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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

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

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

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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 U. S. Nuclear Regulatory Commission (NRC), revealed weaknesses in the design, qualification, testing, and maintenance 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.

The industry and the NRC initiated activities to verify safety-related MOV design-basis capability in nuclear power plants upon identifying weaknesses in MOV performance. After completing these activities, nuclear power plant licensees began establishing long-term programs to maintain their safety-related MOV design-basis capability. This Safety Evaluation addresses the program South Carolina Electric & Gas Company (SCE&G/licensee) developed to periodically verify safety-related MOV design-basis capability at the V. C. Summer Nuclear Station (VCSNS).

2.0 EVALUATION

2.1 Regulatory Requirements

The NRC regulations require that MOVs important to safety be treated in a manner that assures 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. Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 describes the quality assurance program to be applied to safety-related components. In Section 50.55a of 10 CFR Part 50, the

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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.

On June 28, 1989, the NRC staff issued Generic Letter (GL) 89-10 "Safety-Related Motor-Operated Valve Testing and Surveillance" in response to MOV performance concerns. The GL requested that nuclear power plant licensees and construction permit holders ensure their safety-related system MOVs were capable of performing their intended function. Utilities were to review MOV design bases, initially and periodically verify MOV switch settings, test MOVs under design-basis conditions where practicable, improve evaluations of MOV failures and necessary corrective action, and trend MOV problems. The staff requested that licensees complete the GL 89-10 program within approximately three refueling outages or 5 years from GL issuance. 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 GL 89-10 supplements providing 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 design-basis capability preservation. Consequently, the staff decided to prepare additional guidance for periodically verifying MOV design-basis capability.

On September 18, 1996, the NRC staff issued GL 96-05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves." This GL requested that each licensee establish a program, or ensure the effectiveness of its current program, to periodically verify that safety-related MOVs continue to be capable of performing their safety functions within the current facility licensing bases. In GL 96-05, the NRC staff summarized several industry and regulatory activities and programs related to maintaining safety-related MOV long-term capability. 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 Power Plants, OM Code 1995 Edition; Subsection ISTC." OMN-1 allows replacing 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 based on margin and degradation rate. The NRC staff stated In GL 96-05 that the OMN-1 method meets the GL intent 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 NRC-approved relief requests.

The NRC requested licensees to submit the following information in GL 96-05:

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

b. within 180 days from the GL 96-05 date, or upon notifying the NRC of completing GL 89-10 (whichever was later), a written summary describing the licensee's MOV periodic verification program.

The NRC staff is preparing safety evaluations on each licensee's response to GL 96-05. The NRC staff intends to greatly rely 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 inspect GL 96-05 program implementation at nuclear power plants, as necessary.

2.2 Joint Owners Group Program on MOV Periodic Verification

The Boiling Water Reactor Owners Group (BWROG), Westinghouse Owners Group (WOG), and Combustion Engineering Owners Group (CEOG) jointly developed an MOV periodic verification program in response to GL 96-05 to benefit from licensees sharing information. The BWROG describes the Joint Owners Group (JOG) Program on MOV Periodic Verification in its Licensing Topical Report NEDC-32719, "BWR Owners' Group Program on Motor-Operated Valve (MOV) Periodic Verification." The WOG and the CEOG described their program 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 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. Specific JOG program elements are as follows:

- providing an "interim" MOV periodic verification program for applicable licensees to use in response to GL 96-05
- 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
- evaluating dynamic testing program information to confirm or modify the interim program assumptions

The JOG interim MOV periodic verification program includes (1) continuing MOV stroke-time testing required by the ASME Code IST program, and (2) performing 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. Licensees rank MOVs within the JOG program scope according to their safety significance when implementing the interim MOV static diagnostic test program. 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 by relative importance to core-damage frequency and other considerations an expert panel adds. In a February 27, 1996, Safety Evaluation, the NRC accepted, with certain conditions and limitations, the BWROG methodology for risk ranking MOVs in boiling water reactor nuclear plants. In the October 30, 1997, NRC Safety Evaluation on the JOG Program on MOV Periodic Verification, the NRC indicated its view that the BWROG methodology for MOV risk ranking is appropriate for use in GL 96-05 responses. The WOG prepared Engineering Report V-EC-1658, "Risk Ranking Approach for Motor-Operated Valves in Response to Generic Letter

96-05," for Westinghouse-designed pressurized water reactor nuclear plants. The NRC issued an April 14, 1998, Safety Evaluation accepting, with certain conditions and limitations, the WOG approach for ranking MOVs based on their risk significance. Licensees who do not use the BWROG or WOG methodologies need to justify their MOV risk-ranking approach individually.

The JOG dynamic test program objectives are to determine dynamic thrust and torque degradation trends, and to use dynamic test results to adjust the test frequency and method specified in the interim program, if warranted. The JOG dynamic test program includes the following:

- identifying conditions and features which could potentially lead to MOV degradation
- defining and assigning valves for dynamic testing
- 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
- evaluating each test result
- evaluating 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, and establish a long-term MOV periodic verification program that licensees will implement. The JOG will establish a feedback mechanism 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.

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

2.3 VCSNS's GL 96-05 Program

SCE&G responded to the GL 96-05 recommendations, and described its long-term MOV periodic verification program for VCSNS in their November 7, 1996, March 13, 1997, and April 2, 1998, letters. On October 8, 1998, the licensee provided additional information on its GL 96-05 program in response to an NRC request. The NRC inspected the VCSNS facility during October 19 to 21, 1998, using Temporary Instruction (TI) 2515/140, to determine if the licensee's MOV program was consistent with their GL 96-05 commitments and satisfied GL 96-05 recommendations. The NRC documented the inspection results in its December 21, 1998, Inspection Report (IR) No. 395/98-09. SCE&G's November 2, 1998, letter indicated that it agreed to meet or exceed the JOG program described in the July 1997 Topical Report MPR-1807, Revision 2. The licensee also stated that it would justify, and notify the NRC, of any significant deviations from the JOG program in accordance with existing plant procedures and Nuclear Energy Institute guidance for commitment reduction.

The licensee established an interim static diagnostic test program as part of its MOV periodic verification program. This program helps monitor capability margin of its GL 96-05 MOVs when performing the dynamic test program to identify age-related degradation in valve performance. The static diagnostic testing frequency for each specific GL 96-05 MOV at VCSNS is based on its capability margin and risk significance. The licensee uses the JOG recommendations to define MOV margins as follows:

- an MOV with at least 10% age-degradation margin is a high-margin MOV
- an MOV with at least 5% margin, but less than 10% margin, is a medium-margin MOV
- an MOV with less than 5% margin is a low-margin MOV

This age-degradation margin is determined above the uncertainties associated with MOV calculations and measurements. The licensee also stated that they will evaluate any MOV without at least 10% margin for acceptability.

The licensee's October 8, 1998, letter described SCE&G's MOV risk ranking approach in comparison to the methodology described in WOG Engineering Report V-EC-1658. Both the licensee and WOG methods use an at-power probabilistic risk assessment (PRA) model supplemented by Expert Panel judgment for shutdown risk, external events, initiating events and containment performance. The primary difference is the threshold for risk level. SCE&G placed MOVs with a Risk Achievement Worth (RAW) greater than 1.99 (WOG assumed 10) in the high risk category, MOVs with a RAW less than 1.99 but greater than 1 (WOG assumed between 10 and 2) in the medium risk category, and MOVs with RAW equal to 1 (WOG assumed less than 2) in the low risk category. The licensee's Expert Panel reviewed the PRA categorization, as well as MOVs not modeled in the at-power PRA, to ensure that MOVs were included in appropriate risk categories. The licensee also compared the WOG's example list of risk significant MOVs to VCSNS's MOV risk categories. The licensee's plant documentation indicates that SCE&G will perform static diagnostic MOV tests as shown in Table 1.

