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NRC INSPECTION MANUAL INSPECTION PROCEDURE 71111 ATTACHMENT 21N.02: DESIGN-BASIS CAPABILITY OF POWER-OPERATED VALVES UNDER 10 CFR 50.55a REQUIREMENTS INSPECTION IMPLEMENTATION UPDATE AND LESSONS LEARNED

Douglas Bollock*
Division of Reactor Oversight
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Rockville, MD

* This paper was prepared by staff of the U.S. Nuclear Regulatory Commission (NRC). It may present information that does not currently represent an agreed upon NRC staff position. NRC has neither approved nor disapproved the technical content.

ABSTRACT

On July 26, 2019, the NRC issued Inspection Procedure 71111, Attachment 21N.02 (IP 71111.21N.02), "Design-Basis Capability of Power-Operated Valves Under 10 CFR 50.55a Requirements." The objective of this inspection procedure is to assess the reliability, functional capability, and design basis of risk-important power-operated valves (POVs) as required by Section 55a, "Codes and Standards," in Part 50, "Domestic Licensing of Production and Utilization Facilities," of Title 10, "Energy," in the Code of Federal Regulations (10 CFR 50.55a). The NRC staff has implemented this inspection procedure at operating nuclear power plants in the United States (U.S.) since January 2020 and has gained lessons learned through implementation of and feedback from the inspections. The staff has held a public meeting with nuclear power plant licensees to discuss the lessons learned from the inspection activities in December 2020. This paper describes the status of the ongoing NRC staff activities for POV inspections at operating U.S. nuclear power plants and the lessons learned through implementation of the inspections.

1. INTRODUCTION

In an effort to improve the effectiveness and efficiency of the Nuclear Regulatory Commission (NRC) engineering inspections within the Reactor Oversight Process (ROP), as part of the agency reform initiatives, the NRC revised the Component Design Bases Inspection (CDBI) to include inspection of licensee's implementation of key engineering areas. This change was in response to an internal NRC lessons learned report, which was performed in response to a high safety significance (Red) inspection finding at Browns Ferry. The report recommended that periodic inspection of the licensee's implementation of important engineering areas be considered as part of the ROP baseline inspection program. Nuclear industry representatives also provided feedback that the total length of the CDBI inspections took too much of their staff resources at one time to support. After extensive stakeholder engagement, NRC management decided to split the CDBI procedure into two separate inspection procedures: IP 71111.21M, "Component Design Bases Inspection (Teams)," and IP 71111.21N, "Component Design Bases Inspection (Programs)," in order to implement the lessons learned recommendation. Splitting the CDBI inspection procedure into two inspection activities performed in different years allowed a more manageable inspection program for both the NRC and the

licensees. Additionally, the development of IP 71111.21N allowed the addition of periodic inspection of licensee's implementation of key engineering areas as part of the ROP baseline inspection program. Both IP 71111.21M and 71111.21N inspections are conducted on a triennial basis. The IP 71111.21N inspection areas change following the triennial cycle. The first IP 71111.21N inspection was Environmental Qualification and was conducted from January 2017 through December 2019. This paper will focus on the implementation of inspection procedure IP 71111.21N.02, “Design-Basis Capability of Power-Operated Valves Under 10 CFR 50.55a Requirements,” which began in January 2020.

2. MATERIALS AND METHODS

All materials and methods that have been used in the work must be stated clearly. Subtitles should be used when necessary.

2.1 IP 71111.21N.02 Requirements

The inspection objective is to assess the reliability, functional capability, and design basis of risk-important power-operated valves (POVs) as required by 10 CFR 50.55a and applicable 10 CFR Part 50, Appendix A and Appendix B, requirements. The process involves five key areas:

1) Sample Selection

In performing this inspection, the inspectors select a sample of POVs for detailed review of the applicable licensee activities. The inspectors may expand the sample to determine the design-basis capability of other POVs if concerns are identified with implementation of licensee activities. In preparation for this inspection, regional inspectors should consult with subject matter experts from the NRC Office of Nuclear Reactor Regulation, Division of Engineering and External Hazards, Mechanical Engineering and Inservice Testing Branch (NRR/DEX/EMIB), along with the Regional Senior Reactor Analyst (SRA) and use risk insights to identify approximately 30 valves to consider for more detailed inspection. The inspector then requests that the licensee provide design-basis capability information for those POVs including their function, safety significance, sizing and setting calculation assumptions, and operating margin. The NRC inspection team reviews the information and selects approximately 8 to 12 POVs for the detailed review and assessment of their operational readiness to perform their design-basis function.

