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Director, Office of Nuclear Reactor Regulation
Attention: G. E. Lear, Director
PWR Project Directorate No. 1
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket No. 50-206
Safety Injection System Modifications
San Onofre Nuclear Generating Station
Unit 1

References: A. Letter, K. P. Baskin, SCE, to D. M. Crutchfield, NRC, dated October 16, 1981

B. Letter, M. O. Medford, SCE, to G. E. Lear, NRC, dated October 14, 1986

In 1981 San Onofre Unit 1 experienced the common mode failure of the hydraulically operated safety injection pump discharge valves. The event was extensively investigated and design modifications performed. A report on the failure, a description of modifications and testing, and a commitment to study long term design changes was provided by Reference A. In Reference B, SCE indicated that modifications identified as a result of the study were not cost beneficial and that the modifications were being cancelled. We also indicated in the enclosure to that letter that we would be providing further details. Enclosed is a report on SCE's decision to cancel this design modification.

Our action is based on several factors. We recognize the significance of the 1981 failure and have studied the problem exhaustively. We believe the problem has been fully identified, is well understood and has been demonstrated resolved by startup and interim testing. We have also examined alternatives intended to simplify the Safety Injection System design. While each of the designs studied has some merit, they would all be very costly. Therefore, in order to gauge the real need for further design modifications, and to determine what would be the best option, we performed a value-impact analysis. Enclosed is an evaluation of the factors leading to

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our original decision to modify SIS design and also a report on the value impact analysis evaluating selected design options. The analysis confirmed that modifications are not cost beneficial and no modifications are warranted.

I would be pleased to have you or your staff discuss this matter further if required.

Very truly yours,

M. D. Medford

Enclosures

(Enclosure 1)

EVALUATION OF COMMITMENT FOR MODIFICATION TO THE SAFETY INJECTION SYSTEM SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

December 1986

Introduction

The SONGS 1 Safety Injection System (SIS) suffered a common mode failure of hydraulic actuated pump discharge valves in September 1981. As a result of the failure, several system modifications were implemented, extensive startup testing was performed, an interim surveillance program was established and a commitment to replace the valves and perform a study of SIS design was made. Since the valve failures and making of these commitments in 1981, the original problem and potential design modifications have been further evaluated. This document summarizes the work that has been done on the SIS and concludes that further design modifications are not warranted.

Background

The SONGS 1 SIS is designed as a shared system with the dual train Main Feedwater System. (For additional descriptive information, see Section 3 of the enclosed report, "A Comparative Reliability Based Value-Impact Assessment of Proposed Modifications to the Safety Injection System.") During a safety injection event, the large Main Feedwater Pumps switch from supplying condensate to the steam generators to supplying borated water to the Reactor Coolant System. The switch is performed by the sequencing of eight valves (four on each train) which terminate the flow of condensate and align to establish the flow of borated water. Prior to the addition the Standby Power Addition Project, these valves were operated by motor operators. When the Standby Power Addition was added, SCE modified the SIS to be able to be powered by new large capacity diesel generators and changed the motor operators on the valves to fast acting stored energy hydraulic actuators. This allowed much quicker sequencing of the valves which was required due to time lost when the potential stopping of the feedwater pumps due to loss of offsite power was considered in the accident analysis. It is two of these hydraulically actuated valves which failed in 1981.

Cause of 1981 Valve Failures

As detailed in Section 3 of Reference 1, SCE extensively investigated the Common mode valve failures during the outage which followed the event. The investigation included a review of the past operation and maintenance of the valves (in order to determine if improper maintenance was performed or to detect a trend which would point to the cause -- see Section 3 and Appendix 1 to Reference 1); a test program prior to making any modifications (to help simulate the failure and accumulate additional data -- see Section 3 and Appendix 2 to Reference 1) and a study of the design of the valves including system operating parameters (to determine if design/application errors may had been made -- see Section 3 and Appendix 3 to Reference 1).

The result of this investigation was the identification of three contributing factors to the common mode valve failures:

1) Galling of the valve seats,
2) Double drag of the valve discs, and
3) Use of a marginal coefficient of friction for the sizing of the valve hydraulic actuators.