The licensee specified the precise VCSNS MOV static diagnostic test frequency criteria as follows:

Risk Category	Low Margin	Medium Margin	High Margin
High	1 cycle	2 cycles	3 cycles
Medium	2 cycles	3 cycles	6 cycles*
Low	3 cycles	3 cycles	6 cycles**

* Rising-stem MOVs in the medium risk category with margin less than 100% will be subject to static testing once per 5 years or three refueling outages (whichever is longer). Test frequencies may not exceed 10 years.

** Test frequencies may not exceed 10 years.

The licensee also performs motor power testing of each GL 96-05 MOV approximately every 18 months to help trend MOV performance.

Table 1 SCE&G Static Diagnostic MOV Testing

Valve Type	Risk Category	Capability Margin	Test Frequency
Rising Stem	high		at least once every 5 years or three refueling outages, whichever is longer
	medium	<100 %	
		≥100 %	at least once every 10 years or 6 refueling outages, whichever is longer
	low		
Butterfly	high		at least once every 5 years or three refueling outages, whichever is longer
	medium		at least once every 10 years or 6 refueling outages, whichever is longer
	low		
Any	all	<10 %	at least once every 5 years or three refueling outages, whichever is longer

The licensee is conducting repetitive dynamic tests of two MOVs as part of its participation in the JOG dynamic test program. The licensee also plans to conduct dynamic tests on four additional MOVs for plant-specific information to help identify potential age-related degradation. SCE&G has grouped its GL 96-05 MOVs for age-related degradation using guidance provided for the JOG program based on similarities in valve design, materials, and valve application, including fluid conditions. The licensee determined that its MOVs and their applications were within the JOG program scope or would be covered by actual test data at VCSNS. The JOG will establish a long-term periodic test method and interval following the 5-year dynamic test program.

SCE&G is monitoring potential degradation in MOV motor-actuator output through static and dynamic testing. The licensee has established qualitative and quantitative trending programs to monitor MOV performance. The licensee summarizes MOV performance trends every 2 years based on review of VCSNS and industry MOV activities, and detailed review of VCSNS static and dynamic MOV test data.

2.4 NRC Staff Evaluation

The NRC staff has reviewed the information provided in licensee submittals and NRC IRs 98-09 and 97-01. The staff also addressed a GL 89-10 follow-up item in IR 98-06. The NRC staff's evaluation of the licensee's response to GL 96-05 is described below.

2.4.1 MOV Program Scope

The NRC staff indicated in GL 96-05 that licensees should consider all safety-related MOVs covered by the GL 89-10 program when developing their MOV periodic verification program. The program should 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 non-safety position.

As noted in IR 98-09, the licensee's plant documentation states that the GL 96-05 program at VCSNS includes all safety-related MOVs covered by its GL 89-10 program. VCSNS's program also includes any 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 (consistent with the current licensing bases of the plant), and the system or train is not declared inoperable when the MOVs are in their non-safety position. The staff determined that the licensee's MOV program scope is consistent with GL 96-05 recommendations.

2.4.2 MOV Assumptions and Methodologies

The NRC staff expects licensees to maintain assumptions and methodologies used in developing MOV programs for the life of the plant (a concept commonly described as a "living program"). For example, licensees will need to maintain safety-related MOV design basis up-to-date, including any changes from plant modifications or power uprates. In IRs 97-01 and 98-09, the staff evaluated 1) the licensee's justification for the assumptions and methodologies used in the MOV program, and 2) the maintenance of those assumptions and methodologies based on the licensee's review of in-plant and industry information. The NRC staff considers the licensee to have adequate processes in place to maintain the assumptions and methodologies used in its MOV program, including its safety-related MOV design basis.

