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

December 13, 2011

NRC INFORMATION NOTICE 2011-21: REALISTIC EMERGENCY CORE COOLING SYSTEM EVALUATION MODEL EFFECTS RESULTING FROM NUCLEAR FUEL THERMAL CONDUCTIVITY DEGRADATION

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 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."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to notify addressees of recent information obtained concerning the impact of irradiation on fuel thermal conductivity, and its potential to cause errors (specifically, higher predicted peak clad temperature results) in realistic emergency core cooling system (ECCS) evaluation models. [This IN uses the term error consistent with applicable NRC regulations described below regarding "the effect of any change to or error in an acceptable evaluation model." The modeling error in this IN was discovered as a result of research that provided new data and greater understanding of the phenomenon and as such, the word error in this IN is not intended to convey culpability.] The NRC expects the recipients to review the information within this IN for applicability to their facilities and consider actions, as appropriate, for their facility. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

An NRC licensee recently sponsored an analysis to determine the effect that accounting for fuel thermal conductivity degradation due to irradiation would have on the results of a realistic emergency core cooling evaluation that it was proposing to implement. The analysis determined that the effect would be significant in that the predicted peak fuel cladding

temperature from the most severe postulated loss-of-coolant accident would increase by more than 50 degrees Fahrenheit (°F).

The licensee asked for this analysis during the NRC staff's review of its request to implement the ASTRUM realistic Westinghouse Electric Company (WEC) ECCS evaluation model. The licensee's analysis addressed issues discussed in IN 2009-23, "Nuclear Fuel Thermal Conductivity Degradation," dated October 8, 2009. As discussed in IN 2009-23, currently approved fuel performance codes that provide input to realistic ECCS models may not account for fuel thermal conductivity degradation.

Because the licensee currently uses an evaluation model that treats fuel thermal conductivity degradation differently than does the evaluation model that it is proposing to use, there is no immediate safety concern for this licensee. Also, because the results of the licensee's analysis do not cause its proposed results to exceed the acceptance criteria at 10 CFR 50.46(b), the NRC's review of the licensee's request is not affected.

BACKGROUND

IN 2009-23 describes how legacy fuel performance codes may overpredict fuel rod thermal conductivity at higher burn-ups based on new experimental data.

Since the NRC's issuance of IN 2009-23, the vendors of fuel performance analysis codes, and the downstream safety analyses that rely on their results, have engaged with the NRC through numerous public meetings and written correspondence. The vendors have adjusted legacy codes so that the codes correlate better with more recent fuel performance data. The vendors, and the NRC licensees that use these vendors' analytic methods, have been working to quantify the impact of the issue identified in IN 2009-23 on downstream safety analyses.

The operating experience described above indicates that the realistic emergency core cooling evaluation models developed by WEC, which rely on the Fuel Rod Performance and Design (PAD) Code for fuel thermal mechanical performance data, are susceptible to errors of similar magnitude to the plant-specific results described above. As described by 10 CFR 50.46(a)(3)(i), these errors may be significant. Note that the analytic treatment of fuel burnup differs among the realistic ECCS evaluation models, and the impact described in this IN pertains to results obtained using the ASTRUM model.

DISCUSSION

Based on the conclusions reached by this licensee's analyses, the NRC believes that correcting for the effect of this error could cause a number of plant-specific ECCS evaluations to predict significantly higher peak cladding temperatures that exceed the 10 CFR 50.46(b)(1) acceptance criterion.

WEC has indicated that the approved evaluation models contain substantial conservatisms that would more than compensate for this issue, and that as a result, there is no issue of immediate safety concern. The NRC is currently verifying WEC's claims that the evaluation model

conservatisms compensate for the ECCS evaluation model error caused by fuel thermal conductivity degradation.

WEC has stated that the impact of modeling thermal conductivity degradation needs to be considered in the realistic evaluation model methodology because research has provided new data and greater understanding of the phenomenon. According to the vendor, explicit incorporation of thermal conductivity degradation modeling would represent an enhancement to analytic capabilities and not correction of an error. The NRC staff does not agree with WEC's characterization.

Applicable Regulatory Requirements

In 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," the NRC provides the requirements for ECCSs and their evaluations; specifically, 10 CFR 50.46(a)(1)(i) requires the following of realistic ECCS models:

> Each boiling or pressurized light-water nuclear power reactor… must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model…

According to 10 CFR 50.46(a)(1)(i), an acceptable evaluation model has the following characteristics:

> …the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident…
>
> …when the calculated ECCS cooling performance is compared to the criteria set forth in paragraph (b) of this section, there is a high level of probability that the criteria would not be exceeded.

According to 10 CFR 50.46(b)(1), the calculated maximum fuel element cladding temperature shall not exceed 2,200 °F.

Under 10 CFR 50.46(a)(3)(i), the NRC requires licensees to estimate the effect of any change to or error in an acceptable evaluation model or in the application of such a model to determine whether the change or error is significant. For the purposes of 10 CFR 50.46, a significant change or error is one that results in a calculated peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last acceptable model, or that is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F.

Finally, 10 CFR 50.46(a)(3)(ii) promulgates requirements for reporting estimated changes to or errors in ECCS evaluation models, or applications thereof, to the Commission, stating the following:

> If the change or error is significant, the applicant or licensee shall provide this report within 30 days and include with the report a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with §50.46 requirements…
>
> Any change or error correction that results in a calculated ECCS performance that does not conform to the criteria set forth in paragraph (b) of this section is a reportable event as described in §§ 50.55(e), 50.72, and 50.73. The affected… licensee shall propose immediate steps to demonstrate compliance or bring plant design or operation into compliance with § 50.46 requirements.

GENERIC IMPLICATIONS

The NRC has initiated conversations with WEC to address the generic implications of this information. Specifically, these discussions involve other susceptible plants and licensee requirements as provided in 10 CFR 50.46. The NRC will continue considering the safety and regulatory aspects of the information.

CONCLUSION

A potentially significant, as described in 10 CFR 50.46(a)(3)(i), ECCS evaluation model error has been identified. Licensees using WEC realistic ECCS evaluation models may wish to contact the vendor for assistance in estimating the effect this error may have on plant-specific ECCS evaluation results.

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 project managers in the Office of Nuclear Reactor Regulation or Office of New Reactors.

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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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