UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
OFFICE OF FEDERAL AND STATE MATERIALS AND
ENVIRONMENTAL MANAGEMENT PROGRAMS
OFFICE OF NEW REACTORS
WASHINGTON, DC 20555-0001

October 26, 2012

NRC INFORMATION NOTICE 2009-23, SUPPLEMENT 1: NUCLEAR FUEL THERMAL CONDUCTIVITY DEGRADATION

ADDRESSEES

All holders of operating licenses and construction permits for nuclear power reactors under the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," *including* 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 an early site permit, standard design certification, standard design approval, manufacturing license, or combined license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

All holders of, and applicants for, a certificate of compliance for a spent nuclear fuel transportation package under 10 CFR Part 71, "Packaging and Transportation of Radioactive Material."

All holders of a certificate of compliance for a spent fuel storage cask and all holders of a license for an independent spent fuel storage installation under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to notify addressees of information related to the impact of irradiation on fuel thermal conductivity. This supplement to IN 2009-23, "Nuclear Fuel Thermal Conductivity Degradation" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML091550527), dated October 8, 2009, complements the information previously presented regarding fuel thermal performance analysis codes that do not account for fuel thermal conductivity degradation (TCD). In particular, this IN supplement reflects that the NRC has issued letters to the major fuel vendors requesting they evaluate the magnitude of the effects of thermal conductivity degradation on relevant safety analysis parameters. The major fuel vendors have been and are currently working towards improved fuel thermal performance codes that incorporate TCD models. The NRC expects the recipients to review the information within this IN for applicability

to their facilities and consider actions, as appropriate. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

BACKGROUND

Irradiation damage and the progressive buildup of fission products in fuel pellets result in reduced thermal conductivity of the pellets. However, there are fuel thermal performance codes approved by the NRC that do not include models for this behavior. NUREG/CR-6534, Volume 1, "FRAPCON-3: Modifications to Fuel Rod Material Properties and Performance Models for High-Burnup Application" (ADAMS Accession No. ML092950544), issued in October 1997, describes that TCD had been considered negligible when end-of-life burnup levels were less than 4 atom percent but may no longer be negligible as commercial fuel has operated to higher burnup levels of 7 atom percent and greater. NUREG/CR-6534 describes that measurements collected from an instrumented assembly at the Halden ultra-high-burnup experiment during the 1990s showed TCD of approximately 5 to 7 percent for every 10 gigawatt-days per metric tonne of exposure. Based on these experimental data, the NRC updated its confirmatory fuel thermal-mechanical performance software, FRAPCON, to account for TCD as a function of exposure.

Since that time, several reactor fuel vendors have submitted improved fuel thermal performance codes to the NRC for review and approval. These new codes incorporate updates to the fuel thermal conductivity models that account for degradation caused by irradiation. The improved vendor models generally considered experimental qualification data that were substantially similar to the data considered in NUREG/CR-6534. However, the NRC staff is aware that many computer codes that do not account for TCD are still used to perform safety analyses.

DESCRIPTION OF CIRCUMSTANCES

The NRC staff has concerns that fuel thermal performance codes that do not model TCD as a function of burnup, when used at multiple points within the body of the safety analyses, may result in the downstream effect of calculated safety limit margins that are less conservative than previously understood. Following the issuance of IN 2009-23, the NRC staff completed a preliminary review of the impact of fuel thermal conductivity models on the reactor safety analysis codes by the major fuel vendors. The NRC staff determined through this review that several currently approved analysis methods provide results that are less conservative than previously understood. As a result, the NRC issued letters containing the NRC staff's assessment to the major fuel vendors (ADAMS Accession Nos. ML11166A052, ML120580690, and ML120680571) requesting the vendors evaluate the magnitude of the effect of fuel thermal conductivity degradation on relevant safety analysis parameters (e.g., fuel centerline temperature, peak cladding temperature, and rod internal pressure) and determine whether specified acceptable fuel design limits (SAFDLs) for any licensing basis analysis using relevant models and codes are exceeded if TCD as a function of burnup is included in the analysis.

The NRC staff was presented with information from Westinghouse Electric Company that showed the inclusion of an updated thermal conductivity degradation model in the safety analysis could cause compliance issues with 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors." In response, the NRC staff issued IN 2011-21, "Realistic Core Cooling System Evaluation Model Effects Resulting from Nuclear Fuel Thermal Conductivity Degradation" (ADAMS Accession No. ML113430785), dated December 13, 2011, which addresses the potential for TCD to cause

significant errors in realistic emergency core cooling system (ECCS) evaluation models. The NRC staff also issued letters pursuant to 10 CFR 50.54(f) to several licensees that use Westinghouse-furnished realistic ECCS evaluation models to request additional information regarding the effects of the error associated with TCD.

The responses from the major fuel vendors and licensees included interim solution methods that are being evaluated by the NRC staff. The NRC staff understands that the major fuel vendors are currently working towards an appropriate resolution of this issue.

DISCUSSION

General Design Criterion (GDC) 10, "Reactor Design," in Appendix A, "General Design Criteria for Nuclear Power Plants," of 10 CFR Part 50, establishes that licensees should not exceed SAFDLs during any condition of normal operation, including the effects of anticipated operational occurrences, to ensure that the fuel is not damaged. The general requirements to maintain control rod insertability and core coolability appear in GDC 27, "Combined Reactivity Control Systems Capability," and GDC 35, "Emergency Core Cooling." In particular, 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," provides the specific coolability requirements for a loss-of-coolant accident. In addition, 10 CFR 50.46(a)(3) specifies requirements for evaluating and reporting each change to, or error discovered in, an acceptable evaluation model.

Technical specifications require licensees to submit a report on core operating limits that incorporates the revised cycle-specific parameters resulting from the new core configuration implemented during the refueling outage. Technical specifications also require that the analytical methods used to determine the core operating limits be those previously reviewed and approved by the NRC. Licensees rely on computer codes for fuel performance calculations and to perform safety analyses. Within the scope of reload licensing evaluations, they use these computer codes to establish cycle operating limits to ensure that all applicable requirements (e.g., fuel thermal-mechanical limits, core thermal-hydraulic limits, ECCS limits, and nuclear design limits) are met.

The simulation of the fuel element is an integral part of the safety analyses. Within the analyses, the fuel pellet thermal conductivity model determines the rate at which heat is transferred from the fuel pellet, first to the gas gap, then to the fuel cladding, and finally to the coolant. A lower fuel pellet conductivity results in higher fuel temperatures at a given linear heat-generation rate. Therefore, the analytical prediction of the fuel thermal conductivity will affect the results of several types of safety analyses. If fuel thermal performance codes contain models that misrepresent fuel thermal conductivity, then calculated margins to SAFDLs and other limits may be less conservative than previously understood.

GENERIC IMPLICATIONS

Safety analyses performed for reactors using methods that do not model TCD as a function of burnup may be less conservative than previously understood.

Lower fuel pellet conductivity does not appear to significantly influence spent nuclear fuel cladding temperatures that are typically estimated for aged spent nuclear fuel during dry cask storage and transportation operations.

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 NRC project manager.

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

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