January 21, 2010

MEMORANDUM TO: Michael L. Scott, Chief
Safety Issues Resolution Branch
Division of Safety Systems

FROM: Ervin L. Geiger
Safety Issues Resolution Branch ***/RA/***
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Office of Nuclear Reactor Regulation

SUBJECT: BASIS FOR EXCLUDING CHEMICAL-EFFECTS PHENOMENON FROM WCAP-16406-P EX-VESSEL DOWNSTREAM EVALUATIONS

The purpose of this memorandum is to provide a basis for exempting the emergency core cooling system and containment spray system components from a rigorous evaluation of the potential for blockage and wear due to chemical precipitates in the post- loss of coolant (LOCA) recirculated sump fluid. Topical Report WCAP-16406-P, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191" provides Nuclear Regulatory Commission (NRC)-accepted methods for evaluating the effects of emergency core cooling system (ECCS) sump strainer bypassed debris on components and systems. Although chemical precipitates in the circulated sump fluid can significantly affect sump strainer performance, there is no evaluation in WCAP-16406-P, or the NRC safety evaluation of that document, of the need to examine the effect of chemical precipitates on components downstream of the sump strainer (e. g., pumps, valves, nozzles, etc.). Because the rationale for exempting downstream components from chemical effects evaluations in WCAP-16406-P is not well documented, a discussion supporting the staff's conclusion that post-LOCA chemical precipitates do not pose a significant threat to the safety-related functions of ECCS and containment spray system components is provided in the Enclosure.

Enclosure:
As stated

CONTACT: Ervin L. Geiger, NRR/DSS/SSIB
301-415-5680

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CONSIDERATIONS FOR LOSS-OF-COOLANT-ACCIDENT CHEMICAL-EFFECTS PHENOMENON ON EMERGENCY CORE COOLING SYSTEM COMPONENTS

Background/Introduction

Current guidance in topical report WCAP-16406-P-A for evaluating the effects of loss-of-coolant-accident generated debris on emergency core cooling system and containment spray system (CSS) components does not address the need to evaluate the effects of chemical precipitates. The NRC did not document a position in the SE for WCAP-16406-P-A on the potential role of chemical precipitates in the blockage and wear of ECCS and CSS components such as pumps, valves, and heat exchangers. The following discussion supports the conclusion that post-LOCA chemical precipitates do not pose a significant threat to the safety-related functions of ECCS and CSSC components located downstream of the ECCS sump strainer.

Current Knowledge of the Behavior of Chemical Precipitates in PWR Sump Fluids

The staff is not aware of any evidence that suggests that aluminum-oxyhydroxide or calcium phosphate, in combination with strainer-bypassed fiber and particulate debris, will cause blockage or increase the potential for blockage in the restricted flow passages of pumped piping systems similar to the ECCS and CSS systems of pressurized water reactors. Note that potential downstream effects in the reactor vessel are being evaluated separately in WCAP-16793. The following items support the statements above:

1. In-vessel fuel blockage tests conducted at Westinghouse and Continuum Dynamics Inc. (CDI) (see NRC trip reports ML083510620 and ML090720039, respectively) using particulate, fiber and aluminum oxyhydroxide precipitate demonstrated that any flow resistance created by these substances was significantly less than the pump head that is available in the ECCS and CSS piping systems. Even with the much-lower discharge head of the test loop circulating pump and with continuous fluid recirculation, the test loop throttle valves, differential-pressure gages and flow meters did not experience blockage. Therefore, components downstream of the sump strainers are not expected to become clogged with debris and chemical precipitate such that blockage of flow occurs. The downstream effects evaluations performed by licensees include an examination of the flow passages in ECCS and CSS components to ensure that the clearances are larger than the debris that can pass through the sump strainer. Therefore, chemical precipitates are not expected to result in blockage of flow through these components.

2. Integrated chemical-effects testing (ICET) conducted by Las Alamos National Laboratory (NUREG/CR-6914) and vertical loop head loss tests at Argonne National Laboratory (NUREG/CR-6913) showed that aluminum hydroxide type precipitates would not typically form until sump pool temperatures decrease from the initial, elevated post-LOCA temperatures. Therefore, some filtering of aluminum-containing chemical precipitates is expected to occur by the debris bed that forms on the sump strainer. In addition, if elevated temperatures result in delayed precipitation of aluminum species, most of the fiber bypass will have occurred before precipitates form and pass downstream of the strainer.

ENCLOSURE

3. Of the dozens of plant-specific strainer head loss qualification tests observed by NRC staff, not a single case occurred where WCAP-16530 surrogate precipitates, in combination with particulate and fibers, obstructed flow through the test loop (other than across the strainer debris bed).

4. Chemical precipitates by themselves do not appear to have high shear strengths. Precipitate from ICET 1 that had agglomerated following weeks of post-test storage sloughed off a stirring rod and readily broke apart when stirred. Calcium phosphate precipitate, by itself, was not able to build a sustainable bed on a test screen during vertical loop head loss tests conducted at Argonne National Laboratory (NUREG/CR-6913).

5. With regard to flow-induced wear, there is no evidence to suggest that aluminum-oxyhydroxide or calcium phosphate can be a major contributor to erosive or abrasive wear in ECCS and CSS components. Further, the abrasive properties of the debris used in the WCAP-16406-P-A wear evaluations of downstream components are much more severe than that of aluminum oxyhydroxide or calcium phosphate. The prescribed evaluation methods in the WCAP are conservative, and the staff believes these conservatisms would overcome any potential effects that chemical precipitates may have on downstream components. These evaluations consider wear of pump bearings, wear rings and seals due to abrasive particles such as coating chips, fiberglass insulation, calcium silicate insulation, and latent debris. The evaluations typically assume that the gap between the stationary and rotating parts is packed with abrasives. The aluminum oxyhydroxide agglomerated particles would not add to the quantity of debris assumed to be captured in the cavity between the wearing surfaces because the gap is already considered packed.

Conclusion

Based on the above rationale, the NRC staff concludes that chemical precipitates that may form in a PWR post-LOCA environment do not pose a significant threat to the safety-related functions of ECCS and CSS components located downstream of the ECCS sump strainer. However, chemical precipitates, in combination with fiber and particulate, may behave differently in the reactor vessel. Therefore, the NRC staff is evaluating the potential effects of ingested debris and chemical precipitates on core cooling separately, as part of the staff's review of WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid."