UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

GENERIC LETTER 96-05, "PERIODIC VERIFICATION OF DESIGN-BASIS CAPABILITY OF SAFETY-RELATED MOTOR-OPERATED VALVES,"

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2 AND 3

DOCKET NUMBERS STN 50-528, 50-529 and 50-530

1.0 INTRODUCTION

Many fluid systems at nuclear power plants depend on the successful operation of motor-operated valves (MOVs) in performing their safety functions. Several years ago, MOV operating experience and testing, and research programs sponsored by the nuclear industry and the NRC, revealed weaknesses in a wide range of activities (including design, qualification, testing, and maintenance) associated with the performance of MOVs in nuclear power plants. For example, some engineering analyses used in sizing and setting MOVs did not adequately predict the thrust and torque required to operate valves under their design-basis conditions. In addition, inservice tests of valve stroke time under zero differential-pressure and flow conditions did not ensure that MOVs could perform their safety functions under design-basis conditions.

Upon identification of the weaknesses in MOV performance, significant industry and regulatory activities were initiated to verify the design-basis capability of safety-related MOVs in nuclear power plants. After completion of these activities, nuclear power plant licensees began establishing long-term programs to maintain the design-basis capability of their safety-related MOVs. This safety evaluation (SE) addresses the program developed by Arizona Public Service (APS or the licensee) to periodically verify the design-basis capability of safety-related MOVs at Palo Verde Nuclear Generating Station, Units 1, 2, and 3.

2.0 REGULATORY REQUIREMENTS

The NRC regulations require that MOVs important to safety be treated in a manner that provides assurance of their intended performance. Criterion 1 to Appendix A, "General Design Criteria for Nuclear Power Plants," to Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 50) states, in part, that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. The quality assurance program to be applied to safety-related components is described in Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50. In Section 50.55a of 10 CFR Part 50, the NRC requires licensees to establish inservice testing (IST) programs in accordance with Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code.

In response to concerns regarding MOV performance, NRC staff issued Generic Letter (GL) 89-10 (June 28, 1989), "Safety-Related Motor-Operated Valve Testing and Surveillance," which requested that nuclear power plant licensees and construction permit holders ensure the capability of MOVs in safety-related systems to perform their intended functions by reviewing MOV design bases, verifying MOV switch settings initially and periodically, testing MOVs under design-basis conditions where practicable, improving evaluations of MOV failures and necessary corrective action, and trending MOV problems. The staff requested that licensees complete the GL 89-10 program within approximately three refueling outages or 5 years from the issuance of the generic letter. Permit holders were requested to complete the GL 89-10 program before plant startup or in accordance with the above schedule, whichever was later.

The NRC staff issued seven supplements to GL 89-10 that provided additional guidance and information on MOV program scope, design-basis reviews, switch settings, testing, periodic verification, trending, and schedule extensions. GL 89-10 and its supplements provided only limited guidance regarding MOV periodic verification and the measures appropriate to assure preservation of design-basis capability. Consequently, the staff determined that additional guidance on the periodic verification of MOV design-basis capability should be prepared. On September 18, 1996, the NRC staff issued GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," requesting each licensee establish a program, or ensure the effectiveness of its current program, to verify on a periodic basis that safety-related MOVs continue to be capable of performing their safety functions within the current licensing bases of the facility. In GL 96-05, the NRC staff summarized several industry and regulatory activities and programs related to maintaining long-term capability of safety-related MOVs. For example, GL 96-05 discussed non-mandatory ASME Code Case OMN-1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor Operated Valve Assemblies in LWR [Light-Water Reactor] Power Plants, OM Code 1995 Edition; Subsection ISTC," which allows the replacement of ASME Code requirements for MOV quarterly stroke-time testing with exercising of safety-related MOVs at least once per operating cycle and periodic MOV diagnostic testing on a frequency to be determined on the basis of margin and degradation rate. In GL 96-05, the NRC staff stated that the method in OMN-1 meets the intent of the generic letter with certain limitations. The NRC staff also noted in GL 96-05 that licensees remain bound by the requirements in their code of record regarding MOV stroke-time testing, as supplemented by relief requests approved by the NRC staff.

