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AEP
INDIANA
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POWER

March 8, 2000

United States Nuclear Regulatory Commission
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Docket No. 50-315

Document Control Manager:

In accordance with the criteria established by 10 CFR 50.73 entitled Licensee Event Report System, the following report is being submitted:

LER 315/1998-011-03, "LER Retraction - Containment Liner Pitting"

No commitments were identified in this submittal.

If you have any questions, please contact Mr. Robert C. Godley, Director, Regulatory Affairs, at 616/465-5901, extension 2698.

Sincerely,

M. W. Rencheck
Vice President – Nuclear Engineering

/mbd
Attachment

c: J. E. Dyer, Region III
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NRC Resident Inspector

IE22

NRC Form 366 (6-1998) 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 06/30/2001

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TITLE (4)

LER Retraction - Containment Liner Pitting

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 NAME	DOCKET NUMBER
03	05	1998	1998	--	011	--	03	03	08	2000	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	5	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)							
POWER LEVEL (10)	00		20.2201 (b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
			20.2203(a)(1)		20.2203(a)(3)(i)		50.73(a)(2)(ii)		50.73(a)(2)(x)
			20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
			20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)	X	OTHER
			20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or n NRC Form 366A
			20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
M. B. Depuydt, Regulatory Compliance	616/465-5901, x1589

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX

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)

This revision replaces LER 315/98-011-02 in its entirety.

On March 5, 1998, with Unit 1 in Mode 5, an inspection of the steel containment liner identified pitting resulting in the thickness of the steel containment liner being less than 0.250 inches. The pitting of the 3/8-inch steel liner plate occurred along the moisture barrier seal near the containment cylinder base, at the top of the fill-slab over the containment basemat. With pitting of this magnitude the steel containment liner could have potentially not met the stress assumptions made in the design basis. An ENS notification was made at 1522 hours EST on March 5, 1998, under 10 CFR 50.72(b)(2)(i) for a condition outside the design basis, and LERs 315/98-011-00; -01 and -02 were submitted under 10CFR50.73(a)(2)(ii).

The presence of the corrosion and pitting was attributed to the lack of procedural controls requiring rigorous inspection to verify the integrity of the moisture barrier seals essential for corrosion protection of the liner plate. Appropriate visual examinations were performed in and around the accessible floor-liner seal surface area. The existing degraded seal was removed and replaced with new seals. Absence of corrosion at deeper depths was confirmed through additional investigations.

A detailed engineering analysis of the as-found condition of the containment indicated that the ability of the as-found liner to withstand normal and accident loads satisfied design basis assumptions and that the leaktight integrity of the containment has not been impaired. As it has been determined that the as-found condition previously reported does not represent a condition outside the design basis, this LER is hereby retracted.

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

Conditions Prior to Event
Unit 1 was in Mode 5, Cold Shutdown.

Description of Event
In response to NRC IN 97-10, "Liner Plate Corrosion in Concrete Containments", a visual inspection of the Unit 1 containment liner plate was performed in March 1998. On March 5, 1998, the inspection revealed indications of corrosion and pitting of the 3/8-inch steel liner plate along the moisture barrier seal near the containment cylinder base at EL 598 feet, 9-3/8 inches (elevation of top of fill-slab over the containment basemat). The thickness of remaining sound metal at several corrosion pits was less than 0.250 inches, the minimum thickness specified by Engineering for acceptance of the inspection results without a detailed engineering analysis. There were 61 locations where the depth of corrosion pits exceeded 0.125 inches, with pit depth ranging from 0.141 inches to a maximum of 0.172 inches at four locations. With pitting of this magnitude, it was judged that the steel containment liner might not meet the assumptions made in the design basis.

This event was reported in accordance with 10 CFR 50.72(b)(2)(i), as a condition that was found while the reactor was shutdown and which, if it had been found while the reactor was operating, would have resulted in the nuclear power plant being in an unanalyzed condition. The ENS notification was made at 1522 hours EST on March 5, 1998. LERs 315/98-011-00, -01 and -02 were submitted in accordance with 10 CFR 50.73(a)(2)(ii).

