UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO INSERVICE TESTING PROGRAM REQUESTS FOR RELIEF

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

SALEM NUCLEAR GENERATING STATION, UNITS 1 AND 2

DOCKET NOS. 50-272 AND 50-311

1.0 INTRODUCTION

Title 10 of the Code of Federal Regulations, Part 50.55a (10 CFR 50.55a), requires that inservice testing (IST) of certain American Society of Mechanical Engineers (ASME) Code Class 1, 2, and 3 pumps and valves be performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code (the Code) and applicable addenda, except where relief has been requested and granted or proposed alternatives have been authorized by the Commission pursuant to 10 CFR 50.55a(f)(6)(i), (a)(3)(i), or (a)(3)(ii). In order to obtain authorization or relief, the licensee must demonstrate that: (1) conformance is impractical for its facility; (2) the proposed alternative provides an acceptable level of quality and safety; or (3) compliance would result in a hardship or unusual difficulty without a compensating increase in the level of quality and safety. Section 50.55a(f)(4)(iv) provides that inservice tests of pumps and valves may meet the requirements set forth in subsequent editions and addenda that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed, and subject to Commission approval. NRC guidance contained in Generic Letter (GL) 89-04, "Guidance on Developing Acceptable Inservice Testing Programs," provided alternatives to the Code requirements determined to be acceptable to the staff and authorized the use of the alternatives in Positions 1, 2, 6, 7, 9, and 10 provided the licensee follows the guidance delineated in the applicable position. When an alternative is proposed which is in accordance with GL 89-04 guidance and is documented in the Inservice Testing Program (IST), no further evaluation is required; however, implementation of the alternative is subject to NRC inspection.

Section 50.55a authorizes the Commission to grant relief from ASME Code requirements or to approve proposed alternatives upon making the necessary findings. The NRC staff's findings with respect to granting or not granting the relief requested or authorizing the proposed alternative as part of the licensee's IST program are contained in this safety evaluation (SE).

2.0 BACKGROUND

The NRC discussed its evaluation of the IST Program (Revision 2) by Public Service Electric and Gas Company, licensee for the Salem Nuclear Generating Station, Units 1 and 2, in SEs dated October 9, 1992, and April 15, 1994. In those documents, the NRC granted relief from

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the ASME Section XI test method requirements for the following safety injection (SI) accumulator outlet check valves in Salem Units 1 and 2:

11SJ55	12SJ55	13SJ55	14SJ55
21SJ55	22SJ55	23SJ55	24SJ55
11SJ56	12SJ56	13SJ56	14SJ56
21SJ56	22SJ56	23SJ56	24SJ56

During an IST inspection at Salem in December of 1996, the NRC staff found that the licensee was using a calculation method together with a partial accumulator dump test to verify that each check valve disk was exercised to its full accident position. The inspectors could not initially determine whether the licensee's test method was in accordance with the guidance provided in GL 89-04, Position 1, for full flow testing of check valves. Further discussion with the licensee concluded that non-intrusive testing during the partial accumulator dump test was used only for preventative maintenance and not for inservice test acceptance. Therefore, based on the fact that disk position was not directly determined and the valves did not pass the maximum accident flow in accord with GL 89-04, Position 1, an approved relief request was required to use the current test method.

In a letter dated December 26, 1996, the licensee submitted a proposed revision to the IST Program for Salem containing proposed Valve Relief Requests V-24 and V-25 to address the above concern. This relief was granted on an interim basis by the staff in a letter dated February 13, 1997, until the next refueling outage to allow the staff time to perform a more detailed evaluation of the licensee's calculation method. The staff issued a request for additional information (RAI) in a letter dated September 10, 1998, concerning in part, the applicability of a specific equation in the licensee's analysis and the margin applied to the calculated result. The licensee responded to the staff's RAI in a letter dated November 2, 1998.

Because Relief Requests V-24 and V-25 are proposing the same alternative testing, a single evaluation will be provided for both relief requests. The code of record for Salem Units 1 and 2 IST program for pumps and valves is the 1983 Edition of ASME Section XI through the Summer 1983 addenda.

