



U.S. NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

NRC Perspective - History of Air Operated Valve Performance & the Development of ASME OM Code Mandatory Appendix IV

Michael F. Farnan

Component Performance & Testing Branch

Division of Engineering

Office of Nuclear Reactor Regulation

U.S. Nuclear Regulatory Commission

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AOV Issues and Activities 1970's to Present

- AOV Performance Issues
- ASME Code Requirements
- NRC Requirements/Initiatives
- Industry Initiatives



AOV Performance Issues

- Contamination from air system
 - Contaminants affect filters, regulators, solenoid valves, elastomers, I/P transducers, and valve positioners
 - Rust, Dirt, Water, Oil
 - Poor air quality system due to design and/or management deficiencies



AOV Performance Issues

- Design
 - Insufficient actuator size
 - All frictional forces not accounted for (i.e. valve factor, actuator output capability, valve loading)
 - Environment not accounted for
 - Incorrect design calculations



AOV Performance Issues

- Manufacturing Errors
 - Analysis
 - Set up instructions
 - Incorrect calculations
 - Replacement parts inadequate
 - Insufficient guidance on maintenance and/or replacement
 - Original design info and analyses supplied to architect was not forwarded on to plant



AOV Performance Issues

- Maintenance Activities
 - Aged elastomers
 - Improper application of thread locking sealant leads to internal contamination and sticking parts
 - Incorrect valve set up



ASME Code Requirements

- ASME B&PV Code Section XI “Rules For Inservice Inspection of Nuclear Power Plant Components”
- 1975 - Operation & Maintenance (O&M) of Nuclear Power Plants Committee formed
- O&M Committee charter: identify, develop, maintain, and review codes and standards for safe operation and maintenance of nuclear power plants



ASME Code Requirements

- O&M committee reviewed Section XI and determined what O&M standards could replace the Section XI requirements
- ASME/ANSI OM-1987 – added testing standards (relief valves, performance testing of cooling systems, vibration testing of piping, snubbers, inservice monitoring of core barrel axial preload)
- ASME/ANSI Oma-1988 – added pumps and valves
- Inservice Testing (IST) requirements placed in ASME OM Code-1990 (pumps, valves, relief valves, snubbers)



ASME Requirements/Alternatives

- 1995 – ASME Code Case OMN-1 (MOV)
- 1998 – OMN-3 (Categorization Using Risk Insights)
- 2001 - OMN-11 (Risk – MOVs)
- 2001 – OMN-12 (Risk – AOV/HOV)
- 2006 – OMN-1 major revision incorporates OMN-3 & OMN-11 attributes
- 2009 – Mandatory Appendix III (OMN-1)
- 2012 – Mandatory Appendix IV (AOV) submitted for ballot



NRC Requirements/Initiatives

- 1970's - 10 CFR 50.55a endorsed Section XI for testing of valves
- 1980s to 1990s - Contracts issued for independent testing & analysis of valve performance issues
- 1989 - GL 89-10 issued (MOV)
- 1990 to 1995 - Review industry GL 89-10 programs
- 1991 - GSI-158 issued
- 1991 - 10 CFR 50.65 Maintenance Rule issued



NRC Requirements/Initiatives

- 1993 – Recognized ASME/ANSI OM-1987 via 10 CFR 50.55a
- 1995 – Risk Policy Statement developed (adds probabilistic approach to deterministic)
- 1996 - GL 96-05 issued (MOV)
- 1996/2004 – NRC monitoring of GL 96-05 JOG MOV program
- 1997 – Independent evaluation of AOVs at 7 nuclear plants performed (NUREG-1275 Vol. 13 & NUREG/CR-6654)



NRC Requirements/Initiatives

- 1998 – RG 1.174 & RG 1.175 issued (risk informed guides on licensing and IST)
- 1999 – NRC committed to development and use of consensus standards (Public Law 104-113, National Technology and Transfer Act of 1995)
- 1999 – NRC endorsed ASME OM Code 1995 Edition & 1996 Addenda via 10 CFR 50.55a
- 1999 – 10 CFR 50.55a(b)(3)(ii) “Motor-Operated Valve Testing” issued



NRC Requirements/Initiatives

- **RIS 2000-03 – Resolution of GSI-158**
 - Industry initiative to address AOV concerns (JOG formed, Mandatory Appendix IV initiated)
 - Lessons learned for MOV program applied to AOVs
 - Diagnostic tools enhanced maintenance activities
 - Maintenance Rule required industry to focus on performance of safety-related high risk valves
 - All initiatives resulted in a downward trend of component failures



NRC Requirements/Initiatives

- 2001- Component Performance Study – Air Operated Valves 1987-1998 issued (NUREG-1715 Vol. 3)
- NRC staff has maintained an active role in participating and working with the industry via ASME, users groups, research facilities, etc.