Corrective Measures Implemented

Once these causes had been determined, an extensive corrective program was implemented. The program had the following objectives:

1. Reduce the differential pressure across the valve disc faces to lower the average contact stress and thus give margin to valve actuator opening force.

2. Eliminate the internal pressure in the valve body to preclude the possibility of double disc drag.

The more significant modifications accomplished to assure the capability of the SIS to perform as required include:

1. Resequencing of the SIS to incorporate a trip of the feedwater pumps at the initiation of the event, a restart of the pumps after 11 seconds and the addition of a notch and hole in the pump discharge check valves. These modifications allow the discharge pressure to decay such that the differential pressure across the valves, at the time of valve actuation, is not the shutoff head of the pumps. (The pump trip was added only for the SIS event without loss of offsite power (LOP) since the SIS/LOP event sequencing already incorporated this pump stopping.)

2. MOV's 850-A, B and C opening start time was delayed 11 seconds. This delay assures a redundant barrier (with the downstream check valves on each line) to assure RCS pressure does not cause excessive force across the valve discs.

3. Installation of valve body cavity vents on the SIS pump suction and pump discharge hydraulically actuated valves. These valve body vents assure that the pressure internal to the valves does not force both valve faces to seat. Thus, only the force required to overcome the friction of one valve disc would be required.

Details regarding these and other minor modifications are found in Reference 1.

Pre-Operational and Interim Surveillance Testing

Because there was more than one contributor to the valve failures and in order to demonstrate the success of the modifications, an extensive return-to-service testing program was implemented. This program demonstrated the short

term success of the modifications but left open the issue of "long-term set" between the valve discs and the valve seats. An interim valve testing program was proposed by SCE in Reference 2 to verify that adequate valve actuator margin existed to account for long-term set.

This valve testing program was designed to simulate as closely as possible the actual equipment operating conditions that would be experienced during a safety injection event. To provide continuing verification of the success of the modifications, a frequency of one every 92 days was selected for this testing program. By Reference 6, SCE has proposed a long-term surveillance program to further assure valve operability.

The above testing, both pre-operational and interim surveillance, far exceeded the ASME Code required testing typically done at a plant to demonstrate the acceptability of a system. The tests also provided valuable additional information which verified the success of the system modifications.

Commitments Made Prior to Return-to-Service

In Reference 1, SCE indicated that an evaluation would be initiated to replace the hydraulically operated valves and that a study of SIS design and performance would be conducted. This was recognized in the NRC's SER approving the interim surveillance testing program (Reference 3).

Evaluations of Safety Injection System Design and Performance

SCE has conducted several studies of SIS design and performance. These studies have evaluated the existing design, have identified alternative designs and have attempted to determine the real need for any modifications.

The first study conducted after return-to-service and was ongoing while SCE was procuring replacement for the valves which had failed was an investigation of options for improving SIS design. The result of this evaluation was the identification of a modification to add new feedwater pumps, thus dedicating the existing pumps to the SI function. The Reference 4 letter provided the NRC with SCE's plans to cancel the order for replacement valves and to proceed with the installation of new feedwater pumps. It was stated in the enclosure to that letter that the objective of the SIS redesign was to minimize the reliance on extensive sequencing of the SIS hydraulic valves. The stated design would accomplish that purpose. However, following return-to-service from the extensive 1982 seismic backfit outage, SCE decided to reanalyze the system design and to evaluate the earlier conclusions.

There have been five studies performed during the time period between the seismic outage return-to-service and present. These are as follows:

1. Contractor evaluation to revalidate 1982 assumptions used in selecting new feedwater pumps option and to reevaluate alternatives.

2. SCE internal study to evaluate additional modification option which takes into account margin in ECCS analysis.

3. Contractor preliminary engineering study to confirm cost estimates and feasibility of most desirable system modifications.

4. Contractor study of reliability improvements attributable to modified designs.

5. Consultant evaluation of success of interim modifications.

The first study was commissioned in order to consider whether all assumptions made in performing the 1982 work were still valid -- especially considering the extensive work performed during the extended 1982 outage. Better cost estimates and more detailed conceptual design information on the alternatives was developed. The result of the study was the identification of the possibility of modifications other than the addition of new feedwater pumps.