3.0 VALVE RELIEF REQUESTS V-24 AND V-25

Check valves 1SJ55, 2SJ55, 3SJ55 and 4SJ55 for Units 1 and 2 (eight total check valves) are located in the discharge lines from the SI accumulators. The valves must be capable of opening during a large-break loss-of-coolant accident (LOCA) to provide a flow path for the safety injection (SI) accumulator discharge to the reactor coolant system (RCS) cold legs. The valve must be capable of closure to prevent divergence of safety injection and recirculation flow after accumulator discharge. The valve also serves as an RCS pressure isolation valve by preventing exposure of the SI accumulators to RCS pressure.

Check valves 1SJ56, 2SJ56, 3SJ56 and 4SJ56 for Units 1 and 2 (eight total check valves) are located in the discharge lines from the SI accumulators downstream of the branch connection from the residual heat removal (RHR) system. The valves must be capable of opening during a large break LOCA to provide a flow path for the SI accumulator discharge to the RCS cold legs. The valves must also be capable of opening to provide a path for low head safety injection and cold leg recirculation flow. The valves also serve as RCS pressure isolation valves by preventing exposure of the SI accumulators and RHR system piping to RCS pressure.

All 16 check valves are ASME Class 1 Category AC. The licensee requests relief from the requirements in Section XI, Subsection IWV-3521, which requires that check valves be exercised at least once every 3 months. In addition, subparagraph IWV-3522(b) requires that normally-closed check valves whose function is to open on reversal of pressure differential shall be tested when the closing differential pressure is removed and flow through the valve is initiated. Relief from the exercise procedure requirements of IWV-3522(b) will also be evaluated because the licensee's test method does not appear to be in accord with either the Code requirement or the staff's guidance in GL 89-04, Position 1. The licensee has proposed to use a partial accumulator dump test with an acceptance criterion developed by a calculation method every refueling outage for all 16 valves.

3.1 Licensee's Basis for Requesting Relief

3.1.1 Relief Request V-24

The licensee states:

> During power operation, these valves are maintained in the closed position by RCS pressure on the downstream side of the valve disk. Quarterly exercising these valves to the full or partially open position during power operation is impracticable because the only flow path is into the RCS. The operating accumulator pressure cannot overcome normal operating RCS pressure to establish flow. Full stroke exercising these valves at cold shutdown is impracticable because of the potential for low temperature overpressurization due to insufficient expansion volume in the RCS to accept required flow. This testing could also result in the intrusion of nitrogen into the core which could interrupt the normal circulation of cooling water flow. Partial stroke exercising these valves going into cold shutdown is burdensome without a commensurate increase in the level of quality and safety. The associated motor-operated isolation valve (one per accumulator) cannot be partially stroked, but must complete a full stroke before changing direction. This could cause a complete discharge of the water volume in the accumulator and possibly inject nitrogen into the reactor coolant system, causing gas binding of the residual heat removal pumps and a subsequent loss of shutdown cooling. These valves are also verified to close by leak testing per plant technical specifications for Pressure Isolation Valves (PIVs). Reverse exercising these check valves at any time other than refueling is burdensome without a commensurate increase in the level of quality and safety. The valves are normally in the closed position and accumulator pressure is continuously monitored to ensure that an adequate nitrogen blanket is maintained and to verify the lack of RCS inleakage.

3.1.2 Relief Request V-25

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3.2 Proposed Alternate Testing

3.2.1 Relief Request V-24

The licensee proposes:

> These check valves shall be full stroke exercised to the open position during refuelings utilizing a reduced pressure, partial accident flow test method. This controlled method is performed with the reactor vessel head removed. The test method establishes accumulator pressure between 67 and 70 psig, accumulator level between 96 and 100% and refueling cavity level between 125.5 and 126.5 feet. After establishment of the fixed parameters the test then measures the time interval required for the pressure in the associated safety injection accumulator to drop from an initial pressure to 35 psig. Engineering calculation S-2-SJ-MDC-1394 - "Accumulator Pressure Decay during Discharge Testing" establishes the test conditions and acceptance criteria and concludes that this methodology is adequate in determining that the associated check valve disk moves to the full open position. Information from other nuclear stations was reviewed regarding partial flow, full stroke exercising using a calculational method. The testing performed at Salem provides a valid methodology for verifying the open function even though the test method differs from the various methods reviewed.