2) Scope

Determine whether the sampled POVs are being tested and maintained in accordance with NRC regulations along with the licensee’s commitments and/or licensing bases.

3) Design

Determine whether the sampled POVs are capable of performing their design-basis functions.

4) Testing

Determine whether testing of the sampled POVs is adequate to demonstrate the capability of the POVs to perform their safety functions under design-basis conditions.

5) Maintenance and Corrective Actions

Evaluate maintenance activities including a walkdown of the sampled POVs (if accessible).

2.2 POV Inspector Training

In preparation for the implementation of inspection procedure IP 71111.21N.02 for POVs, NRC inspectors received a one and a half day training course on inspection implementation. A prerequisite for this training was successful completion of a 3-day motor-operated valve (MOV) refresher course developed by NRR/DEX/EMIB.

The training course material covered the following areas:

1) Regulatory requirements

2) POV design, operation, experience, lessons learned, and design-basis capability evaluation
3) POV inspection requirements, guidance, and implementation
4) POV inspection planning and logistics
5) Inspector tools

2.3 POV Inspection Implementation

The NRC staff began implementing POV inspections in January 2020. There were fourteen POV inspections completed in 2020. Additional POV inspections are underway in 2021. All POV inspections will be completed by December 31, 2022.

Early communications between NRC inspectors and licensee staff were instrumental in focusing the inspection on safety significant and risk informed valve samples. The NRC updated IP 71111.21N.02 on October 9, 2020, to reflect lessons learned from the first inspections implemented.
Following each POV inspection, the NRC conducts a cross-regional panel of key NRC staff participants to discuss inspection items and issues. The purpose of the panels is to ensure consistency across the NRC Region offices in implementation of the inspections, and consistency in dispositioning inspection findings and violations following the NRC's ROP.

2.4 COVID-19 Public Health Emergency Impacts

Many inspections were conducted partially or completely remotely due to the COVID-19 public health emergency. Effective NRC inspector and licensee communications were critical to facilitate the remote inspection efforts. Many remote inspections conducted short onsite visits to perform walkdowns, or used resident inspectors as proxies in conducting walkdowns. The inspectors successfully met the objectives of the POV inspections while conducting remote inspections.

3. RESULTS AND DISCUSSION

Overall, the NRC has been successful in implementing the POV inspections, both in meeting the inspection objectives, and maintaining consistency in the implementation across every NRC region. This is due, in part, to the early communication with licensees and free flow of information and communication between the NRC and licensees.

3.1 Issues Identified during inspections

The NRC staff identified many issues while implementing the POV inspections. Fourteen of the more repetitive or impactful findings are listed below. Each of the issues below were discussed with the applicable licensees in detail during the POV inspections. The licensees took action to address the immediate concerns related to these issues identified by the NRC inspectors. In some cases, longer term action will be needed as part of the corrective action programs at the applicable nuclear power plants. The NRC inspection reports discuss those findings that were determined to be Green, or of very low safety significance, with no findings to date. The following is a summary of the POV inspection findings to date discussed during a public meeting on December 8, 2020 (ADAMS Accession No. ML20342A041) and described in NRC Information Notice 2021-01, "Lessons Learned from U.S. Nuclear Regulatory Commission Inspections of Design-Basis Capability of Power-Operated Valves at Nuclear Power Plants," May 6, 2021.

1. The NRC inspections found that the Inservice Testing (IST) Program Plans at some nuclear power plants were not fully consistent with the American Society of Mechanical Engineers (ASME) Operation and Maintenance of Nuclear Power Plants, Division 1, OM Code: Section IST (OM Code) as incorporated by reference in Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic licensing of production and utilization facilities," Section 55a, "Codes and standards" (10 CFR 50.55a), for POVs within the scope of the ASME OM Code. For example, some IST Program Plans for specific nuclear power plants

did not address all POV safety functions. In meeting 10 CFR 50.55a(b)(3)(ii), nuclear power plant licensees may pursue risk informed approaches based on the licensing basis including authorizations contained in the applicable ASME OM Code as incorporated by reference in 10 CFR 50.55a, and consistent with the NRC's acceptance of the implementation of the industry's Joint Owners Group (JOG) Program on Motor Operated Valve (MOV) Periodic Verification for the specific nuclear power plant. NRC inspections at some nuclear power plants found that some licensees were not periodically updating their POV risk rankings.