In GL 96-05, licensees were requested to submit the following information to the NRC:

a. within 60 days from the date of GL 96-05, a written response indicating whether or not the licensee would implement the requested actions; and

b. within 180 days from the date of GL 96-05, or upon notification to the NRC of completion of GL 89-10 (whichever is later), a written summary description of the licensee's MOV periodic verification program.

The NRC staff is preparing an SE on the response of each licensee to GL 96-05. The NRC staff intends to rely to a significant extent on an industry initiative to identify valve age-related degradation which could adversely affect the design-basis capability of safety-related MOVs (described in Section 3.0) where a licensee commits to implement that industry program. The NRC staff will conduct inspections to verify the implementation of GL 96-05 programs at nuclear power plants as necessary.

3.0 JOINT OWNERS GROUP PROGRAM ON MOV PERIODIC VERIFICATION

In response to GL 96-05, the Boiling Water Reactor Owners Group (BWROG), Westinghouse Owners Group (WOG), and Combustion Engineering Owners Group (CEOG) jointly developed an MOV periodic verification program to obtain benefits from the sharing of information between licensees. The Joint Owners Group (JOG) Program on MOV Periodic Verification is described by the BWROG in its Licensing Topical Report NEDC-32719, "BWR Owners' Group Program on Motor-Operated Valve (MOV) Periodic Verification," and described by the WOG and the CEOG in their separately submitted Topical Report MPR-1807, "Joint BWR, Westinghouse and Combustion Engineering Owners' Group Program on Motor-Operated Valve (MOV) Periodic Verification." The stated objectives of the JOG program on MOV Periodic Verification are (1) to provide an approach for licensees to use immediately in their GL 96-05 programs; (2) to develop a basis for addressing the potential age-related increase in required thrust or torque under dynamic conditions; and (3) to use the developed basis to confirm, or if necessary to modify, the applied approach. The specific elements of the JOG program are (1) providing an "interim" MOV periodic verification program for applicable licensees to use in response to GL 96-05; (2) conducting a dynamic testing program over the next 5 years to identify potential age-related increases in required thrust or torque to operate gate, globe, and butterfly valves under dynamic conditions; and (3) evaluating the information from the dynamic testing program to confirm or modify the interim program assumptions.

The JOG interim MOV periodic verification program includes (1) continuation of MOV stroke-time testing required by the ASME Code IST program; and (2) performance of MOV static diagnostic testing on a frequency based on functional capability (age-related degradation margin over and above margin for GL 89-10 evaluated parameters) and safety significance. In implementing the interim MOV static diagnostic test program, licensees will rank MOVs within the scope of the JOG program according to their safety significance. The JOG program specifies that licensees need to justify their approach for risk ranking MOVs. In Topical Report NEDC-32264, "Application of Probabilistic Safety Assessment to Generic Letter 89-10 Implementation," the BWROG described a methodology to rank MOVs in GL 89-10 programs with respect to their relative importance to core-damage frequency and other considerations to be added by an expert panel. In an SE dated February 27, 1996, the NRC staff accepted the BWROG methodology for risk ranking MOVs in boiling-water reactor nuclear plants with certain conditions and limitations. In the NRC SE (dated October 30, 1997) on the JOG Program on MOV Periodic Verification, the NRC staff indicated its view that the BWROG methodology for MOV risk ranking is appropriate for use in response to GL 96-05. With respect to Westinghouse-designed pressurized water reactor nuclear plants, the WOG prepared Engineering Report V-EC-1658, "Risk Ranking Approach for Motor-Operated Valves in Response to Generic Letter 96-05." On April 14, 1998, the NRC staff issued an SE accepting with certain conditions and limitations the WOG approach for ranking MOVs based on their risk significance. Licensees not applicable to the BWROG or WOG methodologies need to justify their MOV risk-ranking approach individually.

The objectives of the JOG dynamic test program are to determine degradation trends in dynamic thrust and torque, and to use dynamic test results to adjust the test frequency and method specified in the interim program if warranted. The JOG dynamic testing program includes (1) identification of conditions and features that could potentially lead to MOV degradation; (2) definition and assignment of valves for dynamic testing; (3) testing valves three

times over a 5-year interval with at least a 1-year interval between valve-specific tests according to a standard test specification, (4) evaluation of results of each test; and (5) evaluation of collective test results.

In the last phase of its program, the JOG will evaluate the test results to validate the assumptions in the interim program to establish a long-term MOV periodic verification program to be implemented by licensees. A feedback mechanism will be established to ensure timely sharing of MOV test results among licensees and to prompt individual licensees to adjust their own MOV periodic verification program, as appropriate.

Following consideration of NRC staff comments, the BWROG submitted Licensing Topical Report NEDC-32719 (Revision 2) describing the JOG program on July 30, 1997. Similarly, the CEOG and the WOG submitted Topical Report MPR-1807 (Revision 2) describing the JOG program on August 6 and 12, 1997, respectively. On October 30, 1997, the NRC staff issued an SE accepting the JOG program with certain conditions and limitations as an acceptable industry-wide response to GL 96-05 for valve age-related degradation.

4.0 PALO VERDE GL 96-05 PROGRAM

On November 14, 1996, APS submitted a 60-day response to GL 96-05 notifying the NRC that it would review the MOV program at Palo Verde Nuclear Generating Station, Units 1, 2, and 3, to determine whether any changes were appropriate in light of the information in GL 96-05. On March 18, 1997, APS submitted a 180-day response to GL 96-05 stating that it had implemented a program to periodically verify safety-related MOVs at Palo Verde are capable of performing their safety functions. In this letter, the licensee provided a summary description of its MOV periodic verification program. In a letter dated July 19, 1998, the licensee updated its commitment to GL 96-05. On June 15, 1999, the licensee provided a response to a request for additional information regarding GL 96-05 forwarded by the NRC staff on March 17, 1999. The licensee clarified one aspect of its GL 96-05 program in a telephone conference with the NRC staff on October 6, 1999.

In its letter dated March 18, 1997, the licensee described its MOV periodic verification program, including existing preventive maintenance and static dynamic test programs and the addition of a supplemental dynamic testing program. The licensee stated that the dynamic diagnostic test program was scheduled to begin during the Unit 1 refueling outage scheduled for the spring of 1998. In its letter dated July 19, 1998, the licensee committed to continue its participation in the JOG MOV Periodic Verification Program as a member of the CEOG. The licensee reported that it would implement the program elements described in Topical Report NEDC-32719 (Revision 2) as amended by the NRC SE with an exception regarding interim MOV static test intervals. In its letter dated June 15, 1999, the licensee stated that interim MOV static diagnostic testing is conducted on a two-outage frequency (36 months) with a few justified exceptions, but none beyond 5 years. The licensee also stated that it was in the early stages of developing a formal MOV risk-ranking program.

5.0 NRC STAFF EVALUATION

The NRC staff has reviewed the information provided in the licensee's submittals describing the program to verify periodically the design-basis capability of safety-related MOVs at Palo Verde in response to GL 96-05. NRC Inspection Report 50-528, 529, 530/96-15 (IR 96-15) provided the results of an evaluation of the licensee's program to verify the design-basis capability of safety-related MOVs in response to GL 89-10. The staff closed the review of the licensee's GL 89-10 program in IR 96-15 based on verification of the design-basis capability of safety-related MOVs at Palo Verde. The staff's evaluation of the licensee's response to GL 96-05 is described below.

5.1 MOV Program Scope

In GL 96-05, the NRC staff indicated that all safety-related MOVs covered by the GL 89-10 program should be considered in the development of the MOV periodic verification program. The staff noted that the program should also consider safety-related MOVs that are assumed to be capable of returning to their safety position when placed in a position that prevents their safety system (or train) from performing its safety function; and the system (or train) is not declared inoperable when the MOVs are in their nonsafety position.

In reporting its evaluation of the MOV program at Palo Verde in IRs 95-23 and 96-15, the NRC staff did not identify any concerns with the scope of the licensee's MOV program in response to GL 89-10 and its supplements. In its letter dated November 14, 1996, the licensee did not take exception to the scope of GL 96-05. In its letter dated March 18, 1997, the licensee stated that its periodic verification program applied to MOVs in the scope of GL 89-10. The staff considers the licensee to have made adequate commitments regarding the scope of its MOV program.

5.2 MOV Assumptions and Methodologies

Licensees maintain their assumptions and methodologies used in the development of their MOV programs consistent with the plant configuration throughout the life of the plant (a concept commonly described as a "living program"). For example, the design basis of safety-related MOVs is maintained up to date, including consideration of any plant modifications or power uprate conditions.

In IR 96-15, the NRC staff reviewed the licensee's justification for the assumptions and methodologies used in the MOV program in response to GL 89-10 at Palo Verde. With certain long-term items discussed in the following section, the staff determined that the licensee had adequately justified the assumptions and methodologies used in its MOV program. The licensee's letter dated June 15, 1999, indicated ongoing activities, such as review of motor actuator output, to update its MOV program assumptions and methodologies. The staff considers the licensee to have adequate processes in place to maintain the assumptions and methodologies used in its MOV program, including the design basis of its safety-related MOVs.

5.3 GL 89-10 Long-Term Items

When evaluating the GL 89-10 program at Palo Verde, the NRC staff discussed in IR 96-15 several items of the licensee's MOV program to be addressed over the long term. In its letter dated June 15, 1999, the licensee reported on the status of those long-term GL 89-10 aspects.

In particular, the licensee reported that it had completed the reconciliation of its test data in validating the MOV design-basis performance parameters. The licensee also stated that it had revised its diagnostic test acceptance criteria to include a design-allowable unwedging thrust limit that accounts for test equipment and transducer error. The licensee reported that it applied information from the Electric Power Research Institute (EPRI) Topical Report TR-103229-V1 (dated November 1994), "EPRI MOV Performance Prediction Program - Gate Valve Model Report, Volume 1: Summary Through Appendix C," in support of its use of hydrostatic testing in lieu of dynamic flow tests to determine valve factors for certain valves. The licensee stated that EPRI Topical Report TR-103229-V1 showed close agreement between friction coefficients determined from hydrostatic tests and dynamic flow tests. More detailed and up-to-date information on the use of hydrostatic test data is provided in EPRI Topical Report TR-103244-R1 (dated October 1996), "EPRI MOV Performance Prediction Program-Implementation Guide," and the NRC SE dated March 15, 1996, on the EPRI Topical Report TR-103237-R1, "EPRI MOV Performance Prediction Program." For example, the thrust required to operate a valve can be much lower under hydrostatic conditions than under design-basis differential pressure conditions if the pressure decreases rapidly during the hydrostatic test. The maximum thrust required to open some valves under dynamic conditions has been found to occur later during the stroke than might be evidenced by a hydrostatic test. For the specific application at Palo Verde, the staff found in IR 96-15 that the valve factors derived by the licensee from the hydrostatic tests were reasonable in comparison to valve factors obtained from dynamic tests for similar valve types. Also in GL 89-10, the NRC staff identified pressure locking and thermal binding as potential performance concerns for safety-related MOVs. The NRC staff is reviewing licensee's actions in response to GL 95-07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," and will issue an SE at the completion of the review.

In IR 96-15, the NRC staff discussed qualitative and quantitative aspects of the licensee's program for trending MOV performance at Palo Verde. The NRC staff concluded that the licensee had adequately developed and implemented a comprehensive program for trending MOV performance. For example, the licensee trends static and dynamic diagnostic test data. In its letter dated July 19, 1998, the licensee stated that MOV as-found test results are evaluated on a case-by-case basis to ensure that the actuator has sufficient margin to remain operable until the next scheduled test. In its letter dated June 15, 1999, the licensee indicated that its MOV trending program monitors the results of static testing to identify long-term trends for incorporation into the MOV thrust and torque setpoints, and maintenance practices, as appropriate.