Industry Initiatives

- 1989 – Implement 5 year program to address GL 89-10 concerns (MOVs)
- 1990 – MOV users group
- 1991 – AOV users group
- 1991 – Implement 5 year program to address 10 CFR 50.65 (Maintenance Rule)
- 1990s – EPRI Performance Prediction Methodology (PPM)



Industry Initiatives

- 1996 – EPRI AOV Maintenance Guide
- 1996 – GL 96-05 issued (MOVs)
- 1996 – JOG MOV formed to address GL 96-05
- 1997 – JOG AOV formed to address AOV issues
- 1999 – JOG AOV developed program document
Revision 0
- 2000 – JOG AOV developed program document
Revision 1
- 2000 – Worked with ASME to develop Mandatory
Appendix IV (AOVs)



Generic Communication – Valves

NRC DOC	All Valves	MOV	AOV	SOV
Bulletin	24	5	5	4
Generic Letter	27	10	3	2
RIS	6	3	1	16
Info Notice	234	73	23	0



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
BL 1981-02	4/9/81	Failure of Gate Type Valves to Close Against Differential Pressure	EPRI/NRC testing (MOV)
IN 1981-31	10/8/81	Failure of Safety Injection Valves to Operate Against Differential Pressure	HOV
IN 1982-25	7/20/82	Failures of Hiller Actuators upon Gradual Loss of Air Pressure	Inadequate testing (AOV)
IN 1985-35	4/30/85	Failure of Air Check Valves to Seat	Inadequate testing (AOV)
IN 1985-50	7/8/85	Complete Loss of Main and Auxiliary Feedwater at a PWR Designed by Babcock & Wilcox	Improper switch settings (MOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
IN 1985-84	10/30/85	Inadequate Inservice Testing of Main Steam Isolation Valves	Inadequate testing (AOV)
BL 1985-03	11/15/85	Motor-Operated Valve Common Mode Failures During Plant Transients Due To Improper Switch Settings	MOV
IN 1986-50	6/18/86	Inadequate Testing to Detect Failures of Safety-Related Pneumatic Components or Systems	Test failed under D/P due to missing actuator spring (AOV)
IN 1986-93	11/3/86	IEB 85-03 Evaluation of Motor-Operators Identifies Improper Switch Settings	Improper switch settings (MOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
BL 1985-03s1	4/27/88	Motor-Operated Valve Common Mode Failures During Plant Transients Due To Improper Switch Settings	Supplement issued for clarification of components in scope (MOV)
OM-1987	1987	ASME/ANSI testing standards	Relief valves, cooling systems etc.
Oma-1988	1988	ASME/ANSI added pumps and valves	Pumps/Valves added to standards
IN 1988-24	5/13/88	Failures of Air-Operated Valves Affecting Safety-Related Systems	SOV failure due to high air press (AOV)
IN 1988-94	12/2/88	Potentially Undersized Valve Actuators	Change in packing material (AOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
GL 1989-10	6/28/89	Safety-Related Motor-Operated Valve Testing and Surveillance	MOV (5 year to implement)
IN 1989-61	8/30/89	Failure of Borg-Warner Gate Valves to Close Against Differential Pressure	Design valve factor too low (MOV)
IN 1989-88	12/26/89	Recent NRC Sponsored Testing of Motor-Operated Valves	Valve factor, rate of loading, design calc too low (MOV)
IN 1990-21	3/22/90	Potential Failure of Motor-Operated Butterfly Valves to Operate Because Valve Seat Friction was Underestimated	(MOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
IN 1990-40	6/5/90	Results of NRC Sponsored Testing of Motor-Operated Valves	GSI-87 – standard design calc too low (MOV)
IN 1990-72	11/28/90	Testing of Parallel Disc Gate Valves in Europe	Valve factor too low (MOV)
OM Code	1990	ASME OM Code-1990	Pumps, Valves, Relief Valves, Snubbers
MUG	1990	MOV Users Group	
EPRI PPM	1990's	EPRI Performance Prediction Methodology	Conservative calculation verifies design basis



