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October 18, 1989

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

Subject: Docket No. 50-206
Revised Report
Licensee Event Report No. 89-001, Revision 1
San Onofre Nuclear Generating Station, Unit 1

Reference: Letter, H. E. Morgan (SCE) to USNRC Document Control Desk, dated January 23, 1989

The referenced letter provided Licensee Event Report (LER) No. 89-001, for an condition involving the reactor vessel thermal shield support system. Enclosed is a revision to this LER which provides additional information concerning the cause and corrective action.

If you require any additional information, please so advise.

Sincerely,

HEMorgan

Enclosure: LER No. 89-001, 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 1	0 5 0 0 0 2 0 6	1 of 0 7

Title (4)
REACTOR VESSEL THERMAL SHIELD SUPPORT BLOCK BOLTS OUT OF TOLERANCE

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)
0 1	0 8	8 9	8 9	0 0 1	0 1	1 0	1 8	8 9	NONE	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): 0

POWER LEVEL (10): 0 0 0

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)
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)	50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
20.405(a)(1)(iv)	X 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)	
H. E. Morgan, Station Manager	7 1 4	3 6 8 - 6 2 4 1

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

Yes (If yes, complete EXPECTED SUBMISSION DATE) XX NO

Expected Submission Date (15) Month Day Year

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

On 1/8/89, with Unit 1 in Mode 6 for the Cycle 10 refueling outage, after performing a remote video camera inspection of the thermal shield support system, it was observed that three thermal shield support block bolts were out of tolerance. Three bolts, two on one support block and one on another support block, were protruding from the inner surface of the core barrel by an amount that exceeds normal, original assembly, tolerance. The remaining four blocks and their bolts were acceptable. The three bolts protruding from the inner surface of the core barrel are postulated to have failed. The cause of the failure is believed to be high-cycle fatigue due to flow induced vibration.

As corrective action all accessible support features have been inspected by remote video camera. The bottom of the reactor vessel has been inspected and no broken bolts were found. Engineering analysis has been performed to verify that continued operation through fuel Cycle 10 would not degrade the thermal shield support system to an extent which would lead to significant damage of core internals. Also, analysis has shown that significant loose parts, leading to flow blockage, would not be generated; and that increased vibration due to loose parts, or further bolt failure could be monitored.

License Amendment Number 127 provides for a thermal shield monitoring program which has been implemented and will be continued until the thermal shield fasteners are restored to their designed functional condition during the 10-year ASME Inservice Inspection planned for the fuel Cycle-11 refueling outage. The refueling outage is scheduled to begin no later that June 30, 1990. A conceptual design and plan for restoring the thermal shield supports was submitted on October 6, 1989.

Plant: San Onofre Nuclear Generating Station
Unit: One
Reactor Vendor: Westinghouse
Event Date: 1-8-89

A. CONDITIONS AT TIME OF THE EVENT:

Mode: 6, Refueling

B. BACKGROUND INFORMATION:

The thermal shield, located between the core barrel and the reactor vessel [RV], reduces neutron induced, reactor vessel embrittlement. The thermal shield is cylindrical, approximately 10 feet in height and about 2.5 inches thick. The thermal shield is supported at the bottom by six support blocks and a system of dowel pins and bolts. The shield is supported at the top by six flexures and four displacement limiting keys. The flexures are designed to provide tangential and radial restraint of the thermal shield. The flexures are evenly spaced between the top of the thermal shield and the core barrel. Five of the six flexures have been known to be failed since 1978 (further historical information has been submitted by item d of Section G, subsection 4, Supportive Documentation). The four displacement limiting keys are located approximately 9.5 inches below the top of the thermal shield and initially limit the relative radial motion between the thermal shield and the core barrel.

The six lower support blocks are located every 60 degrees around the thermal shield. Each support block is fastened to the core barrel by two long bolts, three short bolts and two dowel pins. The thermal shield is fastened to the support block by the two long bolts and two additional dowel pins. The bolt holes travel continuously through the core barrel, permitting the threaded end of the bolts to protrude from the core barrel surface opposite the thermal shield.