With the licensee's ongoing MOV activities and trending program, no outstanding issues regarding the licensee's GL 89-10 program remain at Palo Verde.

5.4 JOG Program on MOV Periodic Verification

In its letter dated July 19, 1998, the licensee updated its commitment to the JOG Program on MOV Periodic Verification as described in Topical Report NEDC-32719 (Revision 2) with one exception regarding the interim MOV static test interval. In the first phase of the JOG program, the JOG interim static test program establishes a test frequency ranging from every refueling outage to every six refueling outages (not to exceed 10 years) based on MOV safety significance (risk) and functional capability (margin). In its letter dated July 19, 1998, the licensee stated that the interim MOV static test program at Palo Verde provides for testing of

the MOVs in its GL 96-05 program every two refueling outages (with a few exceptions). In support of its alternate interim MOV test intervals, the licensee evaluates as-found MOV test results to ensure that the actuator has sufficient margin to remain operable until the next scheduled test. In its letter dated June 15, 1999, the licensee reported that its interim MOV static testing continues to be performed every two outages with a few justified and documented exceptions (which do not exceed 5 years). The licensee indicated that establishment of a proceduralized program for extending frequencies was awaiting completion of MOV risk ranking at Palo Verde and the availability of sufficient supporting trend data. The NRC staff finds that the interim MOV static test program proposed by the licensee at Palo Verde as an alternative to the JOG interim static test interval is acceptable, based on (1) the applicability of the alternate static MOV test intervals only to the first phase of the JOG program, (2) the limited extension of the minimal test interval from one to two outages, (3) the reduction of the maximum test interval at Palo Verde from the JOG program, (4) the ongoing evaluation of MOV test data by the licensee, and (5) the reported MOV performance history at Palo Verde.

In its letter dated June 15, 1999, the licensee stated that it is developing a risk ranking approach for the safety-related MOVs at Palo Verde based on improvements to its probabilistic risk assessment model and industry experience. The licensee's MOV risk-ranking approach will include use of an expert panel similar to the WOG methodology. The licensee also stated that the CEOG is considering cross-comparing the MOV risk rankings at CE plants. The staff might evaluate the licensee's ranking of MOVs by their risk significance during a future inspection where applied as part of the licensee's implementation of its commitment to the three phases of the JOG program.

In an SE dated October 30, 1997, the NRC staff accepted the JOG program as an industry-wide response to GL 96-05 with certain conditions and limitations. The JOG program consists of the following three phases: (1) the JOG interim static diagnostic test program; (2) the JOG 5-year dynamic test program; and (3) the JOG long-term periodic test program. The staff considers the licensee's commitment in response to GL 96-05 to include implementation of all three phases of the JOG program at Palo Verde, with the exception described above. The conditions and limitations discussed in the NRC SE dated October 30, 1997, apply to the JOG program at Palo Verde. The staff considers the commitments by the licensee to implement all three phases of the JOG program at Palo Verde to be an acceptable response to GL 96-05 for valve age-related degradation.

The JOG program is intended to address most gate, globe, and butterfly valves used in safety-related applications in the nuclear power plants of participating licensees. The JOG indicates that each licensee is responsible for addressing any MOVs outside the scope of applicability of the JOG program. The NRC staff recognizes that the JOG has selected a broad range of MOVs and conditions for the dynamic testing program, and that significant information will be obtained on the performance and potential degradation of safety-related MOVs during the interim static diagnostic test program and the JOG dynamic test program. As the test results are evaluated, the JOG might include or exclude additional MOVs with respect to the scope of its program. Although the test information from the MOVs in the JOG dynamic test program might not be adequate to establish a long-term periodic verification program for each MOV outside the scope of the JOG program, sufficient information should be obtained from the JOG dynamic test program to identify any immediate safety concern for potential valve age-related degradation during the interim period of the JOG program. Therefore, the NRC staff considers it acceptable for the licensee to apply its interim static diagnostic test program to

GL 96-05 MOVs that currently might be outside the scope of the JOG program with the feedback of information from the JOG dynamic test program to those MOVs. In the NRC SE dated October 30, 1997, the NRC staff specifies that licensees implementing the JOG program must determine any MOVs outside the scope of the JOG program (including service conditions) and justify a separate program for periodic verification of the design-basis capability (including static and dynamic operating requirements) of those MOVs.

