Southern California Edison Company

SAN ONOFRE NUCLEAR GENERATING STATION

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May 18, 1992

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: Docket No. 50-361
Supplemental Report
Licensee Event Report No. 92-004, Revision 1
San Onofre Nuclear Generating Station, Unit 2

Reference: Letter, R. W. Krieger to USNRC Document Control Desk, dated March 19, 1992.

The referenced letter provided Licensee Event Report No. 92-004, Revision 0, for an occurrence involving minor reactor coolant leakage through three pressurizer instrument nozzles due to stress corrosion cracking. The enclosed supplemental LER provides additional information concerning the cause, corrective actions and safety significance of the event. Since this occurrence involves similar systems, causes, and corrective actions applicable to both Units 2 and 3, a single report for Unit 2 is being submitted in accordance with NUREG-1022. Neither the health nor the safety of plant personnel or the public was affected by this occurrence.

If you require any additional information, please feel free to contact me.

Sincerely,

R W Krieger

Enclosure: LER No. 92-004, Rev. 1

cc: C. W. Caldwell (USNRC Senior Resident Inspector, Units 1, 2 and 3)
J. B. Martin (Regional Administrator, USNRC Region V)
Institute of Nuclear Power Operations (INPO)



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LICENSEE EVENT REPORT (LER)

| Facility Name (1) | Docket Number (2) | Page (3) |
|---|---|---|
| SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 2 | 0 5 0 0 0 3 6 1 | 1 of 0 6 |

Title (4)
Primary Water Stress Corrosion Cracking of Pressurizer Instrument Nozzles at SONGS 2 and 3

| EVENT DATE (5) | | | LER NUMBER (6) | | | REPORT DATE (7) | | | OTHER FACILITIES INVOLVED (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Day | Year | Year | Sequential Number | Revision Number | Month | Day | Year | Facility Names | Docket Number(s) |
| | | | | | | | | | SONGS UNIT 3 | 0 5 0 0 0 3 6 2 |
| 0 2 | 1 8 | 9 2 | 9 2 | 0 0 4 | 0 1 | 0 5 | 1 8 | 92 | | 0 5 0 0 0 |

| OPERATING MODE (9) | | THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11) | | | | | |
|---|---|---|---|---|---|---|---|
| | | ___ 20.402(b) | ___ 20.405(c) | ___ 50.73(a)(2)(iv) | ___ 73.71(b) | | |
| POWER LEVEL (10) | 0 0 0 | ___ 20.405(a)(1)(i) | ___ 50.36(c)(1) | ___ 50.73(a)(2)(v) | ___ 73.71(c) | | |
| | | ___ 20.405(a)(1)(ii) | ___ 50.36(c)(2) | ___ 50.73(a)(2)(vii) | ___ Other (Specify in Abstract below and in text) | | |
| | | ___ 20.405(a)(1)(iii) | X 50.73(a)(2)(i) | ___ 50.73(a)(2)(viii)(A) | | | |
| | | ___ 20.405(a)(1)(iv) | ___ 50.73(a)(2)(ii) | ___ 50.73(a)(2)(viii)(B) | | | |
| | | ___ 20.405(a)(1)(v) | ___ 50.73(a)(2)(iii) | ___ 50.73(a)(2)(x) | | | |

LICENSEE CONTACT FOR THIS LER (12)

| Name | TELEPHONE NUMBER AREA CODE |
|---|---|
| R. W. Krieger, Station Manager | 7 1 4 3 6 8 - 6 2 5 5 |

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

| CAUSE | SYSTEM | COMPONENT | MANUFAC-TURER | REPORTABLE TO NPRDS | CAUSE | SYSTEM | COMPONENT | MANUFAC-TURER | REPORTABLE TO NPRDS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |

| SUPPLEMENTAL REPORT EXPECTED (14) | Expected Submission Date (15) | Month | Day | Year |
|---|---|---|---|---|
| ___ Yes (If yes, complete EXPECTED SUBMISSION DATE) ___ XX NO | | | | |

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On 2/18/92, with Unit 3 defueled for the Cycle 6 refueling outage, a dye-penetrant examination of a pressurizer vapor space level instrument nozzle revealed the presence of a crack. The examination was prompted by earlier observations of rust and boric acid crystals in the vicinity of the nozzle during a walkdown of the reactor coolant system (RCS) following the shutdown. On 3/14/92, Unit 2 was shutdown for reasons unrelated to this event. A thorough inspection of the Unit 2 nozzles, prompted by the findings at Unit 3, revealed similar signs of rust and boric acid crystals at two of the nozzles. The observed leakage was attributed to primary water stress corrosion cracking (PWSCC) of the Inconel 600 material from which the nozzles were fabricated. The leaking Unit 3 nozzle, as well as the remaining 3 vapor space nozzles in the Unit 3 pressurizer, were replaced with nozzles made from Inconel 690, a material less susceptible to PWSCC. An interim repair of the Unit 2 nozzles with Inconel 690 was implemented prior to its startup.