Cause of Event
The presence of the corrosion and pitting can be attributed to the lack of procedural controls requiring rigorous inspection of the liner and its seals.

Since the original installation of the liner plate until 1991, no inspection procedure existed. In December 1989, IN 89-79, "Degraded Coatings and Corrosion of Steel Containment Vessels" was issued by the NRC describing the potential for corrosive deterioration of steel containment liners. In response to these notices, inspections were performed of Unit 1 and Unit 2 liner plate coatings in upper and lower containment, and found the coatings acceptable. The scope of these coating inspections did not include inaccessible areas such as those where the current pitting was discovered nor did it include the liner seals. No acceptance criteria were included in the referenced procedure developed in 1991.

In May 1991, Engineering Guideline EG-CE-001, "Protective Coating Surveillance Inspections", was developed for containment coating inspection. The guideline provided adequate information on assessing the condition of the protective coatings; however, it focused on a listing of future coating maintenance and not on an assessment of the integrity of the existing protective coating or the liner. In short, the engineering guideline provided general simplified inspection criteria but did not provide a comprehensive program.

Analysis of Event
During the detailed condition survey performed following the initial discovery of potential liner corrosion, sporadic corrosion with numerous pitted surfaces in the containment shell liner were observed along the moisture barrier seal near the cylinder base. The area affected by corrosion was found confined within a band of approximately 4 to 5 inches in height near the seal.

Visual and magnetic particle examinations indicated no evidence of the presence of sharp notches or micro cracks that could be considered evidence of acute stress raisers.

Pit-gage measurements showed sixty-one locations where the measured corrosion depth exceeded 0.125 inches, with the pit depths ranging from 0.141 inches to a maximum of 0.172 inches at four locations. Ultrasonic test (UT) measurements of

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the thickness of the remaining sound metal at these sixty-one locations showed that there were 44 locations where the thickness of the remaining sound metal was less than 0.250 inches.

An in-depth engineering investigation was performed to determine the conditions that caused the corrosion and the effects of corrosion on the structural integrity of the liner.

Cause of Corrosion:
The corrosion was determined to be due to moisture and oxygen infiltrating below the seal region through degraded seals and contacting the liner. A properly maintained seal would have prevented such an occurrence. The degradation of the liner seals went unnoticed because the plant procedures did not consider the maintenance of the integrity of the seals essential for corrosion protection of the liner. The absence of appropriate inspection procedures allowed the degradation of the liner seals to go undetected.

Structural and Leaktight Integrity Evaluation:
Structurally, the steel liner is not a strength element acting independently or in conjunction with the concrete containment to resist the design loads. The sole function of the liner is to serve as a leaktight pressure boundary and, as such, a very thin liner is adequate to perform the function. As was customary, the liner thickness for the Donald C. Cook (CNP) containments was originally established from constructability considerations.

An in-depth structural evaluation was performed to evaluate the effects of corrosion on the structural and leaktight integrity of the containment structure, taking into account the corrosion-damaged condition of the steel liner in the annular space near its cylinder base. This evaluation assessed the safety function of the liner through the identification of the sources and nature of strains imposed on the liner and the liner anchors critical to design basis maintenance. Through the determination of the effects of corrosion on the mechanical properties and fatigue resistance of the liner plate material, the analysis then evaluated the impact of the corrosion on its design basis including its anchorage system and the containment structure. This evaluation then concluded that:

1. The design basis for the concrete containment structure, the containment liner, or the liner anchorage system was not degraded by the reported inservice corrosion conditions of the containment liner plate.

2. The thickness of the remaining sound metal was adequate to maintain the design safety function of the liner as a leaktight membrane.

3. The ultimate pressure capacity of the concrete containment structure to withstand Severe Accident pressure was not degraded by the reported inservice corrosion conditions of the containment liner plate.

Effects of Corrosion on the Mechanical Properties:
These were evaluated utilizing recently conducted experimental studies of a similar 1/16" thick steel plate material with comparable corrosion and pitting. Sandia National Laboratories conducted these studies on corroded liner material.