2. The NRC inspections found that some licensees did not address the requirement in ASME OM Code, Appendix III, "Preservice and Inservice Testing of Active Electric Motor Operated Valve Assemblies in Light Water Reactor Power Plants," to apply a mix of static and dynamic testing. For MOVs within the scope of the JOG Program, a licensee may rely on the dynamic testing conducted as part of that program to satisfy the requirement in Appendix III for a mix of static and dynamic testing. The NRC inspections found that some licensees are installing new valves and not performing dynamic testing in accordance with ASME OM Code, Appendix III, or otherwise justifying the valve performance assumptions. The JOG Program provides guidance for re-establishing the qualifying basis for a new valve or determining the current operating valve friction coefficient for the new valve to compare to the JOG threshold value.

3. The NRC inspections found that one licensee did not follow its NRC accepted commitment modification process to modify the JOG test intervals or notify the NRC in accordance with that process. For example, the JOG Program does not include grace periods for the specified JOG test intervals. A licensee applied MOV test intervals that differed from the JOG test intervals that were relied upon by the NRC staff to close Generic Letter (GL) 96 05, "Periodic Verification of Design Basis Capability of Safety Related Motor Operated Valves," for that nuclear power plant.

4. The NRC inspections found that some licensees were not properly determining the operating requirements and actuator capability for POVs to perform their safety functions. For example, some licensees did not adequately address all appropriate parameters (such as valve friction coefficients, maximum differential pressure conditions, motor torque temperature derating factors, stem friction coefficients, and butterfly valve bearing friction coefficients) when calculating valve operating requirements or actuator capability. The NRC inspections found some licensees were using improper values for various parameters in their POV calculations (such as incorrect stem pitch and lead assumptions, valve factors and stem friction coefficients that were less than values obtained from valve tests, and incorrect uncertainty values). In some cases, licensees did not justify the use of valve friction coefficients from outside sources. The JOG Program specifies guidance for determining appropriate valve friction coefficients. In some cases, licensees did not address the potential for increased thrust and torque requirements (referred to as side loading) to operate globe valves under high flow dynamic conditions. In some cases, licensees did not consider the presence of radiation hot spots and ambient temperature conditions that can impact the service life of environmental qualification of a valve actuator. The NRC inspections found one licensee had not updated its POV program to incorporate new computer software used in its POV calculations. The NRC inspections found that the capability of individual POV subparts was not determined to be able to withstand the maximum thrust and torque that the POV actuator can produce (sometimes referred to as a weak link evaluation). For example, structural limits specified in the ASME Boiler and Pressure Vessel Code are not applicable to POV internal parts that involve operating motion of the valve and actuator. With respect to previous POV capability issues, GL 79 46, "Containment Purging and Venting During Normal Operation Guidelines for Valve Operability," dated September 27, 1979 (ADAMS Accession No. ML031320191), provides recommendations to demonstrate that containment purge valves can close and seal under design basis conditions, including seismic loads.

5. The NRC inspections found that some licensees incorrectly assumed that the valve friction coefficients determined for MOVs as part of the JOG Program represented a database of friction coefficients that can

be applied in general to calculate the thrust and torque required to operate various MOVs under design basis conditions. The JOG Program determined whether there was the potential for degradation of valve friction coefficients for various valve types and applications, rather than determining specific values of friction coefficients. The NRC provided information on various approaches for obtaining valve performance data in IN 2012 14, "Motor Operated Valve Inoperable Due to Stem Disc Separation," dated July 24, 2012 (ADAMS Accession No. ML12150A046).

