Air-Operated Valves Executive Summary

This report provides the performance evaluation based on industry experience during the 1987 through 1998 period for air-operated valves (AOVs) in the pressurized water reactor (PWR) and in the boiling water reactor (BWR) risk-important (RI) systems. The main steam isolation valves (MSIVs) and power-operated relief valves (PORVs) are excluded from this study because their design and operational features are different from the typical piston/diaphragm AOVs in this study. The objectives of component performance are (1) to determine the reliability of risk important components and compare the results with estimates in probabilistic risk assessments (PRAs) and individual plant examinations (IPEs) and (2) to review the operational data from an engineering perspective to determine trends and patterns and gain insights into component performance.

AOV failure and estimated demand data was obtained from two databases. The Nuclear Plant Reliability Data System (NPRDS) provided component failures and surveillance test frequencies for the 1987–1995 period. The Sequence Coding and Search System (SCSS) provided Engineered Safety Features (ESF) failure and demand data for the 1987–1998 period and some surveillance test failure data for the 1987–1995 period reported in Licensee Event Reports (LERs).

For the PWR and BWR RI systems, the AOV estimated probability of failure on demand distributions were consistent with the generic value range from NUREG/CR-4550 (used as an input to NUREG-1150), although the PWR RHR system mean value (5.2E-4) is about a factor of 4 lower than the generic mean value (2E-3). Table ES-A lists the probability of failure on demand estimates developed for the RI systems selected for this study and the NUREG/CR-4550 values. For AOVs risk important systems, there was no statistically significant yearly trend for probability of failure on demand. Table ES-B gives the standby failure rates for each system.

TABLE ES-A
AOV PROBABILITY OF FAILURE ON DEMAND

	LOWER BOUND	MEAN	UPPER BOUND
NUREG/CR-4550	**5.4E-4**	**2E-3**	**4.8E-3**
PWR RI SYSTEMS			
auxiliary feedwater (AFW)	4.6E-6	1.8E-3	6.9E-3
high pressure injection (HPI)	4.8E-6	1.2E-3	4.7E-3
residual heat removal (RHR)	6.1E-5	5.2E-4	1.3E-3
chemical and volume control system (CVCS)	3.5E-7	3.4E-3	1.5E-2
component cooling water (CCW)	6.7E-5	5.8E-3	2.1E-2
BWR RI SYSTEMS			
reactor core isolation cooling (RCIC)	3.5E-4	3.0E-3	7.7E-3
high pressure coolant injection (HPCI)	4.3E-4	3.6E-3	9.5E-3
low pressure core spray (LPCS)	2.9E-15	2.1E-3	1.2E-2

TABLE ES-B
AOV STANDBY FAILURE RATE

	LOWER BOUND(λ_L)	MEAN(λ)	UPPER BOUND(λ_U)
PWR RI SYSTEMS			
AFW	4.8E-7/hour	8.2E-7/hour	1.3E-6/hour
RHR	6.9E-9/hour	1.3E-7/hour	6.4E-7/hour
CVCS	4.0E-7/hour	6.0E-7/hour	8.5E-7/hour
CCW	1.3E-7/hour	3.8E-7/hour	8.8E-7/hour
BWR RI SYSTEMS			
RCIC	4.1E-8/hour	7.9E-7/hour	3.8E-6/hour
HPCI	3.6E-8/hour	7.0E-7/hour	3.3E-6/hour
LPCS	2.5E-7/hour	7.4E-7/hour	1.7E-6/hour

The AOV mean probabilities of failure on demand used in plant-specific IPE studies were compared with the results of this study. The PWR IPE mean values were generally consistent with the results of this study and the NUREG/CR-4550 generic values. No comparison was made with BWR IPE mean values, since few BWR plant IPEs gave AOV failure probabilities on demand.

For the PWR RI systems during the 1987–1995 period, there was a statistically significant decreasing failure trend. For BWR RI systems, no statistically significant trend was identified. Both the maintenance rule and voluntary industry joint owners group initiatives were begun during this period. While there was insufficient information available to conclude whether these initiatives caused the trend, an improvement in performance had occurred.

Analysis of failure rates, as a function of component-years, showed no significant variance among the PWR plant age groups (three groups of approximately equal size, from older to newer plants by commercial operations date). The review of plant age groups did not show evidence of an increase in failure rates for any plant age groups due to aging mechanisms. For BWRs, failure data was too sparse for trending failure rates by plant age group.

The number of complete AOV common-cause failures (CCF) identified in this study was consistent with the expected number based on the CCF database parameters for the combined PWR and BWR complete failure population used in this study.

The AOVs have two subcomponents (valve body and valve operator). The valve operator was the biggest contributor to AOV failures (76%). Although valve operators were also the biggest contributors to BWR AOV failures, the number of failures (6) was too sparse to use.

Failures of AOV assemblies in PWR RI systems were mainly due to age/wear (47%).