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

June 28, 2012

NRC INFORMATION NOTICE 2012-09: IRRADIATION EFFECTS ON FUEL ASSEMBLY SPACER GRID CRUSH STRENGTH

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 inform addressees of operating experience involving evaluations of fuel assembly structural response to external loads and associated issues the NRC staff identified during recent reviews of fuel designs for design certification applications. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Operating experience regarding the effects of in-reactor service on fuel assembly component response to externally applied forces challenge existing NRC staff guidance. Operating experience from Framatome ANP, Inc. and a fuel design certification application submitted under 10 CFR Part 52 by Mitsubishi Heavy Industries, Ltd., show that the crush strength of fuel assembly spacer grids may decrease during the life of a fuel assembly; whereas, the review guidance contained in the NRC standard review plan is based on an assumption regarding the combined effects of operating conditions on grid strength. Additional information is documented in Framatome ANP, Inc., "Closure of Interim Report 02-002, "Spacer Grid Crush Strength - Effects of Irradiation," dated August 8, 2003, which can be found on the NRC's public Web site in the Agencywide Documents Access and Management System (ADAMS) at Accession No. ML032240425, and in Mitsubishi Heavy Industries, Ltd., "Transmittal of the Revised Technical Report MUAP-08007-P/NP(R2)," dated December 20, 2010 (ADAMS Accession No. ML103640170).

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BACKGROUND

Earthquakes and postulated pipe breaks in the reactor coolant system can result in external forces on fuel assemblies. The fuel assembly structural response to these externally applied forces is evaluated to ensure the fuel system satisfies requirements to maintain control rod insertability and core coolability in 10 CFR Part 50, Appendix A, “General Design Criteria [GDC] for Nuclear Power Plants,” (e.g., GDC 27, “Combined Reactivity Control Systems Capability” and GDC 35, “Emergency Core Cooling”) and 10 CFR 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors.”

The NRC review guidance that is used to evaluate these external forces is NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” (SRP) Section 4.2, “Fuel System Design,” Revision 3, March 2007, Appendix A, “Evaluation Of Fuel Assembly Structural Response To Externally Applied Forces” (ADAMS Accession No. ML070740002). SRP 4.2, Appendix A, Section III, states, “While P(crit) [the crushing load] will increase with irradiation, ductility will be reduced. The extra margin in P(crit) for irradiated spacer grids is thus assumed to offset the unknown deformation behavior of irradiated spacer grids beyond P(crit).” The assumption in the SRP concerning irradiated grids may suggest that only the beginning-of-life condition for spacer grid strength needs to be evaluated for fuel assembly integrity under externally applied forces. However, recent operating experience challenges this assumption. Effects that can influence structural strength include neutron fluence (e.g., grid spring relaxation, irradiation hardening, growth, cladding creep down), corrosion (e.g., thinning, hydrogen uptake), and operating conditions (e.g., temperature) up to the approved limits on fuel assembly burnup and service life, as applicable.

Core dynamics models simulate the behavior of a row of fuel assemblies within a shaking core. The results are used to determine peak stresses in fuel assembly components, and with respect to spacer grid performance, determine if plastic deformation occurs. Spacer grid spring relaxation could have a significant affect on two aspects of the core dynamics model: fuel bundle stiffness and spacer grid strength. Reduced spring force would lower the effective bundle stiffness and may lower the strength of the spacer grid. Both of these phenomena directly affect the fuel assembly structural evaluation.

In addition, SRP 4.2, Appendix A, Section III, states, “The consequences of grid deformation are small. Gross deformation of grids in many PWR [pressurized-water reactor] assemblies would be needed to interfere with control rod insertion during an SSE [safe-shutdown earthquake] (i.e., buckling of a few isolated grids could not displace guide tubes significantly from their proper location), and grid deformation (without channel deflection) would not affect control blade insertion in a BWR [boiling-water reactor]. In a LOCA [loss-of-coolant accident], gross deformation of the hot channel in either a PWR or a BWR would result in only small increases in peak cladding temperature.” This SRP statement conveys that the overall fuel assembly design is robust with respect to being able to function with grid formation. However, this SRP statement does not negate other SRP statements such as SRP, Section II, “Acceptance Criteria,” which states. “Fuel damage criteria should assure that fuel system dimensions remain within operational tolerances and that functional capabilities are not reduced below those assumed in the safety analysis. …Complete damage criteria should address….stress, strain, or loading limits for spacer grids, guide tubes, thimbles, fuel rods, control rods, channel boxes, and other fuel system structural members should be provided.” For instance, to demonstrate compliance with GDC 27, spacer grid strength, loading, and deformation must be evaluated to determine that the guide tubes (or fuel skeleton structure) remains sufficiently straight so as not to impede control rod insertion following a seismic event and/or loss-of-coolant accident.

DISCUSSION

The SRP delineates the scope and depth of NRC staff review of licensee submittals associated with various licensing activities and provides an NRC staff interpretation of measures that, if taken, will satisfy the requirements of the more generally stated, legally binding body of regulations primarily found in 10 CFR. SRP 4.2 provides NRC review guidance regarding the evaluation of fuel assembly integrity under externally applied forces. While SRP 4.2 indicates that it is acceptable to assume that fuel spacer grid strength at the beginning-of-life is most limiting, operating experience discussed in this IN challenges this assumption. The NRC staff is considering appropriate steps to clarify SRP 4.2 and will continue to evaluate this issue when reviewing submittals involving fuel assembly structural response.

CONTACT

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

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