**ENCLOSURE**

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

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| EA No.: | 99-178 |
| Docket Nos.: | 50-275<br>50-323 |
| License Nos.: | DPR-80<br>DPR-82 |
| Report No.: | 50-275/99-07<br>50-323/99-07 |
| Licensee: | Pacific Gas and Electric Company |
| Facility: | Diablo Canyon Nuclear Power Plant, Units 1 and 2 |
| Location: | 7 ½ miles NW of Avila Beach<br>Avila Beach, California |
| Dates: | May 3 through July 14, 1999 |
| Inspectors: | David L. Proulx, Senior Resident Inspector<br>Dyle Acker, Resident Inspector |
| Approved By: | Linda J. Smith, Chief, Project Branch E |

ATTACHMENT: Supplemental Information

# EXECUTIVE SUMMARY

Diablo Canyon Nuclear Power Plant, Units 1 and 2
NRC Inspection Report No. 50-275/99-07; 50-323/99-07

This special inspection covered the licensee's response to indications of voiding of emergency core cooling system piping, which had the potential to gas bind the centrifugal charging pumps and safety injection pumps, rendering these pumps inoperable.

## Operations

- An apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," (EA 99-178) was identified for: (1) failing, on March 27 and 28, 1999, to promptly identify and correct a void in the emergency core cooling crossover piping that exceeded the acceptance criteria specified in Procedure STP M-89A, "Void Volume Measurement in Safety Injection Pump/Centrifugal Charging Pump Suction Crosstie Piping," Revision 1. This void potentially impacted operability of the safety injection pumps and the centrifugal charging pumps; and (2) failing to implement effective corrective actions to preclude voiding. Specifically, as a resolution to a 1991 nonconformance report, the licensee calculated the acceptable void size for the suction of the safety injection pumps and centrifugal charging pumps. However, engineers did not incorporate the results into operating or surveillance procedures or refer to this calculation to address subsequent voiding issues (Sections O4.1 and E1.1.b.2).

## Engineering

- The licensee missed several opportunities to identify the cause and provide corrective action to prevent recurrence for significant voiding that included: review of NRC and industry communications, previous incidences of significant voiding, and corrective actions for previous nonconformances (Sections E1.1.b.1 and E1.1.b.3).

- An apparent violation of Technical Specifications 3.5.2 and 3.0.3 (EA 99-178) was identified for failing, in March 1998, to take action to shut down Unit 2 within 1 hour. This was required when both trains of the emergency core cooling system were inoperable. The licensee identified a 2.2-cubic foot void on the suction of the Unit 2 safety injection pumps and centrifugal charging pumps, which exceeded the 0.44-cubic foot operability limit. This void would have rendered both trains of safety injection pumps or centrifugal charging pumps inoperable because of gas binding for the recirculation phase of accident mitigation. The licensee allowed this condition to exist for 6 days until the gas was vented. The failure to take prompt action to remove the void in the Unit 2 emergency core cooling system piping partially resulted from the 1991 failure to implement the appropriate acceptance criterion into instructions or procedures (Section E1.1.b.5).

- Licensee calculations concluded that the excessive voiding in the emergency core cooling system crossover piping was not risk significant and would not adversely affect public health and safety. However, excessive voiding would result in a significant loss of design diversity (Section E1.2).

- A noncited violation of 10 CFR 50.59 in accordance with Appendix C of the Enforcement Policy was identified for failure to perform a formal safety evaluation. Specifically, a revision to the procedure for identifying voids in the emergency core cooling system piping directed operators to caution tag closed the emergency core cooling system crossover piping isolation valves; however, the Final Safety Analysis Report update, Section 6.3, required the valves to be opened when operators manually aligned the emergency core cooling system for the recirculation phase of accident mitigation. This violation is in the corrective action program as Nonconformance Report N0002095 and Action Request A0482378 (Section E3.1).

## Report Details

Emergency Core Cooling System (ECCS) Operation and Design

During a design basis loss-of-coolant accident (LOCA), each of the ECCS pumps sequence on in turn, taking suction from the Refueling Water Storage Tank (RWST). After the RWST empties, operators are required to manually align the suction of the residual heat removal (RHR) pumps to the containment recirculation sump and align the discharge of the RHR pumps to the suction of the safety injection (SI) pumps and centrifugal charging pumps (CCP) through the ECCS crossover piping. This alignment provides high head injection during the recirculation phase of the accident and is necessary to support the recirculation phase following a small or intermediate break LOCA.

The design of the ECCS for the recirculation phase includes a common line from the discharge of both RHR pumps to the suctions of both SI pumps and both CCPs. This design was intended to enable the facility to sustain a worst-case single failure of an operating RHR pump during the recirculation phase and successfully mitigate the consequences of a small or intermediate break LOCA. However, the common line introduces the potential for common mode pump failure (both SI pumps and/or both CCPs) during the recirculation phase if voids in the common line are not adequately controlled. This special inspection was performed to evaluate licensee corrective actions related to the control of voiding in the ECCS.