2.4.3 GL 89-10 Long-Term Items

In IR 97-01, the NRC staff noted several long-term planned licensee actions to address MOV program weaknesses. These weaknesses involved assumptions for valve factor, load sensitive behavior, and stem friction coefficient in MOV calculations. The NRC documented information in IR 98-06 on the licensee's action to address MOV valve factors. The licensee stated in its October 8, 1998, letter that stem friction coefficient and load sensitive behavior continue to be monitored as part of the VCSNS GL 96-05 program. As noted in IR 98-09, the staff verified that the licensee was addressing the long-term GL 89-10 planned actions.

The NRC staff recommended in GL 89-10 that licensees should trend MOV performance on a long-term basis. As discussed in IR 98-09, the licensee is performing qualitative and quantitative MOV performance trending. They trend MOV failure and deficiency information (such as nonconformance notices and maintenance work requests), MOV diagnostic test results (including static and dynamic testing, and MOV motor power surveillance testing), and industry MOV information (such as JOG letters and vendor notices). The licensee's MOV test data trending program includes motor power/current, open/close stem friction coefficient, valve operating torque, running load/packing load, seating thrust and unseating thrust, and valve capability/margin. The licensee summarizes MOV performance trends every 2 years, based on review of VCSNS and industry MOV activities, and detailed review of VCSNS static and dynamic MOV test data. With the licensee's ongoing implementation of its MOV testing plans and trending program, no outstanding issues regarding the licensee's GL 89-10 program remain at VCSNS.

2.4.4 JOG Program on MOV Periodic Verification

The licensee described its commitment to implement the JOG Program on MOV Periodic Verification in its November 2, 1998, letter. The NRC staff's October 30, 1997, Safety Evaluation accepted the JOG program, with certain conditions and limitations, as an industry-wide response to GL 96-05. The licensee's commitment to implement the JOG program includes (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 NRC staff considers the licensee's commitments to implement the JOG program to be an acceptable response to GL 96-05 for valve age-related degradation. The licensee is responsible for reviewing and implementing the limitations and conditions discussed in the NRC's October 30, 1997, Safety Evaluation in applying the JOG program. This includes coordinating and feeding back test information obtained from the JOG dynamic testing program. The NRC expects the licensee to notify the NRC, and justify proposed alternative approaches, where the licensee proposes to implement an approach different from the JOG program.

The staff compared the licensee's interim MOV static diagnostic test program with the JOG program recommendations for test frequency based on margin and risk significance. In particular, the staff reviewed the licensee's margin and risk significance categories. The staff determined the licensee's margin categories and test schedules were similar to, and in some cases, more conservative, than the JOG recommendations. With respect to MOV risk ranking, the licensee's categorization criteria were more conservative than the WOG engineering report criteria. The staff also evaluated the licensee's MOV categorization against the WOG example list and considered the licensee to have adequately justified the differences from the WOG list. The staff considers the licensee's methodology for risk ranking its GL 96-05 MOVs to be reasonable. SCE&G plans also to perform motor power testing of each GL 96-05 MOV approximately every 18 months. This will provide additional helpful information in trending MOV performance. The staff indicated in IR 98-09 that the licensee could expand its MOV age-related degradation matrix to reference additional planned JOG tests in light of the licensee's decision to strengthen its JOG program commitment.

In IR 98-09, the staff noted that MOVs in some groups were assigned an interim static diagnostic test interval of 10 years or 6 refueling outages. However, the licensee's testing matrix did not specify that they would obtain data over the first 5-year interval to provide confidence in MOV performance over the full 10-year interval (as discussed in the October 30, 1997, NRC JOG program evaluation). The licensee agreed that, for MOV groups with test intervals beyond 5 years, testing needed to be scheduled to provide information on similar MOV performance during the first 5-year interval.