At the same time, a study was being conducted within SCE to evaluate other design options which would take advantage of the margin in the SONGS 1 ECCS analysis. This study specifically evaluated the possibility of replacing the HV's with slower MOV's. The additional time it would take to deliver borated water to the RCS would be made available by changes in the ECCS analysis and possible Technical Specification changes.

When these studies were completed, it was concluded that none had a clear advantage over the others and that a value-impact study should be performed. The value impact study, performed using Probabalistic Risk Assessment (PRA) techniques, evaluated each of several design options to determine the impact on the system. A report on the results of the study is attached. A major conclusion of the report is that SONGS 1 as designed is acceptable under LOCA demand conditions. The report evaluated two options in detail. The first was the addition of a new Safety Injection System which would eliminate the need for valve sequencing. (Since this option would be similar to the new feedwater pumps option, it also represents it in the reliability comparisons.) The second option considered was the addition of new motor operated valves in the place of the hydraulically operated valves. Using conservative assumptions, the study concluded that the modifications would have the following comparative reliabilities:

Modification	Mean Unavailability (per demand)
Existing Design	5.64×10^{-3}
MOV Replacement Design	4.87×10^{-3}
Dedicated SI Option	1.57×10^{-3}

The value of each of these modifications was calculated using the proposed NRC safety goal guideline of \$20,000 per 1.0×10^{-5}/year reduction in core melt frequency. These values were then compared with the estimated cost of each modification to give the following value-impact ratios. A value of less than 1.0 indicates a negative value impact.

Modification	Estimated Cost	Value-Impact Ratio
MOV Replacement (assumes use of gate valves)	$11 Million	3.6×10^{-2}
Dedicated SI Option	$24 Million	9.6×10^{-2}

It is clear from these ratios that none of the identified modifications to the Safety Injection System are justified from the reliability point of view.

In addition to the reliability evaluation performed to determine the efficacy of performing any modifications, an independent consultant was asked to review the success in eliminating the 1981 problem as shown by the results of the interim Technical Specification; and to determine whether long-term set of the valves would influence the test results. A review of the interim surveillance test results and the acceptability of SCE's proposed long-term surveillance program was provided to the NRC via Reference 5.

Kalsi Engineering, Inc. who was contracted to evaluate the results of the interim surveillance program and SCE's proposed long term valve surveillance program in view of the valve failures, examined the potential errors associated with the interim program and also evaluated whether the long-term program will provide sufficient proof of continuing system operability. Dr. Kalsi's conclusion follows:

> The surveillance tests to date have demonstrated that the design modifications in the SIS valves have been successful in eliminating the root causes of the failures; and the actuator force has sufficient margin over the required force to open the valve under long-term set effects.

The overall conclusion of these numerous studies is that the reliability of the system, as designed, is comparable to those in operation at other plants, that the modifications performed by SCE in 1981 are successful and that further system modifications cannot be justified on the basis of improved system reliability.

Future Testing Assures Continued Operability

Reference 6 provided SCE's application for amendment to initiate a long-term surveillance program of the SIS valves. The change proposes a modification to the existing "no-flow" surveillance requirement to specify an acceptable time for stroking of the valves. Our evaluation, as confirmed by our consultant's review (Reference 5) concluded that the long term program is adequate to demonstrate valve operability.

Conclusion

The 1981 valve failures were due to a combination of three problems: valve seat galling, double disc drag and an improperly sized valve actuator. Modifications performed have been successful in remedying the problem as demonstrated by an interim surveillance program and as confirmed by a valve consultant. Further modifications to the system would not provide an increase in the level of safety commensurate with their cost.

References

1. Letter, K. P. Baskin, SCE, to D. M. Crutchfield, NRC, dated October 16, 1981.

2. Amendment Application No. 99, submitted by letter, L. T. Papay, SCE, to H. R. Denton, NRC, dated October 21, 1981.

3. Letter, Dennis M. Crutchfield, NRC, to R. Dietch, SCE, dated November 5, 1981.

4. Letter, K. P. Baskin, SCE, to D. M. Crutchfield, NRC, dated September 28, 1982.

5. Letter, M. O. Medford, SCE, to G. E. Lear, NRC, dated June 25, 1986.

6. Letter, Robert Dietch, SCE, to H. R. Denton, NRC, dated November 20, 1985.