## I. Operations

### O4 Operator Knowledge and Performance

O4.1 Implementation of Void Measurement Procedure

a. Inspection Scope (92901)

The inspectors evaluated the March 1999 implementation of Action Request (AR) A0463533. This AR provided operators temporary direction as to how to respond to indications of voiding. This inspection included review of documentation and personnel interviews.

b. Observations and Findings

Because ECCS void growth was evident on Unit 2 following Refueling Outage 2R8, engineers determined that it was prudent to evaluate the Unit 1 ECCS crossover piping for voiding following Refueling Outage 1R9. On March 10, 1999, because of previous indications of voids on the ECCS crossover piping, engineers identified a small gas void on the Unit 1 crossover piping that was within acceptable limits. On March 11, 1999, the Operations Director issued a shift order to the operating crews instructing them to monitor void growth in accordance with Procedure STP M-89A, "Void Volume Measurement in Safety Injection Pump/Centrifugal Charging Pump Suction Crosstie Piping," Revision 1, every 4 hours. On March 15, 1999, the monitoring requirement was relaxed to every 12 hours.

Under routine conditions, inservice inspection personnel performed Procedure STP M-89A on a weekly basis, using highly accurate instruments. After using these instruments to measure the height of the column of water inside the pipe, the inservice inspection personnel used the chart in Procedure STP M-89A, Attachment 8.1, to convert this height to gallons of water and used the chart in Attachment 8.3 to determine the acceptable void volume based on volume control tank pressure. With the normal volume control tank pressure of 18 psig, the allowable void volume was 3.33 gallons. Procedure STP M-89A, Section 10.3, required that, if personnel detected a void volume within 1 gallon of the limit, they must vent the applicable piping to remove the void. Therefore, the procedure required immediate venting of the ECCS crossover piping if the void volume exceeded 2.33 gallons. Furthermore, Procedure STP M-89A, Section 10.3, required operators to enter Technical Specification 3.0.3 in the event that the void exceeded 3.33 gallons.

To facilitate taking frequent void measurements in the Unit 1 ECCS crossover piping in accordance with Procedure STP M-89A, the licensee installed temporary ultrasonic instrumentation that continuously displayed the height of water in the ECCS crossover piping near the RHR Heat Exchanger 1-1 to SI pumps Suction Valves SI-8807A and -B. Technicians also installed a video cassette recorder to continuously record the ultrasonic instrument data. Thus, the engineers could analyze the gradual growth of any potential void between performances of Procedure STP M-89A.

On March 27, 1999, during the night shift, the nuclear operator logged the height of the water in the ECCS crossover piping as 4.5 inches, as read from the temporary ultrasonic instrumentation. The nuclear operator noted that the height of the water during the previous shift was 5.2 inches and concluded that the decrease in water level (increase in void size) in the pipe was nonsubstantial. Without Procedure STP M-89A in hand and not having any direction from shift supervision, the nuclear operator did not recognize that this height of water equated to a void size of 3.4 gallons. Because Procedure STP M-89A prescribed a void size limit of 3.3 gallons, the operator should have notified the shift foreman, who should have entered Technical Specification 3.0.3. In addition, Procedure STP M-89A required venting of the ECCS piping through Valve SI-1-187, SI piping suction supply from RHR vent, at a gas void volume of 2.33 gallons.

The shift foreman, who reviewed the operator logs, was also unaware of the acceptance criteria in Procedure STP M-89A and provided no direction to take action. Therefore, operations personnel did not initiate an AR. Procedure OM7.ID1, "Problem Identification and Resolution - Action Requests," Revision 11, Section 1.1.2, required initiation of an AR when identifying significant degradation of safety-related structures, systems, or components. The inspectors concluded that Procedure OM7.ID1 required initiation of an AR on March 27, 1999, in that the void size increased such that the ECCS was degraded to the point of potentially impacting operability.

Similarly, on March 28, 1999, during the day shift, the nuclear operator identified that the height of the water within the ECCS crossover piping was 4.6 inches. This height equated to a void size of 3.1 gallons, which required venting of the piping in that the void size was within 1 gallon of the 3.3 gallon limit. The nuclear operator and the shift

foreman were not cognizant of the requirements within Procedure STP M-89A and did not vent the ECCS crossover piping to remove the void, nor did they initiate an AR.

10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," requires that measures shall be established to assure that conditions adverse to quality are promptly identified and corrected. The March 27 and 28, 1999, failures to identify that the void size exceeded the acceptance criteria specified in Procedure STP M-89A and the associated failures to promptly vent the ECCS crossover piping is the first example of an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI (50-275/99007-01, Example 1).

On March 28, 1999, at 8:30 p.m., the shift foreman reviewed the previous shift's nuclear operator logs and noted that the auxiliary building nuclear operator logged that the height of the water within the ECCS crossover piping was 4.5 inches. Because the shift foreman had been involved in performing Procedure STP M-89A during Refueling Outage 1R9, he recognized that a 4.5 inch water height in the ECCS crossover piping correlated to a void size of 3.4 gallons. The shift foreman identified that this void size exceeded the acceptance limit in Procedure STP M-89A and that this condition had existed since March 27, 1999, at 7:45 a.m. Operators entered Technical Specification 3.0.3, placed caution tags on the control room control switches for Valves SI-8807A and -B, declared Pump SI 1-1 inoperable, and exited Technical Specification 3.0.3. Procedure STP M-89A, Section 12.8.b, required operators to take these actions as a compensatory measure to prevent operators from opening Valves SI-8807A and -B during switchover to the recirculation phase of a design basis accident. The desirability of these actions is discussed in Section E3.1.

