

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

March 26, 2014

NRC INFORMATION NOTICE 2014-04: Potential for Teflon<sup>®</sup> Material Degradation in Containment Penetrations, Mechanical Seals and Other Components

## ADDRESSEES

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

All holders of and applicants for a power reactor early site permit, combined license, standard design approval, or manufacturing license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Reactors." All applicants for a standard design certification, including such applicants after initial issuance of a design certification rule.

## PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of the potential for Teflon<sup>®1</sup> material degradation affecting containment penetrations, containment personnel airlocks, pump seals, and other components. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

## DESCRIPTION OF CIRCUMSTANCES

### Fort Calhoun Station

On May 1, 2012, the Omaha Public Power District (the licensee or OPPD) at Fort Calhoun Station (FCS) submitted Licensee Event Report (LER) 2012-002-00, "Inadequate Qualifications for Containment Penetrations Renders Containment Inoperable," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12208A313) and follow up report LER 2012-002-01, dated July 2, 2013 (ADAMS Accession No. ML13184A270). These reports informed the NRC that an environmental qualifications (i.e., qualifications to ensure that equipment will be capable of withstanding the ambient conditions under an accident scenario) review identified multiple containment electrical penetrations that use Teflon<sup>®</sup> seals.

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<sup>1</sup> Teflon<sup>®</sup> or polytetrafluoroethylene (PTFE) material is a synthetic fluoropolymer of tetrafluoroethylene that has numerous applications. The most well-known brand name of PTFE is Teflon<sup>®</sup> which is a registered trademark of the DuPont Company.

**ML13330B698**

The containment seals consist of an inboard and outboard section of Teflon<sup>®</sup> for each electrical penetration.

The licensee had previously identified and replaced Teflon<sup>®</sup> seals on safety related (Class 1E<sup>2</sup>) containment electrical penetrations but did not replace them on the non-Class 1E penetrations. The remaining seals were classified incorrectly as non-safety-related based solely on their electrical function, even though they have a safety function to maintain containment integrity. Following a review of environmental qualification records in May 2012, OPPD performed a dose analysis on the non-Class 1E containment penetration electrical seals to determine if they would maintain containment leak integrity. The analysis determined that the inboard and outboard Teflon<sup>®</sup> seals would receive failure threshold doses during a design basis accident (DBA). The degraded inboard seal would fail in a DBA environment, reducing the safety margin. The leak integrity would then depend on the outboard Teflon<sup>®</sup> seal. Additional functional testing on seals in the laboratory confirmed this finding but also indicated that the external seal would be exposed to less severe environmental conditions and would remain in place due in part to the surrounding electrical penetration and electrical cables. However, the testing did not reproduce conditions that would exist following a DBA.

On June 10, 2013, the NRC staff completed a team inspection at FCS (Inspection Report No. 05000285/2013008 (ADAMS Accession No. ML13197A261). The NRC inspection team determined that from initial construction to the present, the licensee did not perform adequate analysis and/or post-accident condition functional testing of the Teflon<sup>®</sup> insulated and Teflon<sup>®</sup> sealed electrical penetration assemblies to determine if they were suitable for expected post-accident conditions. As a corrective action, the licensee replaced or capped all Teflon<sup>®</sup>-insulated containment electrical penetration assemblies.

In addition, LER 2013-006-00, "Use of Teflon<sup>®</sup> in LPSI [low-pressure safety injection] and CS [containment spray] Pump Mechanical Seals," dated May 3, 2013 (ADAMS Accession No. ML13126A121) and follow-up report LER 2013-006-01, dated August 26, 2013 (ADAMS Accession No. ML13239A120) identified that the mechanical seals used in certain safety related pumps at FCS also contain Teflon<sup>®</sup>. The increased radiation during a DBA could rapidly degrade the Teflon<sup>®</sup> and the increased pressure, temperature, and steam could penetrate the seals, resulting in failure of the associated safety systems.

As described in LER 2013-06-00, the Teflon<sup>®</sup> mechanical seals used in LPSI pumps and CS pumps might adversely affect the integrity of the pumps under certain accident conditions. LER 2013-06-01 stated, "Failure of Teflon<sup>®</sup> seals may have hindered the pumps' ability to operate in post-accident conditions. A failure of one or more pumps could have resulted in insufficient cooling water to keep the core and the containment cooled ...." Causal analysis determined the original construction specifications did not adequately specify a compatible material for the pump seals. As corrective actions, the licensee is performing a material compatibility review and will restrict the use of Teflon<sup>®</sup>. The licensee replaced the affected pump seals prior to startup.