In attempting to utilize the guidance of NUREG 1482, Section 4.1.2 - "Exercising Check Valves with Flow and Nonintrusive Techniques," nonintrusive equipment was used during informational testing. These valves are Darling Valve & Manufacturing Co. "Clear Waterway" swing checks that are fabricated without a backstop. The valve design permits the disk to move sufficiently out of the flow path without contacting the valve body. Nonintrusive testing using acoustic and magnetic technology provides sufficient data for monitoring degradation on a periodic basis however, full open acoustic indication is not detected or expected to show on the test trace. Nonintrusive testing does not verify full stroke exercising however occasional use of this equipment during the pressure decay test provides useful condition monitoring information.

This method of forward flow check valve testing complies with the guidance provided in Generic Letter 89-04, Attachment 1, Position 1.

Regarding reverse flow exercising testing, these valves shall be verified in the closed position during the process of performing seat leakage testing at the frequency specified in Unit 1 Technical Specifications (TS) 4.4.6.3 and Unit 2 TS 4.4.7.2.2. [The licensee subsequently indicated that the Unit 1 SJ55 check valves are not listed in the Unit 1 TS, but are leakage tested in accordance with plant procedures and will be incorporated into the Unit 1 TS before plant startup from its current outage.]

The open stroke frequency change was previously approved in NRC Safety Evaluation April 15, 1994.

3.2.2 Relief Request V-25

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The valves shall be partial stroke exercised at cold shutdown during normal RHR shutdown cooling operations.

This method of forward flow check valve testing complies with the guidance provided in Generic Letter 89-04, Attachment 1, Position 1.

Regarding reverse flow exercising testing, these valves shall be verified in the closed position during the process of performing seat leakage testing at the frequency specified in Unit 1 TS 4.4.6.3 and Unit 2 TS 4.4.7.2.2.

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3.3 <u>Evaluation</u>

IWV-3521 requires that each check valve be exercised every 3 months. IWV-3522 states that when it is not practical to exercise these valves quarterly, they may be exercised during cold shutdowns. Full-stroke exercising of these check valves during power operation is not practicable because the RCS is at a higher pressure than the SI accumulators. During cold shutdowns, the RCS lacks adequate expansion volume to accommodate the required flow and a low temperature overpressure condition could result. These valves could only be full-stroke exercised quarterly or during cold shutdowns if extensive system modifications were performed, such as installing full-flow test loops. The alternative test frequency to exercise these valves each refueling outage is approved pursuant to 10 CFR 50.55a(f)(iv)(4) because the latest edition of the Code incorporated by reference in the regulations (the 1989 Edition of ASME Section XI) allows testing which is impractical on a quarterly frequency and at cold shutdowns to be deferred to refueling outages.

The exercise procedure requirements of IWV-3522(b) state that normally-closed check valves whose function is to open on reversal of pressure differential shall be tested when the closing differential pressure is removed and flow through the valve is initiated. Confirmation of the disk moving away from the seat shall be by visual observation, position indication, system flow, or other positive means. GL 89-04, Position 1, states that a check valve's full stroke to open is valid when a known flow rate is passed through the valve which exceeds the maximum flow rate. The accumulator check valves cannot pass the maximum accident flow through the check valves at any plant condition. These valves are not equipped with a mechanical exerciser or position indication device. In addition, the licensee stated that these valves do not have a backstop and therefore non-intrusive testing does not verify that the valve has moved to its full stroke open position. Therefore, it is impractical for the licensee to meet the Code exercise procedure requirements.

The licensee has proposed to use a timed partial accumulator dump test to verify that each pair of accumulator check valves is exercised to the position required to fulfill its safety function. The acceptance criterion, which is the actual time the accumulator is allowed to decay from 70 psig to 35 psig, was developed by a calculation method and validated through testing. The NRC staff has stated that use of a combination of test and analyses to verify check valve forward exercising meets the intent of the ASME Code requirements for similar check valve applications at other facilities. A detailed review of the licensee's method was performed and revealed one distinct difference in the Salem method from methods used by other licensees which is discussed below.

Each Salem unit has four accumulators which are designed to inject water into the reactor core through the RCS cold legs when the RCS pressure decreases below the accumulator pressure. The flow of water out of the accumulator will pass through the open motor-operated gate valve (SJ54) and two check valves, the accumulator isolation check valve (SJ55) and the combined safety injection header check valve (SJ56). The flow is then directed into the reactor vessel through the cold leg. During the partial accumulator dump test, the flow path is the same with the discharged accumulator water either increasing the level in the reactor cavity or the vented pressurizer, depending on whether the reactor head is off or on. The licensee has modeled both configurations in its analysis.