Operators vented the ECCS crossover piping at Valve SI-1-187 several times over the next several hours. Inservice inspection personnel arrived on site and performed Procedure STP M-89A using accurate, calibrated ultrasonic instruments. At that time, the licensee determined that the actual void size in the ECCS crossover piping was 3.1 gallons, less than the acceptance criterion for entering Technical Specification 3.0.3. Venting operations continued until 4:25 a.m. on March 29, 1999, when the void size was reduced to 2.2 gallons. Following identification of the voiding, the licensee reanalyzed the void size, using the actual piping configuration. Engineers calculated that the actual size of the voids to be approximately 2.7 gallons. The inspectors noted that this value was within the design basis allowable void size and concluded that the CCP and SI pumps had remained operable. However, this void size was still within 1 gallon of the acceptance criterion, indicating that immediate venting of the void had been required. The inspectors determined that the licensee calculations were reasonable.

The licensee previously had initiated Nonconformance Report (NCR) N0002076 in November 1998 to evaluate past occurrences of voiding in the ECCS. On March 29, 1999, following review of the recorded data, the licensee determined that the void increase on March 27, 1999, coincided with cycling of Valve 1-CVCS-8104, emergency boration isolation, and that the void had migrated to the ECCS high point. From the incident that occurred on March 27, 1999, and from past incidences of voiding that occurred relatively shortly after outages, the preliminary root cause analysis identified that voiding at Diablo Canyon resulted from inadequate filling and venting of the ECCS following outages.

On May 5, 1999, following the inspectors' evaluation of this issue, the licensee entered this issue in the corrective action program as AR A0484084. After review of this AR, management elevated this issue to Quality Evaluation Q0012130. The inspectors noted that this AR was initiated more than 1 month after the event, which the inspectors considered untimely.

Licensee planned corrective actions included walkdowns and ultrasonic testing of the ECCS piping to identify other vulnerable locations for gas voiding. In addition, for each unit, the licensee planned to install a high point vent on the 6-inch sections of pipe between Valve SI-8925, RHR Heat Exchanger 1-1(2-1) to SI pumps suction isolation, and Valves SI-8807A and -B on the ECCS crossover piping. The licensee determined that this vent point was necessary in addition to the vent at Valve SI-1(2)-187. Valve SI-1(2)-187 was located downstream of a 6-inch to a 4-inch reducer and was not truly the highest point of this pipe section since gas could become trapped in the 6-inch pipe.

c. Conclusions

The first example of an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI, was identified for failing, on March 27 and 28, 1999, to promptly identify and correct a void in the ECCS crossover piping that exceeded the acceptance criteria specified in Procedure STP M-89A. The void potentially impacted operability of the SI pumps and the CCPs. Subsequent calculations revealed that the SI pumps and CCPs remained operable. However, this issue revealed a deficiency in communicating management expectations with respect to monitoring void growth in the ECCS piping. The issuance of an AR to address this issue was untimely.

## III. Engineering

### E1 Conduct of Engineering

E1.1 Voiding in ECCS Piping

a. Inspection Scope (92903)

The inspectors reviewed documentation and conducted interviews with licensee personnel to determine the history of ECCS voiding issues at Diablo Canyon. The inspectors evaluated the licensee response to ARs A0214415, A0236734, A0339925, A0449380, A0459058, and A0463533; and NCRs N0002076 and DCO-91-TN-N004, which discussed continuing deficiencies that the licensee experienced with ECCS voiding, and reviewed two related licensee event reports. In addition, the inspectors reviewed the licensee responses to Information Notice (IN) 88-23 "Potential for Gas Binding of High-Pressure Safety Injection Pumps during a Loss-of-Coolant Accident," and its supplements.

b. Observations and Findings

b.1 Operating Experience Review History

Adequate control of system voiding to prevent gas binding of safety-related pumps has been an industry issue since May 1988, when the NRC issued IN 88-23. NRC IN 88-23 provided notification to the industry that another facility experienced significant voiding in the ECCS crossover piping to the suction of the CCPs. Specifically, during a design basis LOCA upon switchover to the recirculation phase, gas voids in the ECCS crossover piping would sweep into the suction of the CCPs, which could damage the pumps because of gas binding. Design engineers initially concluded from review of IN 88-23 that the configuration of Diablo Canyon differed from the facility discussed in IN 88-23 and that Technical Specification 3.5.2 already required monthly venting of the ECCS system high points. Therefore, the initial evaluation concluded that voiding in ECCS piping that could damage the pumps was unlikely.

The reactor vendor issued a letter dated November 1, 1988, to augment the information provided in IN 88-23. The vendor recommended establishing a 5 percent void fraction as the design basis of the SI pumps and CCPs to preclude gas binding. In addition, the vendor recommended design changes such as installation of loop seals or continuous high point vents to preclude significant voiding. Licensee management elected not to implement these vendor recommendations. The inspectors considered this response to the vendor letter as a missed opportunity to derive the appropriate acceptance criteria.

