02	1.46E-02	3.84E-02	1.00E-02	7.84E-02	3.24E-02
2009	2	90.0	2.56E-02	1.61E-02	4.07E-02	5.32E-03	6.53E-02	2.32E-02
2010	3	90.0	2.77E-02	1.69E-02	4.55E-02	1.01E-02	7.86E-02	3.25E-02
2011	2	90.0	3.00E-02	1.69E-02	5.32E-02	5.32E-03	6.53E-02	2.32E-02
2012	3	90.2	3.25E-02	1.65E-02	6.42E-02	1.00E-02	7.84E-02	3.24E-02
2013	4	89.1	3.52E-02	1.57E-02	7.89E-02	1.56E-02	9.22E-02	4.22E-02
Total	44	1,440.1						

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

			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	87.0				1.71E-05	3.40E-02	4.35E-03
1999	6	87.0				2.56E-02	1.09E-01	5.65E-02
2000	1	87.2				1.53E-03	4.80E-02	1.30E-02
2001	1	87.0				1.53E-03	4.81E-02	1.30E-02
2002	8	87.0				3.77E-02	1.31E-01	7.39E-02
2003	2	87.0				4.98E-03	6.11E-02	2.17E-02
2004	1	87.2	1.06E-02	4.68E-03	2.42E-02	1.53E-03	4.80E-02	1.30E-02
2005	1	87.0	1.15E-02	5.74E-03	2.32E-02	1.53E-03	4.81E-02	1.30E-02
2006	0	87.0	1.25E-02	6.95E-03	2.26E-02	1.71E-05	3.40E-02	4.35E-03
2007	2	87.0	1.36E-02	8.26E-03	2.23E-02	4.98E-03	6.11E-02	2.17E-02
2008	2	87.2	1.47E-02	9.51E-03	2.28E-02	4.97E-03	6.10E-02	2.17E-02
2009	1	87.0	1.60E-02	1.05E-02	2.44E-02	1.53E-03	4.81E-02	1.30E-02
2010	1	87.0	1.73E-02	1.10E-02	2.74E-02	1.53E-03	4.81E-02	1.30E-02
2011	3	87.0	1.88E-02	1.11E-02	3.20E-02	9.42E-03	7.35E-02	3.04E-02
2012	3	87.2	2.04E-02	1.09E-02	3.84E-02	9.40E-03	7.34E-02	3.04E-02
2013	1	85.6	2.21E-02	1.05E-02	4.67E-02	1.55E-03	4.87E-02	1.32E-02
Total	33	1,391.5						

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

			Regression Curve Data Points			Plot Trend Error Bar Points		
FY	Failures	Reactor Years	Mean	Lower (5%)	Upper (95%)	Lower (5%)	Upper (95%)	Mean
1998	3	90.0				7.58E-03	5.92E-02	2.45E-02
1999	3	90.0				7.58E-03	5.92E-02	2.45E-02
2000	0	90.2				1.37E-05	2.73E-02	3.49E-03
2001	3	90.0				7.58E-03	5.92E-02	2.45E-02
2002	1	90.0				1.23E-03	3.87E-02	1.05E-02
2003	0	90.0				1.38E-05	2.73E-02	3.50E-03
2004	0	90.2	7.92E-03	2.75E-03	2.28E-02	1.37E-05	2.73E-02	3.49E-03
2005	1	90.0	7.82E-03	3.19E-03	1.92E-02	1.23E-03	3.87E-02	1.05E-02
2006	1	90.0	7.72E-03	3.63E-03	1.64E-02	1.23E-03	3.87E-02	1.05E-02
2007	0	90.0	7.63E-03	4.01E-03	1.45E-02	1.38E-05	2.73E-02	3.50E-03
2008	2	90.2	7.54E-03	4.22E-03	1.34E-02	4.00E-03	4.91E-02	1.75E-02
2009	2	90.0	7.45E-03	4.17E-03	1.33E-02	4.01E-03	4.92E-02	1.75E-02
2010	1	90.0	7.35E-03	3.86E-03	1.40E-02	1.23E-03	3.87E-02	1.05E-02
2011	0	90.0	7.26E-03	3.40E-03	1.55E-02	1.38E-05	2.73E-02	3.50E-03
2012	1	90.2	7.18E-03	2.91E-03	1.77E-02	1.23E-03	3.87E-02	1.05E-02
2013	0	89.1	7.09E-03	2.45E-03	2.05E-02	1.38E-05	2.75E-02	3.52E-03
Total	18	1,440.1						

7. REFERENCES

1. Nuclear Regulatory Commission, *Component Reliability Data Sheets Update 2010*, January 2012, http://nrcoe.inl.gov/resultsdb/publicdocs/AvgPerf/ComponentReliabilityDataSheets2010.pdf