The licensee's calculation method is a one-dimensional analysis of the motion of both check valve disks, flow of water from the accumulator to the reactor vessel including accounting for resistance from valves and piping, change in nitrogen pressure of the accumulator, and the effect on the water level in the accumulator and reactor vessel or pressurizer (depending on the analysis). A series of equations were derived and solved simultaneously in a computer program. Accumulator pressures as a function of time for various check valve maximum swing angles (angle of check valve disk in flow stream) were plotted. Discharge flow rate as a function of time was also plotted for various disk angles. Results showed that when the check valve disk was free to move (full open), the time for the accumulator pressure to decay from 70 psig to 35 psig was 24 seconds. As the maximum swing angle of the check valve disk was decreased, the time to decay to 35 psig increased. Table 4.2 of the licensee's calculation package shows that at a maximum swing angle of 60 degrees, the time for the accumulator discharge pressure to decay from 70 psig to 35 psig is approximately 28.5 seconds. Table 4.3 shows that the decay time increases to approximately 40 seconds when the swing angle is reduced to 30 degrees.

The staff's RAI questions asked, in part, for the licensee to specify the degree of swing angle for each check valve disk for it to perform its safety function and to justify the validity for using an equation referenced in the Electric Power Research Institute's Application Guide for Check Valves (EPRI Report Number NP-5479 dated January 1988) for the minimum flow velocity required to maintain the check valve disk in the full open position (V_{min}). The licensee stated that the V_{min} equation was used in order to back calculate the valve disk angle and that the actual V_{min} was provided by valve manufacturer and for this valve, was 20 feet per second (fps). The licensee did not state specifically that the valve was required to travel to the full open position to meet the Code exercise requirements, but the staff inferred that this was the case because the licensee used a minimum flow velocity in its analysis to keep the valve in a full open position. This full open angle is stated by the licensee to be 72.4 degrees. Because the valve does not have a back stop, this angle is the point where the fluid force on the disk assembly is equal to the weight of the disk. The actual travel of the valve disk is assumed to be greater than 72.4 degrees.

The assumption that the V_{min} of this valve is constant as defined by the manufacturer is key to the validity of the analysis. A V_{min} equal to 20 fps assumes that the valve is in good operating condition at the time of the test. This has been verified by the licensee in recent valve inspections. However, over time, there is a potential for this value to change for each check valve as the condition of each check valve changes. The licensee's test methodology does not account for this change. The partial accumulator dump test is attempting to demonstrate that each check valve disk reaches its open safety position. If the check valve condition degrades by corrosion or an obstruction, it is assumed that the velocity to maintain the check valve disk in the full open position would increase. Therefore, the licensee's calculation assumptions would no longer be applicable and the analysis method would be invalid to describe the condition of the valve.

Even though the calculation method will only provide a valid representation of the check valve disk motion when the valve is in good operating condition, using this method to establish an acceptance criterion is an acceptable alternative to the Code requirements because as the condition of the valve degrades, or the valve is obstructed, the accumulator decay time from 70 psig to 35 psig should increase. Results of the calculation method indicated that the time for the accumulator pressure to degrade from 70 psig to 35 psig after the accumulator isolation gate valve opened was 24 seconds. Salem performed a partial dump test on all accumulators in both units to validate its calculation method. For Unit 1, the maximum pressure decay time recorded was 23.9 seconds. Three of the four accumulator dump tests on Unit 2 were just below 24 seconds. The test data validate the calculation results for valves in good operating condition. One test on Unit 2 resulted in a pressure decay time of 27.1 seconds which was attributed to a gate valve failing partially open during testing.

The licensee assigned a final acceptance criterion of 27.5 seconds. This 3.5 second margin over the calculated value of 24 seconds was not justified in the licensee's calculation package. Question 3 of the staff's RAI asked the licensee to describe the basis for the pressure decay time acceptance criterion of 27.5 seconds and how was it confirmed that this decay time would ensure that the check valve achieved its safety position. The licensee responded by stating that the 27.5 second pressure decay time had a corresponding maximum flow rate through the system of 4400 gpm which is greater than the minimum flow of 3537 gpm (corresponding to V_{min}

equal to 20 fps) and therefore, is acceptable. The minimum flow number assumes that the valve is in good operating condition, as stated above. For valves which experience some form of degradation or are partially obstructed, the number is not valid and therefore, the licensee's claim that the maximum flow will be 4400 gpm is not substantiated because it assumes that the valves are in good operating condition.