In December 1989, the licensee had received another letter from the reactor vendor that discussed the possibility of voids forming in the ECCS piping because of an excessive rate of pressure variation in the volume control tank. This letter recommended that the pressurization variation remain less than 1 psig per 15 minutes, which the licensee implemented.

In January 1989, the NRC issued Supplement 1 of IN 88-23, which discussed the discovery of ECCS voiding at two additional facilities. As a result, engineers had added new high point vents to monthly venting Procedure STP M-89, "ECCS System Venting," to include Valve SI-1(2)-187 to aid in venting Valves SI-8807A(B).

In January 1990, the NRC issued Supplement 2 of IN 88-23, which discussed another facility that experienced ECCS voiding but described a different mechanism for the voiding that resulted from blowdown of the volume control tank. Since existing surveillance tests that verified the operability of the volume control tank isolation valves, the licensee had determined that this ECCS voiding mechanism was unlikely. The licensee took no action as a result of Supplement 2.

In December 1990, the NRC issued Supplement 3 of IN 88-23, which discussed the failure of a CCP that resulted from gas binding at an operating facility. Similar to the original IN and previous supplements, significant voiding in the ECCS piping was identified. Operating experience personnel had recommended a program of frequent ultrasonic measurement of ECCS piping to detect potential void growth; however, the licensee took no action.

In December 1992, the NRC issued Supplement 4 of IN 88-23, which discussed discovery of significant voids in the ECCS piping at two additional facilities. The licensee reiterated the desirability of ultrasonic measurement of void formation and installing vents upon discovery of voiding, if required; however, the licensee took no action.

In 1993 the licensee performed ultrasonic measurement of voids in the ECCS piping on a trial basis with limited results. Licensee management determined that ultrasonic measurement for voids should only be used in lieu of the monthly venting of high points. Licensee management noted that this approach required an amendment to Technical Specification 3.5.2 and abandoned ultrasonic measurement for voids.

b.2 Volume Control Tank Depressurization Concern

On December 26, 1991, the licensee initiated NCR DCO-91-TN-N004 because of concerns with the rate of pressure changes in the volume control tank. Operators identified that the then-current acceptance criterion of 1 psig per 15 minutes was routinely violated during routine evolutions such as degassing and letdown system isolation. The licensee initiated the NCR to generate appropriate acceptance criteria given actual plant operations and to provide for any recommended actions for the potential of gas voids in ECCS piping. The Technical Review Group, which provided oversite of this NCR, attributed the root cause of the routine violations to inadequate review of the design change package that established the pressurization limits.

For corrective action, engineers calculated that no limitations on the rate of volume control tank pressurization were necessary. However, as a conservative measure, the licensee imposed a pressurization limit of 2 psig per minute. This limit allowed for normal operations and transients to occur without violating the new pressurization limit. The licensee compensated for the new pressurization limit by taking credit for the monthly high point venting of ECCS piping.

In addition, one of the corrective actions for NCR DCO-91-DCO-N004 (as tracked in AR A0214415) had directed that engineering calculate the allowable gas void volume in the ECCS piping to preclude gas binding and thus pump inoperability. In a letter dated April 17, 1991, the Plant Engineering Manager submitted the calculation to the Technical Review Group. Engineers had calculated that the maximum allowable void in the suction of a CCP was 0.34 cubic feet and then calculated that this equated to a void of 0.496 cubic feet (3.7 gallons) in the ECCS crossover piping. However, the licensee did not incorporate this limit into operations or surveillance procedures. As a result, the licensee accepted voids in the ECCS crossover piping that significantly exceeded 0.496 cubic feet, as discussed in Sections E1.1.b.3 and E1.1.b.5.

10 CFR Part 50, Appendix B, Criterion XVI, requires that, in the case of significant conditions adverse to quality, measures shall assure that corrective action is taken to preclude repetition. Failing to incorporate the maximum design voiding limit of 0.496 cubic feet into operating or surveillance procedures and failing to refer to this

calculation to address subsequent voiding issues is the second example of an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI (50-275; 323/99007-01, Example 2).

b.3 Significant Voiding in Units 1 and 2 ECCS Crossover Piping in 1994

On April 26, 1994, during performance of Procedure STP M-89, operators noted that a large volume of gas was vented through Valve SI-2-187 on the Unit 2 crossover piping. Based on the drop-in volume control tank level, the licensee estimated the void as 3.3 cubic feet (25 gallons). The licensee initiated AR A0339925 to evaluate this condition. The licensee concluded, based primarily on engineering judgement, that this void did not affect operability of the SI pumps and the CCPs. The engineer failed to reference the acceptance limit of 0.496 cubic feet established in 1991 nor did he refer to the vendor letter, dated November 1991, that stated a 5 percent void fraction was the acceptable limit. The inspectors noted that this instance was a missed opportunity to review the corrective action program to determine if a previous limit had been established.

On May 24, 1994, because of the voiding found on Unit 2, the licensee vented the Unit 1 ECCS crossover piping. The licensee identified a 1.1-cubic foot (8 gallon) void. The licensee sampled the vented gas and determined that it was 60 percent hydrogen and 36 percent nitrogen. The licensee concluded that the source of the gas was the volume control tank and added this information to AR A0339925. On July 27, 1994, during venting at Valve SI-1-187, operators identified a 4-cubic foot (30 gallon) void in the Unit 1 ECCS crossover piping. This information was also added to AR A0339925. On December 8, 1994, the licensee identified a 0.3-cubic foot (2.6 gallon) void on the Unit 2 ECCS crossover piping and added this information to the AR.

The final evaluation for each of these instances of significant ECCS voiding concluded that the systems remained operable. The licensee noted that, in an out-of-court settlement in 1994, the NRC declined to take formal enforcement action against another licensee that identified voids significantly larger than those found at Diablo Canyon. Therefore, the engineer established a void acceptance limit of 5 cubic feet (37.5 gallons). In informal discussions with the reactor vendor, the vendor agreed that this conclusion on the acceptable void size was reasonable.

The inspectors noted that the licensee did not attempt to identify and correct the source of the void formation in accordance with AR A0339935, which was closed out with no further action. The inspectors concluded that the failure to identify the root cause and provide corrective action to prevent repetition of significant ECCS voiding in 1994 partially resulted from the 1991 failure to implement the calculated acceptance limit. These 1994 issues constituted another missed opportunity to identify the cause of the ECCS voiding and to correct the problem.

During the root cause investigation for NCR N0002076, the licensee noted that each of the instances of void detection at the facility had occurred shortly after a refueling outage and attributed the root cause to inadequate filling and venting of the ECCS

piping following a refueling outage. Consequently, the inspectors concluded that the significant voiding in 1994 could have existed up to 30 days until identification during the venting process.

b.4 1997 Surveillance Review

The licensee received notification of escalated enforcement action at another facility with respect to ECCS venting and identified a similar issue at Diablo Canyon. The licensee identified a failure to adequately implement Technical Specification 4.5.2.b.1, which was reported in Licensee Event Report 50-275; 323/97-017-00. This Technical Specification requires verification that the ECCS piping is full of water by venting the ECCS pump casings and accessible discharge piping high points. Since initial plant operation, Procedure STP M-89 exempted venting the ECCS pump casings if a pump was in operation. On October 23, 1997, during a review of the past 2 years of test data, the licensee identified that adequate pump casing venting had not been performed, even though the pump was in operation. On November 4, 1997, the licensee also discovered their monthly surveillance test did not identify two accessible high point vents on normally isolated hot leg SI lines. The NRC issued a noncited violation for this event in NRC Inspection Report 50-275; 323/97-19. The licensee review of industry events that led to identification of this problem was considered a strength.

b.5 Significant Voiding in Unit 2 ECCS Crossover Piping in 1998

In December 1997, in response to generic industry information, the licensee initiated AR A0449380 to perform a site-specific analysis of the potential for gas voids in the ECCS piping. As a result, the licensee determined that the previous recommendations concerning ultrasonic measurement of void size would be implemented and trended on each unit on a weekly basis. The initial ultrasonic measurements taken on February 6, 1998, revealed relatively small voids (0.16 cubic feet on Unit 1, and 0.18 cubic feet on Unit 2). None of these voids grew in size so that, in April 1998, the licensee terminated ultrasonic measurement of voids for Unit 1. The licensee continued ultrasonic measurement of voids in Unit 2 on a weekly basis.

On March 27, 1998, the licensee measured a void of 2.2 cubic feet in the Unit 2 ECCS crossover piping. The licensee reviewed documentation in the corrective action program and noted that AR A0339925 (initiated in 1994) contained an evaluation that stated that a void of up to 5.0 cubic feet was acceptable, based on discussions with another facility. The engineer did not perform sufficient research to identify that NCR DCO-91-TN-N004 contained a more restrictive ECCS gas void limit of 0.496 cubic feet. Therefore, the licensee determined that the 2.2-cubic foot void was not an operability concern and could be vented during the next routine surveillance performance in accordance with Procedure STP M-89. The voiding in the Unit 2 ECCS piping was reduced by venting on April 2, 1998. The licensee initiated AR A0459058 to enter this item into the corrective action program and track potential void growth.

Because of the potential safety significance of the gas voids in the Unit 2 ECCS piping, the licensee had initiated NCR N0002076 to provide a root cause analysis and corrective action to prevent repetition. Following issuance of AR A0459058, the

licensee assigned an action item for engineering to analytically determine the acceptable void size. Licensee initial calculations assumed a void fraction of 5 percent delivered to the pumps, as directed by the vendor in 1989. This calculation, completed on October 14, 1998, determined that a 0.44-cubic foot (3.3 gallon) void in the ECCS crossover piping could result in gas binding the SI pumps and CCPs. Since the licensee believed that this limit may have been overly conservative, the licensee had a consultant perform an independent calculation. The final contractor calculation, submitted in December 1998, determined that the acceptable void size was 0.48 cubic feet. While the assumptions for each of the three calculations (January 1991, October 1998, and December 1998) differ, the results were similar in magnitude (0.496, 0.44, and 0.48 cubic feet, respectively) with the difference being nonsubstantial.