In these studies, several samples of ASTM A 516 plates were intentionally corroded and then tested to failure in uniaxial tension. The corrosion damage inflicted on the plates included corrosion and pitting and simulates corrosion as observed at CNP. Test coupons from corroded liner plates reached the same yield and ultimate tensile stress levels as uncorroded test specimens, leading to the conclusion that corrosion damage does not adversely affect the yield and ultimate tensile strength of the liner plate.

Even though the ultimate stress reached by the corroded and uncorroded specimens were the same, corroded test specimens showed considerable reduction in the total elongation at failure indicating the adverse effect of corrosion on

ductility due to stress/strain concentrations around pits and on the rough uneven corroded surfaces. Necking of the corroded specimens began around 12 percent strain and reached an ultimate strain of only 14 percent. In contrast, uncorroded test specimens exhibited necking at 24 percent strain and reached an ultimate strain of 28 percent. This reduction in effective ductility is the primary significant difference in mechanical properties between a corroded and an uncorroded specimen.

The evaluation for fatigue resistance indicated that the number of containment load and thermal cycles that the liner would experience during the plant life is insignificant compared to the large design fatigue life of the uncorroded liner. The corroded plate can easily endure this relatively very small number of load cycles without incurring any fatigue-related degradation. Therefore, the results of the referenced studies indicate that with the exception of a reduction in the effective ultimate strain, the mechanical properties, including the stress-strain curves for the liner and its anchorage system, remain unchanged.

The original safety margin factor for the liner intended by the conservative design basis allowable liner strain limit of 0.005 inch/inch and an ultimate liner strain assumed to be constrained by the weld strain limit of 17 percent or 0.17 inch/inch is calculated to be equal to 34. The calculated margin in the uncorroded liner is 85, the ratio of the liner ultimate strain limit of 0.17 inch/inch (assumed to be constrained by the weld strain limit of 17 percent) and the actual membrane tensile strain level of 0.002 inch/inch in the liner.

The calculated margin in the corroded liner is 70, the ratio of the effective ultimate tensile strain limit of 14 percent or 0.14 inch/inch in the corroded liner and the actual membrane tensile strain level of 0.002 inch/inch in the liner. Therefore, the attrition in margin due to corrosion from its uncorroded condition is not significant and the original safety margin factor of 34 is not affected.

Because the original design basis of the containment structure does not take any credit for the steel liner as a structural element, the design basis structural integrity of the containment structure to resist normal operating and Design Basis Accident loads is not affected by the corroded condition of the liner.

For severe accidents, the ultimate internal pressure capacity of the reinforced concrete containment structure was evaluated. The ultimate internal pressure capacity of the containment is governed by the capacity of the personnel airlock door and is equal to 32.3 pounds per square inch gage (psig) based on the specified minimum material strength and 45.1 psig based on the mean actual material strength. The ultimate internal pressure capacity of the reinforced concrete portion of the containment is governed by flexural bending and shear in the basemat and is equal to 45.8 psig based on the specified minimum material strength and 54.5 psig based on the mean actual material strength. The minimum internal pressure capacity of the reinforced concrete cylinder near the base in the meridional direction based on the specified minimum yield stress of 40,000 pounds per square inch (40 ksi) in the reinforcing steel and neglecting the strength of the liner is 72.15 psig.

Therefore, the design basis structural integrity of the containment to withstand Normal Operating, Design Basis Accident, and Severe Accident loads is not impaired by the observed corrosion damage to the liner in the annular space near the cylinder base.

Based on the results of this evaluation, it was concluded that the structural integrity of the containment to withstand normal operating, DBA, and severe accident loads was not affected by the as-found condition of the liner. The leaktight integrity of the containment was not impaired, and the liner, as found, would have fulfilled its function as an effective leaktight membrane. Therefore, as it has been determined that the as-found condition previously reported does not represent a condition outside the design basis, this LER is hereby retracted.

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Corrective Actions

Corrective actions for this condition, including visual examination of the liner and replacement of the seal, were provided to the NRC in Restart Action Plan 12.

Previous Similar Events

N/A