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
10 CFR 50.65	7/10/91	Requirements for monitoring the effectiveness of maintenance at nuclear power plants	Maintenance Rule (applies risk, 5 year to implement)
GSI-158	9/25/91	Generic Safety Issue 158: Performance of Safety-Related Power-Operated Valves under Design Basis Conditions	AOV, SOV, HOV (MOV addressed via GL 89-10)
AUG	1991	Air Operated Valve Users Group	
IN 1992-26	4/2/92	Pressure Locking of Motor-Operated Flexible Wedge Gate Valves	(MOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
IN 1992-41	5/29/92	Consideration of the Stem Rejection Load in Calculation of Required Valve Thrust	(MOV)
IN 1992-59	8/18/92	Horizontally Installed Motor-Operated Valves	Orientation increased friction factors (MOV)
OM-1987	1993	NRC recognizes ASME/ANSI OM-1987	10 CFR 50.55a
IN 1994-25	3/25/94	Failure of Containment Spray Header Valve to Open Due to Excessive Pressure From Inertial Effects of Water	(AOV)



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
IN 1994-44	6/16/94	Main Steam Isolation Valve Failure To Close On Demand Because of Inadequate Maintenance and Testing	Incorrect setup (AOV)
IN 1995-18	3/15/95	Potential Pressure-Locking of Safety-Related Power Operated Valves	(MOV, AOV, HOV, SOV)
Risk	1995	NRC issues Risk Policy Statement	Adds probabilistic approach to deterministic



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
OMN-1	1995	Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in LWR Power Plants	Code Case OMN-1 first appears in 1996 Addenda
EPRI	1996	EPRI AOV Maintenance Guide	
JOG – MOV	1996	Joint Owners Group – MOV	Formed to address GL 96-05
NUREG-1275 Vol. 13	1997	Independent Evaluation of AOVs	Evaluation of 7 plant AOV programs and performance history



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
JOG – AOV	1997	Joint Owners Group – AOV	AOV JOG formed to address issues
Reg Guide 1.174 & 1.175	1998	Risk informed guides on licensing and Inservice Testing	
OMN-3	1998	Requirements for Safety Significance Categorization of Components Using Risk Insights for Inservice Testing of LWR Power Plants	Risk component categorization



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
P.L. 104-113	1999	Public Law 104-113, National Technology and Transfer Act of 1995	NRC committed to development and use of consensus standard
ASME OM Code	1999	NRC endorses ASME OM Code 1995 Edition & 1996 Addenda	10 CFR 50.55a
10 CFR 50.55a(b)(3)(ii)	1999	Motor Operated Valve Testing	ASME OM Code & MOV program that verifies design basis



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
JOG – AOV	1999	JOG AOV Program Document Revision 0	JOG AOV program plan
JOG – AOV	2000	JOG AOV Program Document Revision 1	JOG AOV program plan
ASME OM Code	2000	Mandatory Appendix IV	ASME Subgroup on AOVs initiate new code
RIS 2000- 03	3/15/2000	Resolution of Generic Safety Issue (GSI) – 158	AOV JOG, MOV lessons learned, Diagnostics, MR



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
NUREG-1715 Vo. 3	2001	Component Performance Study – Air Operated Valves 1987-1998	NRC Research dept.
OMN-11	2001	Risk Informed Testing for Motor-Operated Valves	
OMN-12	2001	Alternate Requirements for Inservice Testing Using Risk Insights for Pneumatically and Hydraulically Operated Valve Assemblies in LWR Power Plants	



Valve Performance Timeline

(set up & ability to meet design requirements only)

Event	Date	Title	Comment
OMN-1 Rev. 1	2006	Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in LWR Power Plants	Major revision incorporating OMN-3 and OMN-11 attributes
Mandatory Appendix III	2009	Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in LWR Power Plants	
Mandatory Appendix IV	2012	Preservice and Inservice Testing of Certain Pneumatically Operated Valve Assemblies in LWR Power Plants	Sent out for 1 st consideration ballot



Summary

- 1970's to present - Many valve performance issues
- AOV issues – air quality, design, manufacturing errors, maintenance activities
- Generic communication ratio of MOV/AOV is 3/1; however, many MOV issues could be related to AOVs as noted by GSI-158
- Industry formed AOV JOG and initiated Mandatory Appendix IV



Summary

- Due to the Maintenance Rule, AOV JOG, GL 89-10 & GL 96-05 lessons learned, and implementation of advanced diagnostics, there has been a downward trend in AOV failures
- The issuance of Mandatory Appendix IV should support the continuation of this downward trend



QUESTIONS?

Future Questions

Michael.Farnan@nrc.gov

301-415-1486