Global Nuclear Fuel

A Joint Venture of GE, Toshiba, & Hitachi

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MFN 10-221
November 8, 2010

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: Temperature Dependent Strong-Rod-Out Cold Shutdown Margin

At the 2010 Technology Update meeting on May 19 & 20, 2010, GNF presented information expressing the observation that the Technical Specification (TS) definition of a 68°F (20°C) moderator temperature for the shutdown margin evaluation may not be the most reactive condition for some fuel designs. Subsequently, there were several phone calls and presentations including communications with the Boiling Water Reactors Owners Group (BWROG). During a phone conference on July 6, 2010 between the NRC, Entergy, and GNF, GNF committed to document its process for determining the Strong-Rod-Out (SRO) Cold Shutdown Margin (SDM) for cases where 68°F may not be the most limiting temperature. This letter provides a discussion of the phenomena causing the most reactive condition to be greater than 68°F and the GNF process used to evaluate the SDM.

General Design Criterion 26 of 10 CFR 50 Appendix A--Reactivity control system redundancy and capability states that ....."One of the systems shall be capable of holding the reactor core subcritical under cold conditions." For cores licensed with GNF methods, the licensing basis requirements for SDM are specified in GESTAR II, NEDE-24011-P-A-17, Section 3.2.4.1, Shutdown Reactivity, which states:

> "The core must be capable of being made subcritical, with margin, **in the most reactive condition** throughout the operating cycle with the most reactive control rod fully withdrawn and all other rods fully inserted."

The Standard Review Plan NUREG-0800 Chapter 4.3 and the Standard Technical Specifications basis discussion in NUREG-1433 & -1434 Section 3.1.1state much the same thing. Namely, that the systems must be capable of making the core subcritical and maintaining it in a shutdown state

for all moderator conditions at any time during the cycle. While these regulatory documents do not precisely prescribe that the temperature of minimum shutdown margin be determined, the requirement of shutting down the reactor and maintaining it in a shutdown condition suggests that all thermal and exposure conditions are appropriate considerations in the determination of the minimum SDM.

For fuel products through GE14, the maximum reactivity condition for SDM always occurs at a moderator temperature of 68°F and the SDM is calculated at this temperature. This occurs because these fuel bundles are designed in such a way that the core is always under moderated at the high control rod density corresponding to SRO. Thus, higher moderator temperatures result in a lower water density and less moderation than at 68°F. For an under moderated core, lower water density translates to lower reactivity. The reference to 68°F is included in the standard technical specification shells provided in NUREG-1433 and 1434 for BWR/4 and BWR/6 and has been incorporated in the SDM definition in many plant technical specifications. However, having the SDM maximum reactivity condition occur at 68°F is not an inherent property of all fuel designs. For cores with GNF2 fuel, or other modern designs with increased moderation, it is possible that the most reactive moderator temperature for SDM may occur at a temperature above 68°F. For normal reload core designs, even those with 100% GNF2, it is expected that the maximum reactivity condition at beginning-of-cycle (BOC) will remain at 68°F. The strong local absorption effects of gadolinia in fresh fuel make the core under moderated. Later in the cycle, as gadolinia is depleted, all cores become less under moderated and the possibility of a positive moderator temperature correction at 68°F increases. Thus, an exposure late in the cycle may yield a more limiting SDM at a temperature greater than 68°F. While this is typically less limiting than the BOC 68°F condition, it is possible that the late-in-cycle condition could be limiting.

To address the possibility that temperatures greater than 68°F are most reactive late-in-cycle, the GNF procedure for the determination of SDM requires that, for cores with GNF2 fuel and/or alternate vendor fuel, calculations be performed over a temperature range that ensures the minimum SDM has been determined. Information provided to the utilities for the BOC SDM demonstration includes consideration of the temperature effect on SDM. Therefore, a satisfactory SDM surveillance assures both literal compliance with the current TS definition to demonstrate SDM at 68°F moderator temperature, and that the SDM requirement is also met at the most reactive moderator temperature.

The BWR Owner's Group is in the process of evaluating the full spectrum of considerations regarding this subject and will recommend any necessary revisions to the standard technical specifications for SDM. In the meantime, GNF is recommending that utilities not make technical specification changes on an individual basis.

If you have any questions about the information provided here, please contact me at (910) 819-5954 or Jim Harrison at (910) 819-6604.

Sincerely,

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Project No. 712

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