Since it is likely that these conditions existed during Modes of reactor operation in which no primary pressure boundary leakage is allowed, Technical Specification 3.4.5.2a, "Reactor Coolant System - Operational Leakage", is considered not to have been satisfied. SCE's evaluation of this phenomenon, indicates that catastrophic failure of a nozzle with PWSCC induced cracking is highly unlikely. However, the consequences of such a failure would be bounded by the existing small break loss of coolant accident analysis.

The 4 vapor space nozzles in Unit 2 will be replaced with nozzles fabricated from Inconel 690 or equivalent during the next refueling outage.

Plant: San Onofre Nuclear Generating Station
Units: Two and Three
Reactor Vendor: Combustion Engineering
Event Date: 2-18-92
Time: 0107

A. CONDITIONS AT TIME OF THE EVENT:

Unit 3:

Mode: 6, Defueled
RCS Temperature: Ambient

Unit 2:

Mode: 3, Hot Standby
RCS Temperature: 330°F

B. BACKGROUND INFORMATION:

Pressurizer:

The pressurizer [PZR] is provided with seven 3/4-inch instrument nozzles [NZL] which allow the connection of instrumentation for determining pressurizer pressure, level and temperature during normal and abnormal reactor operations. Four of the seven nozzles are located in the upper portion, or vapor space of the pressurizer, while the remaining three are located in the lower portion, or water space. Of the vapor space nozzles, two are associated with pressure and two are associated with level instrumentation. The water space nozzles are associated with level (2 nozzles) and temperature (1 nozzle). These nozzles are fabricated from Inconel 600 material.

Inconel 600 Performance:

Industry experience has shown Inconel 600 to be susceptible to Primary Water Stress Corrosion Cracking (PWSCC). PWSCC of Inconel 600 has been shown to occur when several material and environmental conditions are simultaneously satisfied. Of the plant systems and locations containing nozzles fabricated from Inconel 600, the environment associated with the pressurizer is the most aggressive from the standpoint of promoting PWSCC. For example, the temperature is significantly higher than the rest of the RCS and high concentrations of hydrogen exist during normal operation. Consequently, the pressurizer has been an area where PWSCC has most frequently been observed. Industry research has also demonstrated that the susceptibility of Inconel 600 to PWSCC is increased as the material is cold worked and/or the yield strength goes up; however, a threshold yield strength value below which the effect of PWSCC is eliminated has not been determined at this time.

In order to follow the progress of this issue, SCE has been an active member of the Combustion Engineering Owners Group (CEOG) Working Group on Inconel 600. The Working Group has performed a comprehensive test and analysis program on the known pressurizer nozzle failures in this country. The results of this effort are documented in CEN-406-P, "Status Report on CEOG Activities Concerning Primary Water Stress Corrosion Cracking of Inconel-600 Penetrations". In this report, the CEOG concluded that the safety significance of the observed failures is inconsequential due to the following factors: 1) the observed failures were of an axial orientation which means circumferential failure is not credible, 2) fracture mechanics and fatigue crack growth analysis have shown that the axial indications would propagate in a stable and predictable manner, and 3) the resulting loss of pressurizer shell material, due to primary water induced corrosion should a crack initiate, is acceptable.

Technical Specifications:

Technical Specification (TS) 3.4.5.2a, "Reactor Coolant System Operational Leakage", stipulates that no pressure boundary leakage shall occur during Modes 1, 2, 3, and 4. With any pressure boundary leakage present in these Modes, the Unit must be placed in at least Hot Standby within 6 hours and in cold shutdown within the following 30 hours.

C. DESCRIPTION OF THE EVENT:

1. Event:

On 2/18/92, with Unit 3 in Mode 6 and defueled during the Cycle 6 refueling outage, a dye-penetrant examination (PT) of the # 6A pressurizer vapor space instrument nozzle revealed the presence of a through wall crack. The inspection was prompted by earlier observations of rust and boric acid crystals in the vicinity of the nozzle connection to the pressurizer. These observations were made during routine Mode 3 walkdowns of the RCS following shutdown for the refueling outage.

On 3/14/92, with Unit 2 in Mode 3 following a shutdown for reasons unrelated to this event, the Unit 2 pressurizer instrument nozzles were similarly inspected for indications of leakage. Two of the four vapor space nozzles exhibited signs of leakage similar to that found in Unit 3. As a result, Unit 2 was taken to Mode 5 for repairs.

Since it is likely that these conditions existed in Modes of reactor operation during which no RCS pressure boundary leakage is allowed (i.e.; Modes 1, 2, 3, and 4), TS 3.4.5.2a is considered not to have been satisfied for both Units 2 and 3.

2. Inoperable Structures, Systems or Components that Contributed to the Event:

Not Applicable.

3. Sequence of Events:

Not Applicable.

4. Method of Discovery:

See Section C.1 above.

5. Personnel Actions and Analysis of Actions:

Not Applicable.

