Proposed Responses to Test-Related RAIs

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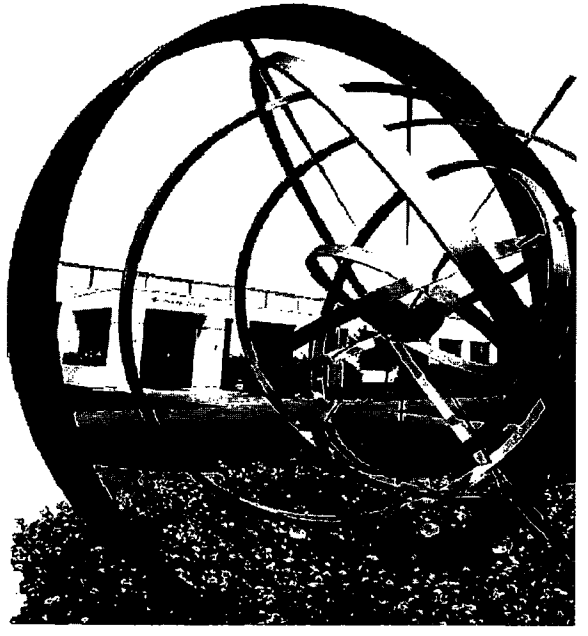

Topics

Purpose of tests

Requests for Additional Information (RAIs) and responses

Purpose of testing

NRC-approved LOCA methods are used to evaluate the response of the system and fuel

Analyses will be performed with and without blockage to determine blockage which meets acceptance criteria

LOCA analysis assumes loss coefficients, and the **testing** confirms the validity of those loss coefficients

RAI 5

(To be addressed at end of presentation)

RAI 6

The current BWROG approach appears to treat in-core debris accumulation and chemical scale / crud buildup as separate and independent issues. However, in that the formation and buildup of scale or crud deposits could affect debris accumulation via impacts to available debris quantities, clearance dimensions, and surface characteristics such as roughness, it is not clear to the staff that the interactions between the two phenomena can be presumed to be negligible. Therefore, please provide adequate justification that debris accumulation tests performed with clean fuel assemblies can adequately represent the debris accumulation behavior that would be experienced by prototypical plant fuel assemblies that have experienced deposits of scale/crud in the post-LOCA environment as well as during normal operation.

RAI 6 Response

The limiting components in regard to debris blockage are the upper and lower tie plates, the latter a consequence primarily of the narrower openings in the debris filter, and the spacer grids. While it is possible that debris will adhere to fuel rod surfaces due to their roughness, surface deposits and surface oxide layer, the fuel rods will not be limiting from a debris capture basis as the rod-to-rod gaps are relatively large. Furthermore, any deposition on the fuel rod surfaces would remove debris from the coolant stream. The BWROG believes that testing under conditions where all of the injected debris is available for capture in the limiting components (i.e., tie plates and spacer grids) is conservative, and debris holdup elsewhere would tend to reduce the amount of debris available for capture in these limiting components.

RAI 6 Response (cont.)

The test program as proposed allows for the photographing of debris accumulation within the test bundles after test completion. This will allow debris accumulation to be evaluated, at least qualitatively.

The effect of crud, oxide, scale and other layers on the surface of the cladding is to slightly increase cladding temperatures as the layers a) have reduced conductivity relative to the cladding itself, and b) increase the distance for heat transport. As discussed in the response to RAI #40a, the BWROG will address this effect through analytical evaluations.

RAI 13

The topical report methodology treats the four test conditions separately and independently of each other. That is, each test condition is begun with a clean fuel assembly / bypass region, even those that simulate conditions that would exist at later stages of an accident; whereas, at an analogous accident stage, a prototypical plant fuel assembly / bypass region may have already accumulated non-negligible quantities of post-LOCA debris. Therefore, the topical report's approach appears justified in general only in the case that preceding tests simulating earlier phases of the accident result in negligible debris accumulation. Please identify whether the BWROG agrees with this statement; if not, please provide adequate basis for considering testing conducted with a clean assembly / bypass region to be sufficiently representative of actual plant conditions in which non-negligible quantities of debris may have accumulated in the fuel assembly / bypass region prior to the phase of the accident simulated in the test.

RAI 13 Response

It is correct that the four tests represent different phases of a postulated LOCA and that the blockage acceptance criteria are initiated from the 'without debris' condition. This is appropriate because the individual tests either represent a reversal in flow direction phenomena (Tests 1 vs. 2, and Tests 3 vs. 4), or the test includes the duration of the previous test (Tests 2 vs. 3), or the blockage criteria represents an unlimited time (Test 4). For example, Test 1 represents reverse flow from the bypass region into the lower plenum with a negligibly small effect on flow. Then Test 2 represents forward flow from lower plenum into bundle inlet and bypass region, opposite that of Test 1, also with a negligibly small effect on flow. Therefore debris from Test 1 phenomena would not be expected to have an effect on Test 2 phenomena debris accumulation.