As this condition underwent an extensive review by the NRC staff, there exists a substantial amount of documented technical information which has previously been provided to the NRC. This information may be found in the documents listed in Section G, Additional Information.

C. DESCRIPTION OF THE EVENT:

1. Event:

On 1/8/89, with Unit 1 in Mode 6 for the Cycle 10 refueling outage, after performing a remote video camera inspection of the thermal shield support system, it was revealed that three thermal shield support block bolts were out of tolerance. Three bolts, two on one support block and one on another support block, were protruding from the inner surface of the core barrel by an amount that exceeded the normal, original assembly, tolerance.

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

   Five of the six upper flexure supports are known to have been failed since 1978. These failures may have contributed to or may have resulted from the cause of the lower support block bolt protrusion.

3. Sequence of Events:

   Not applicable.

4. Method of Discovery:

   In response to an alert from the reactor vendor that thermal shield fasteners at another facility had been found degraded, engineers (utility, nonlicensed) inspected the accessible thermal shield supports using a remote video camera.

5. Personnel Actions and Analysis of Actions:

   Not applicable.

6. Safety System Responses:

   Not applicable.

D. CAUSE OF THE EVENT:

1. Immediate Cause:

   The three bolts protruding from the inner surface of the core barrel are postulated to have failed and traveled inward, away from the thermal shield toward the center of the reactor vessel. The cause of the failure is believed to be high-cycle flow induced vibration. Reactor coolant flows into the reactor vessel above and perpendicular to the thermal shield longitudinal axis. The coolant is directed parallel to the longitudinal axis and down between the vessel and shield, and then redirected at the bottom of the vessel up to the core. As a result of the flow redirection and velocity, turbulence is created which is characterized by local pressure variations. The pressure variations induce vibrational displacement forces on the thermal shield.

2. Intermediate Cause:

The vibrational forces combined with differential thermal movement between the thermal shield and the core barrel caused excessive wear of the displacement limiting keys and failure of five flexures. In this degraded condition, the thermal shield natural frequency shifted to a range that is more susceptible to turbulence excitation forces. As a result, the high-cycle fatigue limit of the support block bolts was exceeded.

In support of conclusions resulting from this cause determination, similar flexures at another facility were determined to have failed early in life during hot functional testing due to flow induced high-cycle fatigue. The symptoms of the degradation were similar to those found here. However, the time to failure at San Onofre Unit 1 is much longer. Four of the six flexures were inspected in 1971 and 1972 (at approximately 4.1 EFPY) and found to be intact (two flexures could not be inspected). In 1976 (at approximately 7.3 EFPY), all six flexures were inspected; two of the flexures were found to have failed since the 1972 inspection, and two of the flexures, which could not be inspected in 1971 and 1972, were found to have failed (i.e., their failure could have occured anytime between 1967 and the 1976 inspection). In 1978 (at approximately 8 EFPY), an additional flexure was observed to have failed. The difference in the operating time to failure, between Unit 1 and the other facility, is consistent with the high-cycle fatigue analysis when several factors are considered:

a) The displacement limiting keys at the other facility restrained less radial movement than those at Unit 1. Thus, additional radial displacement was permitted at the other facility.

b) The flow velocity at the other facility was greater than at Unit 1. Thus, larger local pressure variations caused higher vibrational forces at the other facility.

3. Root Cause:

Our root cause investigation is continuing and will draw upon data obtained from the retrieval of the bolts and subsequent metallurgical analysis. At this time it is believed that the root cause of the bolt failure is inadequate appraisal of the effects that flow induced vibration have on support bolt loading.

