

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

June 18, 2010

NRC INFORMATION NOTICE 2010-12: CONTAINMENT LINER CORROSION

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of or applicants for a standard design certification, standard design approval, manufacturing license, or combined license issued under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent issues involving corrosion of the steel reactor containment building liner. The NRC expects recipients to review the information for applicability to their facilities and to consider actions, as appropriate, to avoid similar problems. The suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Beaver Valley Power Station

On April 23, 2009, during a refueling outage at Beaver Valley Power Station, Unit 1, the licensee performed a visual examination of the interior reactor containment building steel liner in accordance with Subsection IWE, "General Visual Examination," of American Society of Mechanical Engineers (ASME) Section XI of the Boiler and Pressure Vessel Code, "Rules for Inservice Inspection of Nuclear Power Plant Components." At a containment elevation of 746 feet, the licensee identified an area approximately 3 inches in diameter that exhibited blistered paint. The paint blister was intact at the time of discovery. Collapse of the blister during further inspection revealed a protruding rust product underneath. The licensee then cleaned this area to allow further evaluation. The cleaning activity uncovered a rectangular area of approximately 1 inch (horizontal) x 3/8 inch (vertical) that penetrated through the entire liner plate thickness. Ultrasonic testing (UT) of the surrounding area showed liner thinning within an area of approximately 10 square inches. The licensee removed the corroded section of the liner and discovered a partially decomposed piece of wood approximately 2 inches x 4 inches x 6 inches embedded in the concrete behind the section of the liner. The wood was left behind as

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a result of inadequate housekeeping and quality assurance practices during the original construction of the containment wall in the early 1970s.

The licensee determined that the cause of the through-wall liner corrosion was a pitting-type corrosion (rust) originating from the concrete side caused by foreign material (wood) that was in contact with the containment carbon steel liner. Licensee corrective actions included removing the embedded wood, grouting the concrete area that was displaced by the wooden debris, and welding a new section of steel plate to replace the previously removed portion of the liner. The licensee also scheduled an examination of the containment liner during the next refueling outage at Beaver Valley Power Station Units, 1 and 2 to visually inspect 100 percent of the accessible liner area. In addition, the licensee stated in its license renewal submittals that it would perform: (a) supplemental volumetric examinations of 1-square-foot samples in at least 75 random locations of each unit's containment liner in order to statistically determine whether the containment liner is unacceptably degraded by corrosion originating from the concrete side; and (b) supplemental volumetric examinations of a minimum of eight one-foot square locations in the accessible areas of liner plate at locations that operating experience shows are susceptible to localized pitting corrosion.

Additional information is available in Beaver Valley Licensee Event Report 50-334/2009-003-00, dated June 18, 2009, and Beaver Valley Power Station, Unit 1, NRC Routine Inspection Report 05000334/2009006, dated July 6, 2009, which can be found on the NRC's public Web site under Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML091740056 and ML091870328, respectively.

Brunswick Steam Electric Plant

During a refueling outage in 2008 at Brunswick Steam Electric Plant, Unit 1, the licensee performed a VT-1 visual inspection of the primary containment penetration sleeve for the personnel air lock and found two bulged areas. The discovery of thinned areas on the bulges led the licensee to perform UT examinations of the entire Unit 1 personnel air lock penetration sleeve. These additional UT inspections identified many discrete locations that were below the minimum wall thickness established by the design-basis containment liner specification.

During construction, the outside diameter of the sleeve was wrapped with two layers of 1/4 inch felt and the felt was covered with a layer of 60 mil ethylene propylene film. The felt was intended to permit the sleeve to expand when subjected to thermal loading. The licensee's evaluation determined that the bulges were caused by corrosion product buildup between the sleeve and the concrete backing. This corrosion was caused by the felt that wrapped the outside of the containment penetration sleeve; which became wet during the original construction.

Samples of the degraded areas of the sleeve and felt wrapping were sent to the licensee's center for evaluation of potential ongoing corrosion mechanisms. These evaluations identified that the pitting and corrosion on the concrete side of the sleeve were caused by under-deposit corrosion.

Licensee corrective actions include installing a new concentric sleeve inside the personnel air lock penetration to repair the existing containment penetration sleeve. Following this planned modification, the new sleeve will become the primary containment liner for this penetration.

Salem Nuclear Generating Station

In October 2009, at Salem Nuclear Generating Station Unit 2, the licensee inspected the containment moisture barrier (the silicone RTV [room temperature vulcanizing] seal between the concrete floor and containment liner) and found heavy corrosion on the containment liner within 6 inches of the concrete floor. This area of the containment liner was considered inaccessible because it was normally covered by an insulation package that consisted of a layer of sheet metal, a layer of plastic sheeting, and a layer of insulation. The licensee had not inspected the containment liner areas covered by this insulation because ASME Code Section XI allowed an exemption for inaccessible areas. In response to this discovery, and as a conservative approach to the license renewal process, the licensee decided to enhance inspections of the containment liner above the moisture barrier within about 6 inches of the concrete floor and to randomly inspect several other areas that were covered by the insulation package. To perform the inspections, the licensee removed that portion of the insulation package that extended below the lower leak detection channel for the entire containment liner circumference, and cut through and removed the insulation package for four other randomly selected areas. Licensee inspections in these four areas identified some corrosion but subsequent ultrasonic measurements did not indicate significant wall loss.