In addition to the recent experience at Fort Calhoun, the potential for Teflon<sup>®</sup> material degradation affecting components has been discussed in 10 CFR Part 21, "Reporting of defects

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<sup>2</sup> Institute of Electrical and Electronics Engineers (IEEE), IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Piscataway, NJ. NOTE: The terms "Class 1E equipment" and "safety related electric equipment" are synonymous.

and noncompliance” notifications, LERs, and NRC Inspection and Enforcement Circulars associated with experience at Vermont Yankee, Fermi 2, and with Foxboro transmitters.

### Vermont Yankee

On June 19, 1985, the licensee at Vermont Yankee issued 10 CFR Part 21 Notification 85-287 (ADAMS Accession No. ML14052A079) that identified four Conax containment personnel airlock electrical penetrations which contained Teflon<sup>®</sup> insulation and sealant materials. As part of the corrective actions, the licensee stated that it intended to replace the penetrations with ones that contain materials which are more radiation resistant and further recommended that all licensees using Conax electrical penetrations investigate the construction of all safety and non-safety related electrical penetrations to determine if they contained Teflon<sup>®</sup>.

On November 2, 1990, the licensee submitted LER 90-014-00 (ADAMS Accession No. 9011160182<sup>3</sup>) which stated that Teflon<sup>®</sup> seal material existed in the containment personnel airlock. The seals were located where shafts penetrate a bulkhead and in stem packing and seals for equalizing valves. The Teflon<sup>®</sup> that existed in the airlock seals had characteristic material damage limits in the range of  $10^4$  to  $10^6$  rad. For containment design, the Vermont Yankee DBA radiation dose is  $8 \times 10^7$  rad, one order of magnitude greater than that required for Teflon<sup>®</sup> material damage. Therefore, the Teflon<sup>®</sup> material could potentially fail under accident conditions and compromise primary containment. The licensee took prompt corrective actions to comply with the DBA dose limit by replacing the Teflon<sup>®</sup> in the shaft seals with graphite and the equalizing valves with equivalent valves that use metallic seats.

### Fermi 2

On February 28, 1991, the Fermi 2 licensee was notified by Whittaker Electronic Resources Division that a flow switch manufactured by Chem-Tec for the Exo-Sensor Hydrogen/Oxygen monitoring system could contain Teflon<sup>®</sup>, rather than Tefzel, lead wire insulation. Teflon<sup>®</sup> is not qualified for the postulated radiation environment encountered following a design basis Loss of Coolant Accident. See LER 05000341/ 91-003-01, ADAMS Accession No. 9106120238<sup>4</sup>. The root cause of this condition was a breakdown in the procurement process between Whittaker Electronic Resources Division and their flow switch supplier, Chem-Tec, and inadequate work instructions for the Raychem repair of the flow switch. Whittaker filed a 10 CFR Part 21 report with the NRC and the flow switch was replaced during the unit’s next Refueling outage with a flow switch containing Tefzel insulated lead wires.

### Foxboro Transmitters

NRC Inspection and Enforcement Circular 81-06, “Potential Deficiency Affecting Certain Foxboro 10 To 50 Milliampere Transmitters,” (ADAMS Accession No. 8011040288<sup>4</sup>) was issued after the NRC staff received a Technical Letter from Foxboro regarding deficiencies identified in certain E-10 Series Foxboro transmitters which could adversely affect their operation during DBA conditions. According to Foxboro, the Teflon<sup>®</sup> insulation material in question had demonstrated a tendency to embrittle and deteriorate when subjected to an integrated radiation dose of 200 megarads. A total integrated dose of 200 megarads was called for in the qualification test sponsored by the Utility Transmitter Qualification Group which led to Foxboro’s discovery of the Teflon<sup>®</sup> insulation qualification deficiency.

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<sup>3</sup> The text of this document is available in the legacy library portion of ADAMS.

