May 30, 2001

U.S. Nuclear Regulatory Commission
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DOCKET 50-255 - LICENSE DPR-20 - PALISADES PLANT
LICENSEE EVENT REPORT 01-002, CONTROL ROD DRIVE SEAL HOUSING LEAK AND CRACK INDICATIONS

Licensee Event Report (LER) 01-002 is attached. The LER describes the discovery of a through-wall crack in a control rod drive seal housing which comprises a portion of the Primary Coolant System pressure boundary. This condition was found following plant shutdown for a routine refueling outage.

This event is reportable in accordance with 10 CFR 50.73(a)(2)(ii)(A).

SUMMARY OF COMMITMENTS

This letter contains no new commitments and no revisions to existing commitments.

Douglas E. Cooper
Plant General Manager

CC Administrator, Region III, USNRC
Project Manager, NRR, USNRC
NRC Resident Inspector - Palisades

Attachment

IE22

NRC FORM 366 (1-2001) | U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

APPROVED BY OMB NO. 3150-0104 | EXPIRES 6-30-2001

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)

CONTROL ROD DRIVE SEAL HOUSING LEAK AND CRACK INDICATIONS

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
										05000
03	31	2001	2001	– 002 –	00	05	30	2001	FACILITY NAME	DOCKET NUMBER
										05000

OPERATING MODE (9)	3
POWER LEVEL (10)	0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check all that apply) (11)

20.2201(b)	20.2203(a)(3)(ii)	50.73(a)(2)(ii)(B)	50.73(a)(2)(ix)(A)
20.2201(d)	20.2203(a)(4)	50.73(a)(2)(iii)	50.73(a)(2)(x)
20.2203(a)(1)	50.36(c)(1)(i)(A)	50.73(a)(2)(iv)(A)	73.71(a)(4)
20.2203(a)(2)(i)	50.36(c)(1)(ii)(A)	50.73(a)(2)(v)(A)	73.71(a)(5)
20.2203(a)(2)(ii)	50.36(c)(2)	50.73(a)(2)(v)(B)	OTHER Specify in Abstract below or in NRC Form 366A
20.2203(a)(2)(iii)	50.46(a)(3)(ii)	50.73(a)(2)(v)(C)	
20.2203(a)(2)(iv)	50.73(a)(2)(i)(A)	50.73(a)(2)(v)(D)	
20.2203(a)(2)(v)	50.73(a)(2)(i)(B)	50.73(a)(2)(vii)	
20.2203(a)(2)(vi)	50.73(a)(2)(i)(C)	50.73(a)(2)(viii)(A)	
20.2203(a)(3)(i)	X 50.73(a)(2)(ii)(A)	50.73(a)(2)(viii)(B)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
RICHARD J. GERLING, LICENSING SUPPORT SUPV	616-764-2594

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
B	AA	DRIV	C490	Y					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE).	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On March 31, 2001, during an inspection of the reactor head area following shutdown for a refueling outage, a boric acid deposit and a small amount of water were found on the Control Rod Drive Mechanism (CRDM) seal housing for Control Rod Drive (CRD)-22. The CRD seal housing assemblies comprise a portion of the ASME Class 1 Primary Coolant System (PCS) pressure boundary. The housing was removed from the reactor vessel head when conditions permitted. Subsequent investigation confirmed the presence of reactor coolant system through-wall leakage through a small (approx. 0.70 inches long) circumferentially oriented crack on the inside diameter of the seal tube. The housing also contained a confirmed axial crack (approx. 0.05 inches long) that was not through-wall. All 44 remaining seal housings were removed for examination. 100% of the seal tubes were inspected using visual and/or fluorescent dye penetrant non-destructive examination (NDE) methods. In addition to CRD-22, the inspections confirmed a circumferentially oriented crack (approx. 0.15 inches long) in CRD-8 that was not through-wall. No other crack-like indications were confirmed. A total of 13 seal housings were not returned to service due to NDE indications, confirmed cracks (in CRD-22 and CRD-8), or mechanical seal performance deficiencies.