To evaluate the effect of the identified general corrosion on the safety function of the containment boundary and to meet the expanded inspection requirements of ASME Code Section XI, the licensee performed ultrasonic testing of 440 locations on the bottom 6 inches of the cylindrical portion of the containment liner. Based on the results of the measurements at these locations, the licensee determined that the liner remained operable because the lowest thickness measured was 0.677 inches, which was above the design-required minimum wall thickness of 0.43 inches. The actual safety significance of this general corrosion was minor because there was significant design margin for the liner in this area.

The licensee reviewed the circumstances that led to the identified areas of heavy corrosion on the liner and determined that previous containment liner inspections were not performed adequately. Specifically, examinations should have identified evidence of corrosion (rust on floor) and prompted removal of lagging to determine the source of the corrosion products.

The licensee determined that the source of the moisture that caused the liner corrosion at the joint between the containment liner and concrete floor was service water leakage from the containment fan coil units and associated piping. Licensee corrective actions included conducting frequent containment walk-downs to identify, isolate, and repair any identified service water leaks; verifying that the leakage from existing service water leaks did not reach the containment liner; and, until the base of the containment liner is re-coated during a future refueling outage, revising procedures to ensure liner inspections were performed when containment service water leaks were identified. In addition, the licensee stated in its license renewal submittals that it would perform supplemental and augmented examinations of the liner plates at random and non-random locations.

BACKGROUND

Related NRC communications include the following:

- IN 2004-09, "Corrosion of Steel Containment and Containment Liner," dated April 27, 2004 (ADAMS Accession No. ML041170030)
- IN 1997-10, "Liner Plate Corrosion in Concrete Containments," dated March 13, 1997 (ADAMS Accession No. ML031050365)

DISCUSSION

This IN provides examples of containment liner degradation caused by corrosion. Concrete reactor containments are typically lined with a carbon steel liner to ensure a high degree of leak tightness during operating and accident conditions. The reactor containment is required to be operable as specified in plant technical specifications to limit the leakage of fission product radioactivity from the containment to the environment. The regulations at 10 CFR 50.55a, "Codes and Standards," require the use of Subsection IWE of ASME Section XI to perform inservice inspections of containment components. The required inservice inspections include periodic visual examinations and limited volumetric examinations using ultrasonic thickness measurements. The containment components include the steel containment liner and integral attachments for the concrete containment, containment personnel airlock and equipment hatch, penetration sleeves, moisture barriers, and pressure-retaining bolting. The NRC also requires licensees to perform leak rate testing of the containment pressure-retaining components and isolation valves according to 10 CFR Part 50, Appendix J, "Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors," as specified in plant technical specifications. This operating experience highlights the importance of good quality assurance, housekeeping and high quality construction practices during construction operations in accordance with 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

Operating experience shows that containment liner corrosion is often the result of liner plates being in contact with objects and materials that are lodged between or embedded in the containment concrete. Liner locations that are in contact with objects made of an organic material are susceptible to accelerated corrosion because organic materials can trap water that combined with oxygen will promote carbon steel corrosion. Organic materials can also cause a localized low pH area when they decompose. Organic materials located inside containment can come in contact with the containment liner and cause accelerated corrosion. However, corrosion that originates between the liner plate and concrete is a greater concern because visual examinations typically identify the corrosion only after it has significantly degraded the liner. In some cases, licensees identified such corroded areas by performing ultrasonic examination of suspect areas (e.g., areas of obvious bulging, hollow sound).

The objects and materials that caused liner corrosion that licensees have found lodged between or embedded in the containment concrete include both foreign material (e.g., wooden pieces, workers' gloves, wire brush handles) and material that was deliberately installed as part of the design such as the felt material described in the above example at Brunswick Steam Electric

Plant, Unit 1. Although there is no regulatory requirement to do so, one or more licensees have chosen to review design documents to identify locations where organic material was intentionally installed between the liner or penetration sleeve and schedule additional examinations of these areas to monitor for liner material loss.

GENERIC IMPLICATIONS

In response to the above through-wall corrosion at Beaver Valley Power Station, Unit 1, the NRC Office of Nuclear Reactor Regulation requested the NRC Office of Regulatory Research to begin an assessment to better understand the possible mechanisms responsible for through-wall corrosion of containment liners. The NRC staff has also engaged committee members for ASME Section XI to devise a formal tracking mechanism to monitor industry experience and events involving containment liner corrosion. Subsection IWE of ASME Section XI could then be updated using insights from these events.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or to the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/RA/

Timothy McGinty, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

/RA by MShuaibi for/

Glenn Tracy, Director
Division of Construction Inspection and
Operational Programs
Office of New Reactors

Technical Contacts: Mike Brown, NRR
301-415-4096
E-mail: Michael.Brown@nrc.gov

William Jessup, NRR
301-415-2972
E-mail: William.Jessup@nrc.gov

Paul Klein, NRR
301-415-4030
E-mail: Paul.Klein@nrc.gov

Note: NRC generic communications may be found on the NRC public Web site, <http://www.nrc.gov>, under Electronic Reading Room/Document Collections.

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Technical Contacts: Mike Brown, NRR
301-415-4096
E-mail: Michael.Brown@nrc.gov

William Jessup, NRR
301-415-2972
E-mail: William.Jessup@nrc.gov

Paul Klein, NRR
301-415-4030
E-mail: Paul.Klein@nrc.gov

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