The licensee subsequently issued Procedure STP M-89A to formalize the ultrasonic measurement of voiding in the ECCS crossover piping and incorporate the 0.44-cubic foot void limit into the procedure. Since the void detected in the Unit 2 ECCS piping significantly exceeded the operability limit of 0.44 cubic feet, either both SI pumps or CCPs were inoperable when the 2.2-cubic foot void had existed. Two trains of an ECCS were inoperable for Unit 2 from March 27 through April 2, 1998, a 6-day period. Technical Specification 4.5.2 requires two trains of ECCS to be operable but, if both trains of ECCS are inoperable, Technical Specification 3.0.3 applies. Technical Specification 3.0.3 requires that, when a limiting condition for operation is not met, the licensee must take action within 1 hour to place the plant in: hot standby in the next 6 hours, hot shutdown in the following 6 hours, and cold shutdown withing the next 24 hours. The failure to take the shutdown actions prescribed by Technical Specification 3.0.3, when both trains of ECCS were inoperable because of gas voids, is an apparent violation of Technical Specification 4.5.2 and Technical Specification 3.0.3 (50-323/99007-02).

Upon recognition that this violation existed, the licensee made a 1-hour nonemergency notification to the NRC Operations Center because the plant was outside its design basis. In addition, the licensee submitted Licensee Event Report 50-275; 323/98-011-00.

c. Conclusions

A second example of an apparent violation of 10 CFR Part 50, Appendix B, Criterion XVI, was identified for failing to implement effective corrective actions to preclude repetition of significant emergency core cooling system voiding from 1994 through 1999. Specifically, as resolution to a 1991 nonconformance report, the licensee calculated the acceptable void size for the suction of the SI Pumps and CCPs. However, engineers did not incorporate the results into operating or surveillance procedures or refer to this calculation to address subsequent voiding issues.

The licensee missed several opportunities to identify the cause and provide corrective action to prevent recurrence for significant voiding that included: review of NRC and industry communications, previous incidences of significant voiding, and corrective actions for previous nonconformances.

An apparent violation of Technical Specifications 3.5.2 and 3.0.3 was identified for failing, in March 1998, to take action to shut down Unit 2 within 1 hour when both trains of the ECCS were inoperable. The licensee identified a 2.2-cubic foot void on the suction of the Unit 2 SI pumps and CCPs. This void volume exceeded the 0.44-cubic foot operability limit and would have rendered both trains of SI pumps or CCPs inoperable because of gas binding for the recirculation phase of accident mitigation. The licensee allowed this condition to exist for 6 days before venting the gas. The failure to take prompt action to remove the void in the Unit 2 ECCS piping partially resulted from the 1991 failure to implement the appropriate acceptance criterion into instructions or procedures, discussed above.

E1.2 Safety Significance Determination for ECCS Voiding (92903)

a. Inspection Scope (92903)

The inspectors reviewed the licensee evaluation of the effects on analyzed accidents of loss of either both SI pumps or both CCPs. Similarly, the inspectors reviewed the licensee probabilistic risk assessment for having either both SI pumps or both CCPs unavailable for a 2-month period.

b. Observations and Findings

b.1 Deterministic Safety Significance of Previous ECCS Voids

The inspectors noted that the SI pumps and the CCPs were required to be operable for the recirculation phase to mitigate small and intermediate break LOCAs. With voids in excess of the calculated acceptance criterion of 0.48 cubic feet, the gas would be swept into the suction of the SI pumps or CCPs, which share a common suction header during the recirculation phase of accident mitigation Licensee calculations demonstrated that voids in excess of 0.48 cubic feet would not meet the void fraction requirements specified by the vendor and could cause gas binding and damage to an operating SI pump or CCP. This would potentially render either both CCPs or both SI pumps inoperable for the time period that the voids existed. In addition, because the licensee stated that the voiding resulted from an inadequate fill and vent of the Unit 2 ECCS following Refueling Outage 2R8, the voiding reasonably could have existed from March 21 to April 2, 1999. The licensee also postulated that the larger voids detected in 1994 could have existed for up to 30 days.

With the aid of the vendor, the licensee performed a deterministic analysis of the effect the inoperable SI pumps and CCPs would have on the plant's ability to mitigate the consequences of an accident. For a small break LOCA (1 to 3-inch) the licensee removed the conservatisms from the calculations and used nominal values as input, which included three containment fan cooler units operating. Using these parameters, the licensee noted that a small break LOCA would not result in actuation of containment sprays. Without containment spray actuation, an additional 2 hours of cold leg injection was credited with suction from the RWST. The licensee postulated that, with the additional 2 hours of injection without the RHR pumps tripping and initiation of the recirculation phase, operators would have ample time to cool down the reactor and

initiate RHR shutdown cooling. Therefore, the recirculation phase of accident mitigation would never be entered, and the voids would not be swept into the suction of the SI pumps or CCPs.