Thirteen new Inconel (Alloy 600) housings were installed on the reactor vessel head. The cracking confirmed in CRD-22 and CRD-8 has been determined to be transgranular stress corrosion cracking (TGSCC), most likely resulting from inadequate post-weld heat treatment which left residual stresses of sufficient magnitude to support cracking.

EVENT DESCRIPTION

During an inspection of the reactor head area following shutdown for a refueling outage, a boric acid deposit and a small amount of water were found on the Control Rod Drive Mechanism (CRDM) [DRIV] seal housing for Control Rod Drive (CRD)-22 (serial number 2966-87). The CRD seal housing assemblies comprise a portion of the ASME Class 1 Primary Coolant System (PCS) [AB] pressure boundary. The housing was removed from the reactor vessel head when conditions permitted. Subsequent investigation confirmed the presence of reactor coolant system through-wall leakage through a small (approx. 0.70 inches long) circumferentially oriented crack on the inside diameter of the seal tube in the vicinity of the weld attaching the housing tube to the autoclave flange. The housing also contained a confirmed axial crack (approx. 0.05 inches long) that was not through-wall. All 44 remaining seal housings were removed for examination. 100% of the seal tubes were inspected using visual and/or fluorescent dye penetrant non-destructive examination methods. Inspection activities focused on the dye penetrant examination since it has proven to be reliable for identifying small, tight cracks experienced in these CRD seal housings.

The inspections revealed the following information:

One housing (in addition to the housing in the location of CRD-22) was confirmed to have a crack which was not through-wall. This housing was located in the position of CRD-8 and is serial number (S/N) 2966-65. It was not returned to service.

Five housings were found to have crack-like indications as evidenced by the fluorescent dye penetrant examination. Replication of these indications was attempted, but the crack-like indication was removed during the replication process. None of these housings were returned to service. These housings were serial numbers: 2966-69,- 89,-108,-109, and -110. S/N 2966-108 was in the location of CRD-44 and was found to have an inclusion (not a crack) which will need to be repaired if it is ever to be placed in service again.

A total of 13 seal housings were not returned to service due to either NDE indications, confirmed cracks (in CRD-22 and CRD-8), or mechanical seal performance deficiencies. Thirteen new Inconel (Alloy 600) housings were installed on the reactor vessel head.

ANALYSIS OF EVENT

Each control rod at Palisades is driven by an electric motor through a drive shaft and bevel gears which engage a rack assembly coupled to the control rod. The drive shaft is offset from, and parallel to, the axis of its associated control rod. Figure 1 provides a sketch of the CRD seal housing assembly configuration. The primary coolant pressure boundary is provided by a rotating mechanical seal located at the top of the seal housing tube. The lower flange of the seal housing (autoclave flange) is fastened to the support tube with the autoclave nut. The lower region of the seal housing below the mechanical seal provides the primary coolant pressure boundary. The drive motor and clutch assembly mount on the atmospheric side of the mechanical seal at the top of the seal housing. The tool access tube penetrates the autoclave flange directly above the rack assembly. The tool access tube provides access for coupling and uncoupling rods, and is closed with a blank flange when the primary coolant system is filled.

This event is a direct extension of the event described in LER 99-004. That LER provided a detailed description of the configuration, materials, fabrication and operating conditions of the CRD seal housings. It

concluded that the observed cracking was due to transgranular stress corrosion cracking (TGSCC), combined with an inadequate post-weld heat treatment of the Type 347 stainless steel seal housings during manufacture, which left residual stresses of sufficient magnitude to promote the initiation of cracking. As described in LER 99-004, following the 1999 event, all 45 seal housings were removed and examined using some combination of visual, dye penetrant, eddy current and/or ultrasonic inspection techniques. Appropriate repairs were made, and only housings believed to be acceptable were returned to service.