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 JOG program scope of applicability. In the NRC's October 30, 1997, Safety Evaluation, the NRC staff specifies that licensees implementing the JOG program must identify any MOVs outside the the JOG program scope (including service conditions) and justify a separate program to periodically verify the design-basis capability of those MOVs. The NRC staff recognizes that the JOG has selected a broad range of MOVs and conditions for the dynamic testing program. Consequently, the NRC staff expects that utilities will obtain significant information on safety-related MOV performance and potential degradation during the interim static diagnostic test program and the JOG dynamic test program. The JOG might include or exclude additional MOVs with respect to its program scope as the test results are evaluated. The MOV test information from the JOG dynamic test program might not be adequate to establish a long-term periodic verification program for each MOV outside of the JOG program scope. However, 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 SCE&G to apply its interim static diagnostic test program, along with the feedback of information from the JOG dynamic test program, to GL 96-05 MOVs that currently might be outside the JOG program scope. As discussed in IR 98-09, the licensee has determined that, at this time, its MOVs and their applications are within the scope of the JOG program or will be covered by actual test data at VCSNS. The NRC expects the licensee to establish a long-term MOV periodic verification program for those MOVs outside the scope of the JOG program. To do this, licensees should apply information from the JOG program or additional dynamic tests, as necessary, upon completing the JOG dynamic test program and development of the JOG long-term MOV periodic verification criteria.

2.5.5 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's October 30, 1997, JOG program Safety Evaluation, the NRC staff specifies that licensees are responsible for addressing MOV motor-actuator thrust or torque and their potential degradation. Although the JOG does not plan to evaluate motor-actuator output degradation, 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.

The licensee described actions in plant documentation for monitoring degradation of parameters affecting MOV motor-actuator output. The licensee is monitoring potential MOV motor-actuator output degradation at VCSNS through static and dynamic testing as noted in IR 98-09 and the licensee's October 8, 1998, letter. The licensee established a computerized trending program to monitor changes in several MOV parameters that could indicate MOV motor-actuator output degradation. These parameters included the following:

- valve factor/capability margin
- stem friction coefficient when opening and closing the valve under static and dynamic conditions
- stem loads, motor running current and power during opening and closing the valve
- load sensitive behavior

To date, the licensee has not identified any appreciable actuator degradation.

Limitorque Corporation's Technical Update 98-01 and its Supplement 1 provided updated guidance for predicting the torque output of its motor actuators. As discussed in IR 98-09, SCE&G revised the design-basis capability of the VCSNS rising-stem GL 96-05 MOVs to address the new information on motor-actuator output. The licensee implemented the motor-actuator output methodology developed by Commonwealth Edison Company (ComEd) to accomplish this. As noted in NRC IRs, the NRC staff has accepted the use of the ComEd methodology for estimating MOV motor-actuator output capability, based on test data obtained by ComEd. The NRC expects SCE&G to address any changes in the ComEd methodology that might result from the Limitorque updated guidance. As indicated in IR 98-09, the licensee had established a plan to revise its GL 96-05 butterfly valve calculations to incorporate the new Limitorque guidance, and had determined that the affected MOVs had acceptable capability.

Limitorque reported in Technical Update 98-01 and its Supplement 1 that it will issue a future technical update to address dc-powered MOV applications. At VCSNS, the licensee reported that they do not currently use dc-powered MOVs in safety-related applications.

The NRC staff considers the licensee to have established sufficient means to monitor MOV motor-actuator output and its potential degradation. As discussed in IR 98-09, the licensee plans to strengthen its documentation of the process for trending potential MOV motor-actuator output degradation for static and dynamic conditions. This includes considering as-found and as-left test data, and changes in stem friction coefficient and load sensitive behavior.

3.0 CONCLUSIONS

On the basis of this evaluation, the NRC staff finds that the licensee has established an acceptable program to periodically verify safety-related MOV design-basis capability at VCSNS. Therefore, the staff concludes that the licensee has adequately addressed the actions requested in GL 96-05. The NRC staff may conduct inspections to verify MOV periodic verification program implementation in accordance with the licensee's commitments, this NRC Safety Evaluation, and the NRC's October 30, 1997, Safety Evaluation on the JOG Program on MOV Periodic Verification.

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