RISK-INFORMED VERSUS DETERMINISTIC TREATMENT

The regulation at Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46(a)(1)(i) currently describes two types of deterministic evaluation models that can be used to demonstrate compliance with the emergency core cooling system (ECCS) design requirements, one of which is a bounding analysis and the other a best-estimate analysis. Both the bounding and the best-estimate analysis calculate parameters that are compared to acceptance criteria (e.g., peak cladding temperature) and provide a high level of confidence that acceptance criteria will not be exceeded. In the bounding analysis, evaluation models and correlations are justified on the basis of conservatism. Best-estimate calculations are performed with realistic models and correlations with uncertainties explicitly addressed in the calculations. The best-estimate analysis must additionally estimate the uncertainty in the calculated parameter and demonstrate that there is a high level of probability that the acceptance criteria would not be exceeded. The U.S. Nuclear Regulatory Commission (NRC) staff has determined, in Regulatory Guide 1.157, "Best-Estimate Calculations of Emergency Core Cooling System Performance," that a 95-percent probability level is acceptable to the staff for comparison of best-estimate predictions to the applicable limits.

The acceptance criterion for the design of the ECCS as it relates to sump performance is that sufficient net positive suction head (NPSH) is available at the inlet to the low-pressure injection pumps during operation in the recirculation mode. A collection of methods or "technical elements" that can be used to evaluate the loss of NPSH from debris generation, transport, and collection on the sump screens is endorsed with identified conditions and limitations in the NRC's safety evaluation (SE) of Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Methodology."

These methods are bounding analyses for evaluating sump performance during and following design basis loss of coolant accidents. A best-estimate analysis of the probability of successful sump performance that would be necessary to support a best-estimate compliance evaluation permitted by 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors," is presently not possible because of the complex phenomena that is not understood well enough for industry to develop, or staff to evaluate, an integrated model of debris generation, transport, and deposition on the sump screens. Such an integrated model would also need to propagate the uncertainty of the constituent input parameter distributions through all of the elements. This would be necessary to eventually support an estimate of the uncertainty in the results and permit the determination that there is a high level of probability that the acceptance criteria are not exceeded. Therefore, it will not be possible to estimate the uncertainty on the available NPSH, and a best-estimate compliance evaluation permitted by 10 CFR 50.46 is presently not possible. Similarly, a more complete understanding of the complex phenomena would be needed to develop more detailed models to support analysis via a probabilistic risk assessment. The complexities of sump performance evaluations and the lack of success in past attempts to model aspects of sump performance has led the staff to determine that a comprehensive, defensible sump performance model cannot be developed in the foreseeable future. The staff considered the option of developing a generic integrated probabilistic model for sump phenomena that could be applied in a plant-specific manner, but determined this option not to be viable for similar reasons, as discussed in Enclosure 2.

Section 6 in NEI 04-07 proposed a limited risk-informed alternative evaluation methodology for demonstrating acceptable sump performance. The alternate methodology proposed to use more realistic analysis methods and assumptions to evaluate sump performance for large breaks. The more realistic analysis did not include estimating the uncertainty in the available NPSH and was therefore not a best-estimate evaluation, as defined in 10 CFR 50.46. The staff's SE noted that the requirements of 10 CFR 50.46 are applicable and stated that licensees could request, on a plant-specific basis, exemptions from the requirements associated with demonstrating long-term core cooling capability in 10 CFR 50.46(b)(5). NEI 04-07 also proposed a risk impact calculation to be performed when changes to the existing facility design are necessary to meet the acceptance criteria using the alternate methodologies described in Section 6. The NRC staff's SE noted that exemptions from the requirements of 10 CFR 50.46(b) may be required for use of Section 6. However, no licensee has requested an exemption for the purpose of implementing the Section 6 approach for Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance." The staff and licensees have, to date, found application of risk tools for resolution of GSI-191 to be challenging and of limited use. However, there is some potential for expanding the use of these tools. At a meeting in June 2010, an NEI representative stated that additional implementation guidance is needed to enable licensees to better determine whether the Section 6 approach would be useful to plants that have not yet resolved strainer performance issues.

In addition, regarding risk informing the remaining elements of GSI-191, the agency is currently in the process of developing a risk-informed alternative to the ECCS rule, which may have implications for GSI-191. This risk-informed effort is intended to determine what relaxations in ECCS analyses are appropriate. Based on the new proposed risk-informed ECCS rulemaking, "Risk-Informed Redefinition of Large Break LOCA ECCS Requirements," at 10 CFR 50.46a, licensees would still be required to demonstrate adequate strainer performance considering the impacts of larger breaks, albeit with more realistic methods. These evaluations might still predict very large debris source terms for some plants with large amounts of fibrous insulation. Moreover, a limited risk-informed approach to addressing GSI-191 is already available to licensees via the 2004 SE previously discussed, but this approach has not been used for reasons discussed in Enclosure 4.

In summary, 10 CFR 50.46 is not a risk-informed rule, and no provisions exist in the rule to utilize risk to demonstrate compliance with the rule. As summarized above, the realistic approach can utilize probability, but only in the context of addressing the uncertainties in the parameters and the probability of not exceeding the acceptance criteria (in this case, NPSH) and not any measure of risk. Therefore, exemptions under 10 CFR 50.12, "Specific Exemptions," would be necessary to utilize a risk-informed treatment of the remaining elements. The exemption criteria in 10 CFR 50.12 that would be applicable, and the regulations from which exemptions must be sought, would depend on the specific application. However, if the Commission approves the risk-informed 10 CFR 50.46a rulemaking effort, a viable regulation would exist that would allow licensees to adopt and subsequently implement risk-informed methods without the need for exemptions. Thus, exemptions to 10 CFR 50.46 under 10 CFR 50.12 might be difficult to justify upon promulgation of 10 CFR 50.46a.