The licensee performed a second analysis that assumed: (1) both containment spray pumps were operated prior to recirculation, (2) both CCPs failed because of gas binding that resulted from the excessive voiding, and (3) only one SI pump continued to operate. The analysis results indicated that peak cladding temperatures would reach 1616°F. Although this temperature was greater than the Final Safety Analysis Report (FSAR) update limit of 1346°F, it was less than the 10 CFR 50.46 acceptance criterion of 2200°F. Therefore, the licensee concluded that this event did not adversely affect public health and safety.

In addition, the licensee evaluated the potential degradation of the SI pumps and CCPs. The licensee determined that the 5 percent void fraction operability limit was conservative. Generic pump data indicated that multistage pumps (such as the SI pumps and CCPs) could tolerate void fractions larger than 5 percent. The licensee noted that generic pump data stated that voids of this size would degrade pump performance but would not result in pump failure. However, the licensee contacted the vendor who agreed in principle but would not provide an updated limit on void fractions.

b.2 Probabilistic Risk Assessment

The licensee performed a probabilistic risk assessment to determine the change in core damage frequency given the excessive voids in the suction of the SI pumps and the CCPs. Using the assumption that either both SI pumps or both CCPs were not available for 2 months, the licensee calculated an 8.7E-7 increase in the conditional core damage frequency. Based on the industry guidance that only increases greater than 1E-6 were risk significant, the licensee concluded that the existence of voids in the ECCS crossover piping was not risk significant. In addition, the licensee stated that future analysis may prove the SI pumps and CCPs to have been operable despite the voids. The licensee stated if this were true the existence of voids in the ECCS had no risk significance.

c. Conclusions

Licensee calculations concluded that the excessive voiding in the ECCS crossover piping was not risk significant and would not adversely affect public health and safety. While not risk significant, the inspectors noted that loss of either both SI pumps or both CCPs represented a significant loss of design diversity.

## E3 Engineering Procedures and Documentation

### E3.1 Procedure Revisions

a. Inspection Scope (92903)

The inspectors evaluated revisions to Procedure STP M-89A to determine if the licensing and design bases were properly maintained in accordance with the FSAR update and design basis documentation.

b. Observations and Findings

On March 28, 1999, after detecting a gas void in the Unit 1 ECCS crossover piping, operators followed the direction of Procedure STP M-89A, Revision 1, Section 12.8 (refer to Section O4.1). Following tagging of the valves, Procedure STP M-89A directed operators to exit Technical Specification 3.0.3, declare Pump SI 1-1 inoperable, and enter the 72-hour shutdown action statement of Technical Specification 3.5.2. After the venting the void, operators exited Technical Specification 3.5.2.

On April 1, 1999, the inspectors questioned the logic behind declaring Pump SI 1-1 inoperable when Valves SI-8807A and -B were closed. The inspectors noted that these valves were on a common crossover line between both SI pumps and both CCPs, which did not appear to be specifically related to Pump SI 1-1. The system engineering director stated that tagging shut Valves SI-8807A and -B removed the ability of each train of ECCS to withstand a single failure; therefore, one train of ECCS was inoperable.

On April 7, 1999, the inspectors noted that Section 6.3 of the FSAR update provided specific directions to manually align the ECCS for the recirculation phase of accident mitigation. This FSAR update stated that operators would open Valves SI-8807A and -B for transfer to the recirculation phase. The licensee provided these instructions in Emergency Operating Procedure (EOP) E-1.3, "Transfer to Cold Leg Recirculation." The inspectors concluded that Procedure STP M-89A, Revision 1, which added the provision to tag shut Valves SI-8807A and -B in the event of voiding, required a 10 CFR 50.59 evaluation since it reflected a change in procedures as described in the FSAR.

The inspectors noted that Procedure TS3.ID2, "Licensing Basis Impact Evaluations," Revision 5, contained a two-step process for implementing 10 CFR 50.59. The first included a screening process applied to each change, test, or experiment to determine if the change, test, or experiment impacted the plant licensing basis, as described in the FSAR or other licensing basis documents. If any of the screening questions were answered "yes," then a formal safety evaluation would be performed to determine if an unreviewed safety question existed.

On December 10, 1998, an engineer performed the screening evaluation for Procedure STP M-89A, Revision 1. The engineer answered each of the screening questions "no;" therefore, a formal safety evaluation was not performed. On April 7,

1999, the inspectors determined that the licensing basis impact evaluation screening performed for Procedure STP M-89A, Revision 1, was inadequate and a formal 10 CFR 50.59 evaluation was required.

The licensee stated that engineers also determined on April 7 that the 10 CFR 50.59 review was inadequate, independent of the inspectors. The licensee rescinded Procedure STP M-89A, Revision 1, so that the procedure steps directing operators to tag Valves SI-8807A and -B shut upon indication of voiding were removed. The operations superintendent initiated a shift order to communicate this procedure change. The system engineer initiated AR A0482378 to enter this item into the corrective action program. Following management review, the licensee elevated this issue to NCR N0002095.

The failure to perform a safety evaluation for a change to a procedure as described in the FSAR is a violation of 10 CFR 50.59. However, this Severity Level IV violation is being treated as a noncited violation in accordance with Appendix C of the Enforcement Policy. This violation is in the corrective action program as NCR N0002095 and AR A0482378 (50-275; 323/99007-03).