6. Safety System Responses:

Not Applicable.

D. CAUSE OF THE EVENT:

The cause of the leakage noted at the pressurizer instrument nozzles has been attributed to PWSCC. This conclusion is substantiated by the fact that the operating environment in the pressurizer vapor space is known to be consistent with PWSCC in Inconel 600 material, and the axial orientation of the observed indications (as determined from dye penetrant examination of the leaking # 6A nozzle associated with Unit 3) is consistent with PWSCC as observed and studied in pressurizers at several nuclear plants, including SONGS 3 in 1986 (ref. LER 86-003, Docket Number 50-362).

Detailed laboratory testing and analysis of the leaking Unit 3 # 6A nozzle was performed. The indications were not examined since they were altered during the process of removing the nozzle from the pressurizer. However, the testing did show signs that the nozzle had been cold worked on the inner diameter surface and was machined in a non-uniform manner during fabrication. These conditions could have provided crack initiation sites and therefore may have accelerated the PWSCC process.

During the interim repair of the Unit 2 pressurizer nozzles, portions of the nozzles farthest from the weld region were removed. Analysis and evaluation of the removed nozzle portions suggests that the crack indications in the weld areas may have resulted from nozzle fabrication defects and/or cold working during fabrication.

E. CORRECTIVE ACTIONS:

1. Corrective Actions Taken:

Unit 3:

a. The # 6A vapor space instrument nozzle was replaced with a new nozzle made of thermally treated Inconel 690. Inconel 690 has been shown to be less susceptible to PWSCC and is the current industry accepted replacement for Inconel 600.

b. PTs of the three remaining vapor space instrument nozzles were performed and revealed much smaller indications in two of the three nozzles; however, no leakage was observed or evident in these locations. These three nozzles were also replaced with nozzles fabricated from Inconel 690.

c. During the fabrication of the new nozzles, added precautions were taken to ensure precision machining with minimal cold work and no defects.

d. The water space instrument nozzles were visually inspected for external signs of leakage. No signs of leakage were evident.

Unit 2:

a. The two Unit 2 nozzles, which showed signs of leakage, were repaired with an interim repair which replaced portions of the leaking nozzles with Inconel 690. The interim repair was evaluated and determined to be acceptable for at least 1 refueling interval.

b. The five remaining instrument nozzles (2 of which are located in the vapor space and 3 in the water space) were visually inspected for signs of boric acid and leakage. No signs of leakage were observed.

2. Planned Corrective Actions:

a. During the next scheduled refueling outage (Cycle 7), all of the Unit 2 pressurizer vapor space instrument nozzles will be replaced with nozzles fabricated from Inconel 690 or equivalent.

b. A periodic inspection plan will be developed to monitor and track the performance of the Inconel 690 replacement nozzles. This plan will also address inspection requirements of the remaining Inconel 600 nozzles in both Units 2 and 3.

c. SCE will continue to be involved with the CEOG and other industry groups until final resolution of the PWSCC in Inconel 600 issue.

F. SAFETY SIGNIFICANCE OF THE EVENT:

SCE has concluded that the existence of a through wall pressurizer vapor space nozzle crack is of minimal safety significance as discussed below.

Industry experience, in addition to calculations and analysis performed by the CEOG, demonstrates that cracks which result from PWSCC will initiate and propagate in the axial direction due to predominantly circumferential stresses. Therefore, catastrophic circumferential failure is not credible. Additionally, fracture mechanics analysis demonstrates that a 2 inch crack at normal RCS temperatures and pressures has a high safety factor against any additional crack growth due to mechanical means. This evidence suggests that catastrophic failure of an Inconel 600 nozzle due to PWSCC is not credible.

The SONGS leakage detection methodology has proven capable of detecting very small through wall cracks, as evidenced by the 1986 Unit 3 pressurizer nozzle crack, which was more severe than those recently observed (ref. LER 86-003, Docket Number 50-362). Leakage associated with the bounding 2 inch crack noted above, would therefore have been detected, allowing the implementation of appropriate TS Action requirements regarding RCS leakage.

Although Edison does not believe that catastrophic failure is credibel; the consequences of such a failure are bounded by the small break LOCA analyzed in the UFSAR. The leakage area introduced by the complete failure of an instrument nozzle is substantially less than the smallest area evaluated in the UFSAR for small break LOCAs. Thus, a catastrophic failure of an instrument nozzle is bounded by previous analysis.

G. ADDITIONAL INFORMATION:

Previous LERs for Similar Events:

LER 86-003, Revision 1, (Docket No. 50-362) reported a small RCS pressure boundary leak in a 3/4 inch diameter pressurizer level instrument nozzle. The cause was attributed to PWSCC and the nozzle was cut out and replaced. Further evaluation determined that two other vapor space nozzles and one water space nozzle at SONGS 3, as well as, one water space nozzle at SONGS 2, were fabricated from the heat of material as the failed nozzle. These nozzles were all subsequently replaced with new Inconel 600 nozzles.