The 2001 destructive examination of the CRD-22 seal housing confirmed that the observed through-wall crack was caused by the same mechanism(s) observed in 1999, although the crack's existence was unexpected due to the extensive repair and examination efforts that had been completed in 1999. The CRD-22 seal tube was segmented and subjected to detailed inspection of the fracture surface. A cross section cut of the fracture surface was taken as well. The fracture surface revealed four different colorations. Adjacent to the ID crack line, a significant discoloration of the steel was detected. This apparent oxidation layer indicated a significant time of fluid exposure. Other local areas of the crack surface indicated similar, but much lighter, discoloration. The entire fracture surface of the housing tube was not able to be recovered during the process of cutting the specimen from the housing. Significant ductile tearing was observed adjacent to the ID crack where the tube segment had been separated for inspection and evaluation. These observations confirmed the crack propagation mechanism to be TGSCC. Although the age of the crack could not be determined, the apparent oxidation layer suggested it may have existed in 1999. For the crack to have existed in 1999, either the repair methods used in 1999 (flap wheel polishing operations) had some potential to move material over small existing cracks, rendering them undetectable, or the limitations of the inspection techniques could have contributed to not detecting a small microstructure crack.

While extensive inspections and corrective actions were completed during the 1999 refueling outage, and the cause of the cracking is considered well defined, it has been recognized and reported (in LER 99-004) that investigations into alternate seal housing designs and/or materials were necessary. These investigations have led to the change in design and material to the new Alloy 600 seal housings replaced in 13 locations during the 2001 refueling outage. The Alloy 600 housing design is expected to address the most fundamental issues associated with the CRD cracking over the past 15 years. The Alloy 600 material is not amenable to stress corrosion cracking at the relatively low housing temperatures and it does not contain the seal tube-to-housing weld responsible for a complicated residual stress pattern. In addition, it was subject to a controlled heat treatment that is intended to prevent generation of a separate set of residual stresses. By placing only 13 Alloy 600 housings in service, Palisades can evaluate the suitability of the new design in actual service conditions prior to a full-scale implementation.

SAFETY SIGNIFICANCE

This event is of minimal safety significance. Total failure of a CRD seal housing due to this cracking phenomenon without prior detection is not considered credible. Based on past experience with cracks and leakage in CRD seal housings at Palisades, only tight cracks and small leakage have occurred. The seal tube itself is believed to have very high design margins to failure from circumferential cracks, given that the design axial pressure stress (from design PCS pressure) is less than one-tenth the ultimate strength of the Type 347 material. Plant Technical Specification LCO 3.4.13.b limits Primary Coolant System operational leakage to one gallon per minute of unidentified leakage. In the event of reaching this limit, Technical Specification Action Statement B of LCO 3.4.13 directs the initiation of a controlled plant shutdown. In addition, plant operations Off Normal Procedures also direct that the plant be manually tripped upon leakage increase to 20 gallons per

minute. The unlikely total failure of any one of the housings would be equivalent to an approximate 2 1/4 inch diameter small break loss of coolant accident (SBLOCA). SBLOCA is an analyzed event that has been demonstrated to result in acceptable consequences.

CAUSE OF THE EVENT

The apparent cause of this condition is transgranular stress corrosion cracking (TGSCC), combined with an inadequate post-weld heat treatment of the Type 347 stainless steel seal housing assemblies during manufacture which left residual stresses of sufficient magnitude to promote the initiation of cracking.

CORRECTIVE ACTIONS

Corrective Actions Taken:

1. All 45 CRD seal housings in service during the last operating cycle were examined. 100% of the seal tubes were inspected. Any indications noted were characterized as to nature and extent.

2. Thirteen new Inconel (Alloy 600) housings were installed on the reactor vessel head.

Corrective Actions Remaining:

1. A plan for the replacement of the remaining stainless steel control rod drive housings with Inconel (Alloy 600) housings will be developed. This will be based on the performance of the 13 newly installed housings.

PREVIOUS LERs

LER 86-40	01/16/87	Cracking of Control Rod Drive Seal Housing
LER 86-40, Rev 1	02/16/87	Cracking of Control Rod Drive Seal Housing
LER 86-40, Rev 2	04/16/87	Cracking of Control Rod Drive Seal Housing
LER 86-40, Rev 3	12/02/87	Cracking of Control Rod Drive Seal Housing
LER 98-14	01/26/99	Control Rod Drive Seal Housing Leak
LER 99-004	12/01/99	Control Rod Drive Seal Housing Leaks and Crack Indications
LER 99-004-001	11/08/00	Control Rod Drive Seal Housing Leaks and Crack Indications

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NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)* **(17)**

FIGURE 1

Control Rod Drive Seal Housing