In examining the calculation results and test data, the margin appears to have been established at the current value either arbitrarily or to provide additional margin to ensure an acceptable test result even with a failure of the SJ54 gate valve to open completely as was experienced during validation testing. However, a 27.1 second decay time could also be equated to one or both check valves not reaching their full open position. Because the analysis results indicated that the decay time of a valve with a maximum swing angle of 60° was approximately 28.5 seconds and the decay time of a valve with a maximum swing angle of 72.4° is 24 seconds, it appears that the 27.5 second acceptance criterion does not bound the analysis and test data. If the test with a 27.1 second decay time is considered to represent a partially open check valve (or check valves), and the calculational method for a check valve with a 60° swing angle is valid, then this test demonstrates that the decay time remains sensitive to disk angle position between 72.4° and 60°. Because the licensee cannot verify disk position, the acceptance criterion cannot be considered to bound the test and analysis results. The license did not conduct studies to determine the sensitivity of the analysis between disk angles of 72.4° and 60°. Therefore, to bound the available test and analysis data, the staff requires pursuant to 10 CFR 50.55a(f)(6)(i) that the acceptance criterion must be changed to 27.0 seconds. This value allows operator flexibility in data collection while ensuring that the valve achieves its full-stroke exercise as required by the Code.

Another concern with the licensee's proposed alternative is the extent that corrective action is pursued when a test exceeds its acceptance criterion. Because of the system configuration, both the SJ55 and SJ56 check valves are tested during each partial accumulator dump test. The licensee has not explicitly stated in their proposed testing for both relief requests that when the acceptance criterion is exceeded, both check valves associated with the specific accumulator will be subject to corrective action. The staff requires pursuant to 10 CFR 50.55a(f)(6)(i) that the licensee must revise both relief requests to include this condition.

The licensee's test method of using a calculation does not meet the Code requirements because it does not verify directly that the check valve has moved to its safety position or passed the required accident flow rate. The licensee's test methodology does not meet the intent of the language "other positive means" as stated in Paragraph IWV-3522(b) of the Code. However, the calculation method is used to establish an acceptance criterion when the valve is performing acceptably. This calculation method is validated by performance data when the valve is known to be in acceptable operating condition. The licensee's proposed alternative testing, with the above conditions imposed by the staff, provides reasonable assurance of operational readiness because the calculation method is validated by test results, the acceptance criterion bounds the test data and analysis, and corrective action will be applied to both check valves associated with each test when the acceptance criterion is exceeded.

3.4 Summary

The licensee's proposed alternative to the Code test frequency requirements of IWV-3521 and IWV-3522 of testing each check valve every refueling outage is approved pursuant to 10 CFR 50.55a(f)(4)(iv) because the proposed alternative frequency meets the test frequency requirement in the 1989 edition of ASME Code, Section XI which is the latest edition of the Code incorporated by reference in the regulations.

Provisional relief from the exercise procedure requirements of IWV-3522(b) to use a partial accumulator dump test to verify that the check valve is exercised to its safety position is granted pursuant to 10 CFR 50.55a(f)(6)(i) based on the impracticality of performing testing in accordance with the Code requirements, and in consideration of the burden on the licensee if the Code requirements were imposed on the facility. The relief is granted provided the licensee adjusts its acceptance criterion to 27.0 seconds and stipulates in the relief request that if the acceptance criterion is exceeded, both the SJ55 and SJ56 check valves of the associated accumulator will be subject to corrective action.

4.0 CONCLUSION

The NRC staff concludes that the relief requests, as evaluated in this SE with stated conditions, will provide reasonable assurance of operational readiness of the subject check valves on a permanent basis. The staff has determined that granting relief requests and approving later editions and addenda of the Code pursuant to 10 CFR 50.55a(f)(6)(i) and (f)(4)(iv) respectively, are authorized by law and will not endanger life or property, or the common defense and security and are otherwise in the public interest. In making a determination of impracticality, the staff has considered the burden on the licensee if the requirements were imposed.

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