April 14, 2014

MEMORANDUM TO: Brian W. Sheron, Director
Office of Nuclear Regulatory Research

FROM: Jack R. Davis, Generic Issue Review Panel Chair ***/RA/***
Division of Safety Systems
Office of Nuclear Reactor Regulation

SUBJECT: GENERIC ISSUE REVIEW PANEL RECOMMENDATION FOR THE PROPOSED GENERIC ISSUE PERTAINING TO THE DISPERSAL OF FUEL PARTICLES DURING A LOSS-OF-COOLANT ACCIDENT

Summary

In October 2011, a proposed Generic Issue (GI) concerning the dispersal of fuel particles during a loss-of-coolant accident (LOCA) was submitted to the Generic Issues Program. The Generic Issues Program convened a Generic Issue Review Panel for this proposed GI. The Generic Issue Review Panel has completed its review of the related screening analysis and recommends that the proposed GI not move on to the safety/risk assessment stage of the generic issue process because the proposed GI does not pass the seven GI screening criteria. Specifically, the proposed GI does not pass the third criterion which states, "The issue cannot be readily addressed through other regulatory programs and processes; existing regulations, policies, or guidance; or voluntary industry initiatives." A rulemaking process was initiated to address issues associated with separate LOCA phenomena (i.e. embrittlement and breakaway oxidation) that will also consider the need for addressing fuel rupture during a LOCA, and therefore the third criterion is no longer met.

Discussion

The Division of Systems Analysis in the Office of Nuclear Regulatory Research (RES) submitted the proposed GI to the Generic Issues Program on October 6, 2011. The proposed GI was submitted to the Generic Issues Program to evaluate the possibility of fuel dispersal into the core from ballooned and ruptured fuel rods during a LOCA and the potential for such an event to create adverse effects on accident progression and radiological activity levels. During acceptance review (the first stage of processing within the Generic Issues Program) the staff determined that the proposed GI warranted further investigation. The staff completed the acceptance review on October 21, 2011, and designated the proposed GI, PRE-GI-010, "Dispersal of Fuel Particles during a LOCA." The acceptance review is available under Agencywide Documents Access and Management System (ADAMS) Accession No. ML112910156. The proposed GI then moved into the screening stage.

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In the screening stage, RES prepared a preliminary screening analysis of the proposed GI and selected members for a Generic Issue Review Panel. The panel reviewed the screening analysis of the proposed GI (see enclosure) and received briefings on the subject from staff in RES. Management Directive (MD) 6.4, "Generic Issues Program," dated November 17, 2009, provides seven specific criteria which an issue must meet to be recommended as a GI. The Generic Issue Review Panel completed its review of the screening analysis and concluded that the proposed issue on dispersal of fuel particles during a LOCA does not meet all seven criteria.

The enclosed screening analysis of the proposed GI shows that potential consequences of fuel fragmentation, relocation, and dispersal could include the following: (1) a change in axial linear heat generation and temperature profile, (2) fuel coolant interaction, (3) hydraulic and mechanical effects of fuel material in the reactor coolant system (i.e., flow blockage), and (4) radiological consequences. A preliminary assessment of these potential consequences is documented in NUREG 2121, "Fuel Fragmentation, Relocation, and Dispersal during the Loss-of-Coolant Accident." Current analyses of a PWR LOCA by fuel vendors consider the effect of pellet fragment axial relocation on linear heat generation. Regarding potential fuel coolant interaction effects on fuel dispersal, the staff recognized that a vapor explosion can only occur when hot (e.g., molten) fuel contacts a colder liquid (coolant). For a design-basis LOCA, the fuel does not melt, and without liquid-liquid contact, a vapor explosion is not possible. Further, there was no indication of fuel coolant interaction in any of the LOCA experiments where fuel dispersal occurred.

The staff also considered that a low number of high burnup fuel rods are expected to rupture during a LOCA and that radiological consequences for a postulated LOCA are calculated in a conservative manner. Experimental testing to date indicates that fuel fragmentation is related to the amount of burn-up experienced by each fuel rod. Generally, significant fine fragmentation of fuel pellets, which would promote dispersal, is limited to fuel rods with a high level of burn-up. Fuel assemblies with a relatively high level of burn-up are typically located on the periphery of the reactor core, where heat generation is lower, and the likelihood of the fuel cladding rupturing is therefore reduced.

This preliminary screening analysis has concluded that the consequence of fuel fragmentation and dispersal is low. This is based on the staff completing independent calculations of the number of rods expected to rupture during a LOCA. The results are that few of the high burn-up rods vulnerable to significant fuel fragmentation, relocation and dispersal will rupture. In addition, the likelihood of a large-break LOCA event occurring, which would result in ballooned and ruptured fuel rods, is very low. Ballooning and rupture could also occur in a more likely small-break LOCA, but those ruptures occur at high elevations on the rod (instead of mid-height), and the burn-up there is less, therefore less fuel material will relocate and disperse.

As directed by Staff Requirements Memo (SRM) SECY-12-0034, "Proposed Rulemaking - 10 CFR 50.46c: Emergency Core Cooling System Performance During Loss-Of-Coolant Accidents," the staff will consider the need for rulemaking related to fuel dispersal during rulemaking for the proposed 10 CFR 50.46c. If it is determined by NRR staff that fuel dispersal is not appropriate to be addressed by the proposed new rule, the NRR staff will document the basis in their rulemaking package responding to the Commission's SRM and return the issue to the Generic Issues Program. The final 10 CFR 50.46c rule is scheduled to be submitted to the Commission on February 28, 2016, as directed by Commission Action Memoranda (COM)

COMSECY-13-0006, “10 CFR 50.46c Rulemaking: Request to Defer Draft Guidance and Extension Request for Final Rule and Final Guidance.” Therefore, the third criterion is no longer met. The panel unanimously recommends that this issue no longer receive analysis under the Generic Issues Program.

In the unlikely event of a LOCA, only a few potential fuel ruptures should occur, so only limited fuel dispersal is expected in the event of a fuel rupture. Therefore, the staff also concludes that there is no imminent safety hazard during the period when the rule is being developed.

Note: Dr. Ralph Landry was a member of the Generic Issue Review Panel and has since retired. Before his retirement, Dr. Landry stated his support of this recommendation.

Enclosure:
Screening Analysis Report for the Proposed Generic Issue on Dispersal of Fuel Particles during a Loss-of-Coolant Accident

Approval of Recommendation: /s/ Brian Sheron 4/24/14
Brian Sheron, Director
Office of Nuclear Regulatory Research

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