6. The NRC inspections found that contrary to the industry topical report MPR 2524A on the JOG Program on MOV Periodic Verification, some licensees who committed to the JOG Program to satisfy GL 96 05 and are implementing the JOG Program as part of their compliance with 10 CFR 50.55a(b)(3)(ii) had not established methods to periodically demonstrate the design basis capability of their MOVs that are JOG Class D valves (defined by JOG as outside the scope of the JOG Program). In addition, the NRC inspections found that some licensees had modified the JOG classification of their MOVs from a JOG Class D valve to a JOG Class A valve (defined by JOG as not susceptible to degradation). The basis for reclassifying a valve that is outside the scope of the JOG Program (JOG Class D valve) to a valve not susceptible to degradation (JOG Class A valve) was not apparent. The NRC inspections also found that some licensees were applying guidance developed by the Electric Power Research Institute (EPRI) for evaluating MOV diagnostic test data obtained under static conditions (i.e., without differential pressure or flow) beyond the capability of that testing to predict MOV performance under dynamic conditions (i.e., differential pressure and flow).

7. The NRC inspections found that some licensees that evaluated MOVs using the EPRI MOV Performance Prediction Methodology (PPM) were not addressing all of the applicable provisions when implementing the EPRI MOV PPM to determine valve operating requirements. In accepting the EPRI MOV PPM, the NRC staff noted that EPRI assumed that each valve is maintained in good condition for the EPRI MOV PPM to remain valid for that valve. The NRC inspections found that some licensees were incorrectly assuming that a valve is JOG Class A or JOG Class B (defined by JOG as not susceptible to degradation by extension) because the EPRI PPM was applied without ensuring that the valve is maintained with good internal condition. The NRC provides more information on the EPRI MOV PPM in NUREG-1482, "Guidelines for Inservice Testing at Nuclear Power Plants," Revision 3, issued July 2020 (ADAMS Accession No. ML20202A473).

8. The NRC inspections identified an instance of improper justification for increasing the thrust ratings for certain Limitorque motor actuators beyond their qualified design limits. Limitorque Technical Update 92 01, "Thrust Rating Increase SMB 000, SMB 00, SMB 0 & SMB 1 Actuators" (which is available from Limitorque), evaluated Kalsi Engineering Document #1707C (which is a proprietary report by Kalsi Engineering) and approved its use to increase the maximum allowable thrust for Limitorque actuator models SMB 000, SMB 00, SMB 0, and SMB 1 up to 140 percent of the original ratings, with certain conditions. The 140 percent maximum thrust that Limitorque allows in Technical Update 92 01 is less than the 162 percent maximum thrust limit discussed in Kalsi Engineering Document #1707C. Despite the limitations of the Limitorque analyses, NRC inspections found some licensees had applied Kalsi Engineering Document #1707C to increase the allowable maximum thrust for Limitorque actuators to 162 percent of the original ratings. Previously, licensees had to have specific permission from Limitorque to increase the allowable maximum thrust for Limitorque actuators to 162 percent of the original ratings. Limitorque has since indicated that licensees that participated in the Kalsi study or have possession of the proprietary Kalsi Engineering Document #1707C report may apply the 162 percent maximum thrust rating described in the Kalsi report where the specific conditions are implemented without an individual letter from Limitorque.

9. The NRC inspections at some nuclear power plants identified that POV testing was not conducted properly, and the results were not adequately evaluated to demonstrate that the POVs could perform their safety

functions. For example, POV test acceptance criteria were not properly translated from POV design calculations to test procedures. Diagnostic equipment was not verified to be installed and operating properly as part of the POV testing and evaluation of results. Operating requirements for valves were not evaluated throughout the full valve stroke. POV test data evaluations were not fully completed to ensure that the required parameters (such as valve friction coefficient, stem factor, and rate of loading) were being calculated and that they were within the acceptable range. Valve friction values from testing were not compared to the JOG threshold values for valve friction when implementing the JOG Program. Overthrust events when testing POVs were not addressed. The potential variation of valve performance was not addressed when relying on a single test to establish POV operating requirements. Licensees relying on the use of POV static testing associated with containment leakage testing in accordance with 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water Cooled Power Reactors," are responsible for justifying when using such testing to demonstrate that the requirements of 10 CFR 50.55a(b)(3)(ii) for periodic verification of MOV design basis capability are satisfied. The NRC inspections found that the performance of thermal overload devices that can impact the safety function of MOVs was not evaluated periodically. The NRC inspections also found that monitoring reports were not prepared in accordance with plant procedures to identify any adverse performance indications of POVs.