E. CORRECTIVE ACTIONS:

1. Corrective Actions Taken:

a. All accessible support features have been inspected by remote video camera.

b. The bottom of the reactor vessel has been inspected and no broken bolts or dowel pins were found.

c. Engineering analysis has been performed to verify that continued operation through fuel Cycle 10 would not lead to catastrophic support failure and would not lead to further significant degradation of the supports. Also, analysis has shown that significant loose parts, leading to flow blockage, would not be generated; and that increased vibration due to loose parts, further key wear or bolt failure could be monitored.

d. A conceptual design and plan for restoring the thermal shield supports was submitted to the NRC October 6, 1989.

2. Planned Corrective Actions:

License Amendment Number 127 provides for a thermal shield monitoring program which has been implemented. The monitoring program will be continued until the thermal shield fasteners are restored to their designed functional condition during the 10-year ASME Inservice Inspection planned for the fuel Cycle-11 refueling outage which is scheduled to begin by June 30, 1990.

F. SAFETY SIGNIFICANCE OF THE EVENT:

There is no safety significance to this occurrence since the thermal shield continues to be adequately supported and degradation of the support system has not resulted in loose parts which may obstruct cooling flow to the core.

G. ADDITIONAL INFORMATION:

1. Component Failure Information:

The three bolts which are postulated to have failed were supplied by Westinghouse Electric Corporation of ASTM A193, Type B8M (316) stainless steel. One bolt is 2.75 inches long by 0.75 inches diameter. The other two bolts were 5 inches long by 0.875 inches diameter.

2. Previous LERs for Similar Events:

None.

3. Results of NPRDS Search:

Not applicable.

4. Supportive Documentation:

Significant information has been submitted to the NRC in support of the observations, analyses, conclusions, and corrective actions related to this occurrence. This LER serves as a summary of this information pursuant to regulatory reporting requirements. A list of these documents follows:

a. Letter, H. E. Morgan (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, 30-Day Report, Licensee Event Report No. 89-001, San Onofre Nuclear Generating Station, Unit 1, dated January 23, 1989. Enclosure: LER 89-001, Reactor Vessel Thermal Shield Support Block Bolts Out Of Tolerance.

b. Viewgraphs, Southern California Edison and Westinghouse Electric presented to NRC staff, Subject: Technical Presentation on Issues Related to Degraded Fasteners for Thermal Shield Support Blocks at San Onofre Unit 1, dated January 27, 1989.

c. Letter, Charles M. Trammell (NRC) to Kenneth P. Baskin (SCE), Subject: Summary of Meeting Held on January 27, 1989, RE: Broken Bolts Found in Reactor Vessel Thermal Shield, dated February 8, 1989.

d. Letter, Kenneth P. Baskin (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Amendment Application No. 165, San Onofre Nuclear Generating Station, Unit 1, dated February, 17 1989.

e. Letter, F. R. Nandy (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Response on Issues Related to Degraded Fasteners for Thermal Shield Support Blocks, San Onofre Nuclear Generating Station, Unit 1, dated March 21, 1989.

f. Letter, F. R. Nandy (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Response To Thermal Shield Questions, San Onofre Nuclear Generating Station, Unit 1, dated March 23, 1989.

g. Letter, Kenneth P. Baskin (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Supplement 1 to Amendment Application No. 165, San Onofre Nuclear Generating Station, Unit 1, dated May, 3, 1989.

h. Letter, Kenneth P. Baskin (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Revision to Supplement 1 to Amendment Application No. 165, San Onofre Nuclear Generating Station, Unit 1, dated May 8, 1989.

i. Letter, Charles M. Trammell (NRC) to Kenneth P. Baskin (SCE), Subject: Issuance of Amendment No. 127 to Provisional License, San Onofre Nuclear Generating Station, Unit No. 1 (TAC No. 71853), dated May 15, 1989.

j. Letter, F. R. Nandy (SCE) to U. S. Nuclear Regulatory Commission, Subject: Docket No. 50-206, Thermal Shield Conceptual Design and Repair Plan, San Onofre Nuclear Generating Station, Unit 1, dated October 6, 1989.