5.5 Motor Actuator Output

The JOG program focuses on the potential age-related increase in the thrust or torque required to operate valves under their design-basis conditions. In the NRC SE dated October 30, 1997, on the JOG program, the NRC staff specifies that licensees are responsible for addressing the thrust or torque delivered by the MOV motor actuator and its potential degradation. Although the JOG does not plan to evaluate degradation of motor actuator output, significant information on the output of motor actuators will be obtained through the interim MOV static diagnostic test program and the JOG dynamic test program. Several parameters obtained during MOV static and dynamic diagnostic testing help identify motor actuator output degradation when opening and closing the valve including, as applicable, capability margin, thrust and torque at control switch trip, stem friction coefficient, load sensitive behavior, and motor current.

In IR 96-15, the NRC staff reported that the licensee monitors stem friction coefficient under static and dynamic conditions and compares these results to program assumptions. In its letter dated July 19, 1998, the licensee indicated that as-found test results are used to ensure adequate actuator output capability for safety-related MOVs at Palo Verde to perform their design-basis functions. In its letter dated June 15, 1999, the licensee stated that any MOVs found outside of their expected thrust and torque setpoint range are evaluated in accordance with station procedures to ensure that they will remain operable until the next scheduled static test. Further, the licensee noted that its MOV trending program will monitor the results of static testing to identify long-term trends, and that these trends will be incorporated into the MOV thrust and torque setpoints, and maintenance practices, as appropriate.

In Technical Update 98-01 and its Supplement 1, Limitorque Corporation provided updated guidance for predicting the torque output of its ac-powered motor actuators. In its letter dated June 15, 1999, the licensee reported that this guidance had been incorporated into the MOV setpoint calculations at Palo Verde. Further, the licensee indicated that its GL 89-10 MOVs have been evaluated for continued operability. Any MOV operability concerns that might be identified in the future will be processed in accordance with established regulatory requirements and plant-specific commitments.

In its letter dated July 17, 1998, forwarding Technical Update 98-01, Limitorque indicates that a future technical update will be issued to address the application of dc-powered MOVs. In IR 95-23, the NRC staff reported that the licensee was applying nominal rated starting torque and pullout efficiencies in evaluating the output capability of safety-related dc-powered MOVs at Palo Verde. In its June 15, 1999, letter, the licensee indicated that the guidance in Technical Update 98-01 had been applied to all GL 89-10 MOVs. In the telephone conference with the NRC staff on October 6, 1999, the licensee clarified that the recommendations of Technical Update 98-01 regarding use of pullout efficiency and a 0.9 application factor had been applied to the dc-powered MOVs in its GL 96-05 program. The industry is sponsoring a testing

program to support updated guidance for the application of dc-powered MOVs that should be made available in the near future.

The NRC staff considers the licensee to be establishing sufficient means to monitor MOV motor actuator output and its potential degradation.

6.0 CONCLUSION

The NRC staff finds that the licensee has established an acceptable program to verify periodically the design-basis capability of the safety-related MOVs at Palo Verde through its commitment to all three phases of the JOG Program on MOV Periodic Verification and the additional actions described in its submittals. Therefore, the staff concludes that the licensee is adequately addressing the actions requested in GL 96-05. As part of this review, the staff finds that the interim MOV static test program proposed by the licensee at Palo Verde as an alternative to the JOG interim static test interval is acceptable.

The NRC staff may conduct inspections at Palo Verde to verify the implementation of the MOV periodic verification program is in accordance with the licensee's commitments cited in this SE and in the NRC's SE dated October 30, 1997, on the JOG Program on MOV Periodic Verification. Such an inspection could include an evaluation of the licensee's ranking of MOVs by their risk significance where applied as part of the licensee's implementation of its commitment to the three phases of the JOG program.

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