10. The NRC inspections found that some licensees, with MOVs that had a safety function to close, had set the motor control switch trip circuit to be controlled by the limit switch gear train, instead of the torque switch. For example, some licensees were relying on static testing of limit switch controlled MOVs performed as part of containment leakage testing in accordance with 10 CFR Part 50, Appendix J, in their effort to meet the 10 CFR 50.55a(b)(3)(ii) requirement for periodic verification of MOV design basis capability. Although the MOVs are required to close and seal under dynamic conditions, some licensees set those MOVs using the limit switch during a periodic static test. The NRC inspections identified that some licensees did not have a valid test or analysis demonstrating that the limit switch control setting of the MOV under static conditions will achieve the required leak tight performance when the MOV is closed under dynamic conditions.

11. The NRC inspections identified that some licensees did not provide adequate justification to extend the qualified life of POVs installed in their nuclear power plants. Limitorque qualified its safety related MOV actuators for 40 years or 2,000 cycles, whichever comes first. Licensees are permitted to extend the qualified life of their Limitorque actuators if they have adequate justification. The justification for the extension of the qualified life of the actuator, including attention to radiation levels and ambient temperature conditions where MOVs are located, should provide assurance that the environmental qualification requirements are not exceeded, and that appropriate replacement frequencies for POVs or their individual parts are established. EPRI has developed guidance for extending the qualified life of Limitorque actuators that includes provisions for a valve assembly that is considered to be functional beyond its qualified life. Licensees may follow this guidance or choose their own method where justified.

12. The NRC inspections found that some licensees were not properly implementing the Boiling Water Reactor Owners Group (BWROG) guidance (such as evaluating the weak link of the wedge pin under motor stall conditions) in assessing the susceptibility for separation of the stem disk connection in Anchor/Darling double disk gate valves. This guidance was established by the BWROG to address the issue of potential failure of the stem disk connection in Anchor/Darling double disk gate valves, which is discussed in IN 2017-03, "Anchor/Darling Double Disc Gate Valve Wedge Pin and Stem Disc Separation Failures," dated June 15, 2017 (ADAMS Accession No. ML17153A053).

13. The NRC inspections found that some licensees were not meeting the requirement in 10 CFR 50.55a(b)(3)(xi), to supplement the valve position indication testing required in paragraph ISTC-3700, "Position Verification Testing," in Subsection ISTC, "Inservice Testing of Valves in Water Cooled Reactor Nuclear Power Plants," of the 2012 Edition and later editions of the ASME OM Code. Paragraph ISTC

3700 requires, as conditioned by 10 CFR 50.55a(b)(3)(xi), that valves with remote position indicators be observed locally at least once every 2 years to verify that valve operation is accurately indicated. The NRC regulations in 10 CFR 50.55a(b)(3)(xi) state that when implementing ASME OM Code, 2012 Edition (or later editions), paragraph ISTC 3700, licensees shall verify that valve operation is accurately indicated by supplementing valve position indicating lights with other indications, such as flow meters or other suitable instrumentation, to provide assurance of proper obturator position. In the July 18, 2017 Federal Register notice (82 FR 32934) for the final rule, the NRC emphasizes the provisions in the ASME OM Code, 2012 Edition, paragraph ISTC 3700, requiring verification that valve obturator position is accurately indicated, and does not state or indicate that the condition in 10 CFR 50.55a(b)(3)(xi) represents a new test. In particular, paragraph ISTC 3700 requires licensees to test valves every 2 years to verify their remote position indicating lights. The NRC responses to public comments on the proposed rule (ADAMS Accession No. ML16130A531) included a response to a specific public comment requesting an additional 24 months to implement 10 CFR 50.55a(b)(3)(xi) for licensees nearing their IST Program update deadline. The NRC response stated that licensees would not be allowed additional time to comply with this condition as part of the rulemaking, and that licensees determining that they will need additional time to implement the 2012 Edition of the ASME OM Code (including the condition on valve position indication in 10 CFR 50.55a(b)(3)(xi)) may submit a request for an alternative in accordance with 10 CFR 50.55a(z) for NRC staff review. Additional information on this topic is found in two monthly ROP meeting summaries (ADAMS Accession Nos. ML21041A409 and ML21047A290).

14. With respect to POV preventive maintenance and walkdowns, the NRC inspections found that some licensees were not justifying the lubrication interval for the MOV stem where brittle or degraded lubrication grease was identified that could have impacted the operation of the MOV. The NRC inspections found MOVs installed in non-normal positions that can cause MOV maintenance issues (such as potential grease leakage into the limit switch compartment that might lead to grease interfering with the actuator wiring, or abnormal performance of a gate valve with the disk in the horizontal plane resulting in increased wear over time).

4. CONCLUSION

Engineering inspections play an important role in the ROP. They enable the NRC to verify safety system capability under accident conditions that do not reveal themselves through testing or plant operation. The POV inspections are important to assess the reliability, functional capability, and design basis capability of risk important POVs to determine whether licensees are maintaining the POV capability to perform as intended under design basis conditions.

ACKNOWLEDGEMENTS

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REFERENCES

1. American Society of Mechanical Engineers (ASME) *Operation and Maintenance of Nuclear Power Plants*, Division 1, OM Code: Section IST, and Code Cases.

2. ASME Standard QME-1-2007, “Qualification of Active Mechanical Equipment Used in Nuclear Power Plants.”

3. Bulletin 85-03 (November 15, 1985), “Motor-Operated Valve Common Mode Failures During Plant Transients Due to Improper Switch Settings,” and Supplement 1 (April 27, 1988).

4. *Federal Register*, 64 FR 51370, “Industry Codes and Standard; Amended Requirements,” September 22, 1999.

5. *Federal Register*, 82 FR 32934, “Incorporation by Reference of American Society of Mechanical Engineers Codes and Code Cases,” July 18, 2017.

6. Generic Letter (GL) 89-10, “Safety-Related Motor-Operated Valve Testing and Surveillance,” June 28, 1989, and seven supplements (June 13, 1990; August 3, 1990; October 25, 1990; February 12, 1992; June 28, 1993; March 8, 1994; and January 24, 1996).

7. GL 95-07, “Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves,” August 17, 1995.

8. GL 96-05, “Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves,” September 18, 1996.

9. Information Notice (IN) 92-83, “Thrust Limits for Limitorque Actuators and Potential Overstressing of Motor-Operated Valves,” December 17, 1992.

10. IN 96-48, “Motor-Operated Valve Performance Issues,” August 21, 1996, and Supplement 1, July 24, 1998.

11. IN 97-16, “Preconditioning of Plant Structures, Systems, and Components Before ASME Code Inservice Testing or Technical Specification Surveillance Testing,” April 4, 1997.
12. IN 2003-15, “Importance of Follow up Activities in Resolving Maintenance Issues,” September 5, 2003.

13. IN 2006-03, “Motor Starter Failures due to Mechanical-Interlock Binding,” January 25, 2006.

14. IN 2006-15, “Vibration-Induced Degradation and Failure of Safety-Related Valves,” July 27, 2006.

15. IN 2006-29, “Potential Common Cause Failure of Motor-Operated Valves as a Result of Stem Nut Wear,” December 14, 2006.

16. IN 2008-20, “Failures of Motor-Operated Valve Actuator Motors with Magnesium Alloy Rotors,” December 8, 2008.

17. IN 2010-03, “Failures of Motor-Operated Valves Due to Degraded Stem Lubricant,” February 3, 2010.

18. IN 2012-06, “Ineffective Use of Vendor Technical Recommendations,” April 24, 2012.

19. IN 2012-14, “Motor-Operated Valve Inoperable Due To Stem-Disc Separation,” July 24, 2012.

20. IN 2013-14, “Potential Design Deficiency in Motor-Operated Valve Control Circuitry,” August 23, 2013.

21. IN 2014-11, “Recent Issues Related to the Qualification and Commercial Grade Dedication of Safety-Related Components,” September 19, 2014.

22. IN 2015-13, “Main Steam Isolation Valve Failure Events,” December 10, 2015.

23. IN 2016-05, “Operating Experience Regarding Complications from a Loss of Instrument Air,” April 27, 2016.

24. IN 2016-09, “Recent Issues Identified When Using Reverse Engineering Techniques in the Procurement of Safety-Related Components,” July 15, 2016.