The licensee noted that the engineer, who performed the screening, and the independent reviewer were both aware of the FSAR update description of the switchover to recirculation. However, the EOP usage document directed operators to skip steps and continue on if a step could not be performed in the EOPs. Therefore, the engineer incorrectly concluded, since tagging the ECCS crossover valves would only result in operators skipping steps in EOP E-1.3, that the FSAR update described switchover process was not affected and that a 10 CFR 50.59 safety evaluation was not required. In addition, the engineer and the independent reviewer incorrectly believed that, since the Plant Staff Review Committee deemed that the change was safe, a 10 CFR 50.59 evaluation was not necessary.

Subsequently, the licensee performed a 10 CFR 50.59 evaluation of Procedure STP M-89A, Revision 1, and concluded that an unreviewed safety question did not exist. The inspectors reviewed the safety evaluation and agreed with the conclusions.

c. Conclusions

A noncited violation of 10 CFR 50.59 in accordance with Appendix C of the Enforcement Policy was identified for failure to perform a formal safety evaluation. Specifically, a revision to the procedure for identifying voids in the ECCS piping directed operators to caution tag closed the ECCS crossover piping isolation valves; however, FSAR update, Section 6.3, required the valves to be opened when operators manually aligned the ECCS for the recirculation phase of accident mitigation. This violation is in the corrective action program as NCR N0002095 and AR A0482378.

**E8 Miscellaneous Engineering Issues (92700, 92903)**

E8.1 (Closed) Licensee Event Report 275; 323/98-011-00: ECCS outside of design basis because of gas voiding in the suction piping.

This licensee event report discusses several periods in which gas voiding in the suction of the ECCS pumps resulted in the plant being outside its design basis. The licensee calculated that the allowable void size in the ECCS crossover piping was 0.44 cubic feet (3.3 gallons). Upon reviewing previous plant conditions, the licensee identified several occasions from 1994 to 1998 in which voids of this magnitude and greater were identified, which potentially rendered two trains of ECCS inoperable for significant periods of time.

Corrective actions included: (1) venting the applicable piping at high points to reduce the size of the gas voids, (2) adding a chart to a surveillance test procedure to reflect the calculation of allowable void volume, (3) implementing weekly measurement of void formation using ultrasonic instrumentation, and (4) employing data acquisition equipment to determine the sources and size of voiding.

Application of the enforcement policy with respect to this event is discussed in Section E1.1 of this inspection report.

## V. Management Meetings

**X1 Exit Meeting Summary**

The inspectors presented the inspection results to members of licensee management at the conclusion of the inspection on July 14, 1999. The licensee acknowledged the findings presented.

The inspectors asked the licensee whether any materials examined during the inspection should be considered proprietary. No proprietary information was identified.

## ATTACHMENT

SUPPLEMENTAL INFORMATION

PARTIAL LIST OF PERSONS CONTACTED

J. R. Becker, Manager, Operations Services
P. T. Nugent, Acting Director, Regulatory Services
D. B. Miklush, Manager, Engineering Services
D. H. Oatley, Vice President and Plant Manager
G. M. Rueger, Senior Vice President and General Manager
L. F. Womack, Vice President, Nuclear Technical Services

INSPECTION PROCEDURES (IP) USED

| | |
|---|---|
| IP 92700 | Onsite Followup of Written Reports of Nonroutine Events at Power Reactor Facilities |
| IP 92901 | Followup - Operations |
| IP 92903 | Followup - Engineering |

ITEMS OPENED AND CLOSED

Opened

| | | |
|---|---|---|
| 50-275; 323/ 99007-01 | EEI | Two examples of failure to take appropriate corrective action upon identification of excessive voids in ECCS piping (Sections O4.1 and E1.1.b.2) |
| 50-323;99007-02 | EEI | Failure to implement Technical Specifications 4.5.2 and 3.0.3 (Section E1.1.b.5) |

Closed

| | | |
|---|---|---|
| 50-275; 323/ 98-011-00 | LER | ECCS outside of design basis because of gas voiding in the suction piping (Section E8.1) |

Opened and Closed

| | | |
|---|---|---|
| 50-275; 323/ 99007-03 | NCV | Failure to perform a 10 CFR 50.59 evaluation for a change in the FSAR method of initiation of cold leg recirculation (Section E3.1) |

## LIST OF ACRONYMS USED

| | |
|---|---|
| AR | Action Request |
| CCP | centrifugal charging pump |
| ECCS | emergency core cooling system |
| EEI | Escalated Enforcement Item |
| EOP | Emergency Operating Procedure |
| FSAR | Final Safety Analysis Report |
| IN | Information Notice |
| IP | inspection procedure |
| LER | licensee event report |
| LOCA | loss-of-coolant accident |
| NCV | noncited violation |
| NRC | Nuclear Regulatory Commission |
| PDR | Public Document Room |
| RHR | residual heat removal |
| RWST | refueling water storage tank |
| SI | safety injection |
| STP | surveillance test procedure |