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## DISCUSSION

Although previous industry efforts have addressed the replacement of Teflon<sup>®</sup> material for equipment that are relied upon to remain functional during and following design basis events, Teflon<sup>®</sup> seals and insulation may remain in use as recently identified at FCS. General Design Criteria require among other things that reactor containment penetrations, regardless of their electrical classification, be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident. In other words, the non-Class 1E electrical penetration seals have a pressure-boundary safety-related function for maintaining containment integrity. Therefore, they must be able to accommodate the effects of, and to be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents as required by the General Design Criteria. Similarly, safety related mechanical equipment such as pump seals and valve seats must maintain their integrity under accident conditions as required by the General Design Criteria.

With respect to maintaining containment integrity, all containment electrical penetrations should be designated safety-related, designed to American Society of Mechanical Engineers (ASME) Section III, seismic category 1, and should be Type B tested under 10 CFR Part 50 Appendix J, "Primary reactor containment leakage testing for water-cooled power reactors."

In addition, specific requirements pertaining to qualification of certain electric equipment important to safety are contained in § 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants," of 10 CFR Part 50. Section 50.49 requires that three categories of electric equipment important to safety be qualified for their application and specified performance and provides requirements for establishing environmental qualification methods and qualification parameters. These three categories are (1) safety-related electric equipment (Class IE), (2) non-safety-related electric equipment (non-Class IE) whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions by safety-related equipment, and (3) certain post-accident monitoring equipment. This equipment is relied upon to remain functional during and following design basis events to ensure the integrity of the reactor coolant pressure boundary; the capability to shut down the reactor and maintain it in a safe shutdown condition; or the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guidelines in § 50.34(a)(1), § 50.67(b)(2), or § 100.11.

In accordance with paragraph 50.49(k), applicants for and holders of operating licenses are not required to requalify electric equipment important to safety (replacement equipment excepted) in accordance with the provisions of this section if the NRC has previously required qualification of that equipment in accordance with "Guidelines for Evaluating Environmental Qualification of Class IE Electrical Equipment in Operating Reactors" (DOR Guidelines), or NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment." These applicants and licensees may continue to use the criteria in these documents for qualifying electric equipment important to safety in the affected plants, with the exception of replacement equipment.

The following documents contain additional related information and guidance.

- A. Electrical Power Research Institute, "Guidance for Accident Function Assessment for [Risk-Informed Safety Class] RISC-3 Applications," Final Report 1009748, October 2005, Palo Alto, CA (ADAMS Accession No. ML12041A226). (Note: This EPRI document has not been endorsed by the NRC.) This document specifically discusses exclusion of Teflon<sup>®</sup> from components in elevated radiation environments.
- B. Westinghouse Electric Company, "AP1000<sup>®</sup> Design Control Document," Rev. 19, Tier 2 Chapter 3, Appendix 3D, "Methodology for Qualifying AP1000 Safety-Related Electrical and Mechanical Equipment" (ADAMS Accession No. ML11171A437) addresses new reactors. In Attachment C, "Effects of Gamma Radiation Doses Below 1E4 Rads on the Mechanical Properties of Materials," beginning on page 3D-87, this document summarizes the available information about the effects of gamma radiation on the material mechanical properties of Teflon<sup>®</sup> and indicates that it is susceptible to alteration at a gamma dose of less than 10<sup>5</sup> rads.
- C. ASME QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Facilities," as endorsed by Regulatory Guide 1.100, Revision 3, "Seismic Qualification Of Electrical And Active Mechanical Equipment And Functional Qualification Of Active Mechanical Equipment For Nuclear Power Plants," provides guidance for the qualification of nonmetallic parts used in nuclear safety-related active mechanical equipment that can be used for new reactor design and construction.

## CONTACT

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

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Note: NRC generic communications can be found on the NRC public Web site, <http://www.nrc.gov>, under NRC Library.

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- B. Westinghouse Electric Company, "AP1000® Design Control Document," Rev. 19, Tier 2 Chapter 3, Appendix 3D, "Methodology for Qualifying AP1000 Safety-Related Electrical and Mechanical Equipment" (ADAMS Accession No. ML11171A437) addresses new reactors. In Attachment C, "Effects of Gamma Radiation Doses Below 1E4 Rads on the Mechanical Properties of Materials," beginning on page 3D-87, this document summarizes the available information about the effects of gamma radiation on the material mechanical properties of Teflon® and indicates that it is susceptible to alteration at a gamma dose of less than 10<sup>5</sup> rads.
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ADAMS Accession No.: ML13330B698

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