25. IN 2017-03, “Anchor/Darling Double Disc Gate Valve Wedge Pin and Stem-Disc Separation Failures,” June 15, 2017.

26. IN 2021-01, “Lessons Learned from U.S. Nuclear Regulatory Commission Inspections of Design-Basis Capability of Power-Operated Valves at Nuclear Power Plants,” May 6, 2021.

27. Inspection Manual Part 9900, “Technical Guidance on Maintenance – Preconditioning.”

28. Inspection Procedure (IP) 61726, “Surveillance Observations.”

29. IP 62708, “Motor-Operated Valve Capability.”

30. IP 62710, “Power-Operated Gate Valve Pressure Locking and Thermal Binding.”

31. IP 71111.22, “Surveillance Testing.”

32. Joint Owners Group, Topical Report MPR-2524-A, “Joint Owners Group (JOG) Motor Operated Valve Periodic Verification Program Summary,” November 2006 (ADAMS Accession No. ML063490194).

33. Licensee Event Report 424/2012-005-00, “Main Steam Isolation Valve Failure,” dated November 29, 2012, submitted by Southern Nuclear Operating Company (ADAMS Accession No. ML12339A190).

34. Nuclear Energy Institute, “Joint Owners Group Air Operated Valve Program Document,” Revision 0, March 27, 2001 (ADAMS Accession No. ML020360091).

35. Nuclear Energy Institute, “Joint Owners Group Air Operated Valve Program Document,” Revision 1, March 27, 2001 (ADAMS Accession No. ML010950310).

36. NRC Inspection Procedure 95003 Supplemental Inspection Report 05000259/2011011, 05000260/2011011, and 05000296/2011011 (Part 1) for Browns Ferry Nuclear Plant, dated November 17, 2011 (ADAMS Accession No. ML113210602).

37. NRC Inspection Report No. 50-275/2016010 and 50-323/2016010, for Diablo Canyon Power Plant Units 1 and 2, dated October 3, 2016 (ADAMS Accession No. ML16277A340).

38. NRC Inspection Report No. 50-361 and 362/99-18, for San Onofre Nuclear Generating Station, Units 2 and 3, dated January 4, 2000 (ADAMS Accession Nos. ML003672750 and ML003672773).

39. NRC Inspection Report No. 50-237 and 249/2012008 for Dresden Nuclear Power Station, Units 2 and 3, dated April 23, 2012 (ADAMS Accession No. ML12114A356).

40. NRC letter, Eugene V. Imbro, “Comments on Joint Owners’ Group Air Operated Valve Program Document,” October 8, 1999 (ADAMS Accession No. ML020360077).

41. NRC Safety Evaluation Report, “Final Safety Evaluation on Joint Owners’ Group Program on Motor-Operated Valve Periodic Verification,” September 25, 2006, with supplement, September 18, 2008 (ADAMS Accession Nos. ML061280315 and ML082480638).

42. NUREG-1482, “Guidelines for Inservice Testing at Nuclear Power Plants.”

43. Regulatory Guide (RG) 1.100, Revision 3, “Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants,” September 2009.

44. RG 1.106, Revision 2, “Thermal Overload Protection for Electric Motors on Motor-Operated Valves,” February 2012.

45. RG 1.175, “An Approach for Plant-Specific, Risk-Informed Decision making: Inservice Testing,” August 1998.

46. RG 1.192, “Operation and Maintenance Code Case Acceptability, ASME OM Code.”

47. RG 1.200, Revision 2, “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities,” March 2009.

48. Regulatory Issue Summary (RIS) 2000-03, “Resolution of Generic Safety Issue 158, Performance of Safety-Related Power-Operated Valves under Design Basis Conditions,” March 15, 2000.

49. RIS 2001-15, “Performance of DC-Powered Motor-Operated Valve Actuators,” August 1, 2001.

50. RIS 2007-06, “Regulatory Guide 1.200 Implementation,” March 22, 2007.

51. RIS 2011-13, “Follow up to Generic Letter 96-05 for Evaluation of Class D Valves Under Joint Owners Group Motor-Operated Valve Periodic Verification Program,” January 6, 2012.

52. Special Inspection Report 05000400/2012008 (dated July 12, 2012) on the MSIV failure at Shearon Harris Nuclear Power Plant (ADAMS Accession No. ML12194A281).

53. Standard Review Plan Section 3.9.6, “Functional Design, Qualification, and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints,” Revision 3, dated March 2007.