RAI 13 Response (cont.)

Then Test 3 can be considered a continuation of Test 2, though at increased flow because of the increased head. However, since the time duration of Test 3 includes the period of Test 2, e.g. represents time of injection prior to reflooding, and reflects debris for the later period (e.g., as though the core had never uncovered), it conservatively accounts for Test 2 debris. Finally, Test 4 represents a reversal in flow, from upper plenum into the bundle, compared to Test 3, and since the significant debris from Test 3 is expected to be below the inlet grid, little effect would be expected from Test 3 debris into the channel on Test 4. Furthermore, since Test 4 is a long term test, the final blockage would not be expected to be influenced by any Test 3 limited debris passing through the inlet grid (i.e., lower tie plate) over the Test 3 limited time.

RAI 23b

The topical report states that the testing of fuel assemblies with debris-laden water will be conducted at room temperature. Testing at room temperature would not account for two phenomena that would affect the quantity of debris that could accumulate in a fuel assembly, as well as its distribution within the assembly. Sufficient justification was not presented to justify the neglect of these phenomena. Please consider the Test 4 condition (for plants with and without jet pumps) in responding to the following items:

RAI 23b (cont.)

b. Please provide adequate basis that the absence of boiling in the test condition would not lead to excessive washing of debris from the upper tie plate, spacer grids, and even out of the test fuel assembly, in a manner that is not prototypical of the plant condition. As noted on Page 66 of the topical report, in the plant condition, very little of the debris-laden water flows through the lower tie plate.

RAI 23b Response

b. The BWROG appreciates the concern that if the debris testing is performed using water only and not a two phase mixture with countercurrent flow, the debris bed morphology and/or distribution across the surfaces of the upper tie plate and spacer grid surfaces may be non-prototypic as the effects of the countercurrent steam on the debris bed would not be modeled. The BWROG will be performing a series of simple bench top tests to evaluate this effect. The tests would use a prototypic upper tie plate, spacer grid and fuel rod tubing to explicitly evaluate, on a qualitative basis, debris bed formation, and water movement through and about the debris bed under various spray flow rates, countercurrent air flow rates, and debris mixtures.

RAI 45

In Appendix A, repeatability of test results is addressed. For the baseline clean water tests, the topical report states that five tests are expected to be sufficient, but that more tests may be necessary, depending on the statistical relevance of the data. A similar statement regarding statistical relevance of the test data with debris-laden water is not included. While generally expecting the BWROG's plans for addressing repeatability to be sufficient and recognizing that the anticipated variability in tests conducted with debris-laden water is substantially greater than clean water tests, the staff nevertheless expects that large variations in debris accumulation test results be adequately understood. If test results are incoherent, additional testing could still be necessary to develop an adequate understanding of debris accumulation behavior. Please clarify the BWROG's position regarding whether additional debris accumulation tests may be necessary in cases where the results are incoherent and inadequately understood.

RAI 45 Response

The BWROG position is that when repeating debris tests, if there are significant differences in the debris accumulation between individual tests that cannot be attributed to random variations in the test inputs or conditions, the results will be evaluated for possible root causes. Based on this evaluation of test results, a course of action will be determined, including additional analysis and/or tests if needed.

RAI 5

A significant number of BWR licensees have adopted the alternate source term. As such, the standby liquid control system (SLCS) would be used to inject sodium pentaborate solution into the reactor vessel following a LOCA to control the pH in the suppression pool. The topical report does not address whether significant debris blockage in the reactor core could inhibit mixing and thereby promote boron precipitation inside the reactor vessel. Please address this concern, if possible generically, accounting for the fact that differences in plant configurations would influence the expected behavior. For instance, considering a plant design with LPCI injection into the recirculation lines and SLCS injection through a core spray line, could boron precipitation occur if significant debris blockage occurred at the core inlet?

RAI 5 Response

The Standby Liquid Control System (SLCS) would be manually initiated by some BWR licensees in response to a LOCA event. The timing of the SLCS injection depends on the specific plant operating procedures. For some plants the initiation will commence based on symptom-based Emergency Operation Procedures (EOP) when there is evidence of fuel damage such as high drywell pressure and a high radiation level in the drywell. Other plants use an EOP with a prescriptive SLCS injection time (typically several hours after LOCA occurrence) if the operator determines that a LOCA event has occurred.

RAI 5 Response (cont.)

The boron moderator for the Standby Liquid Control System (SLCS) is maintained in solution in a SLCS tank. Upon SLCS initiation this moderator is pumped into the recirculating water and becomes well mixed with the cooling water prior to injection into the reactor vessel by the ECCS systems. Significant debris blockages in the reactor core would only affect the flow path of the moderated cooling water to the fuel rods. As a) the volume of the recirculating reactor and ECCS water is significantly greater than the volume of the SLCS tank, and b) the recirculating water has a temperature well in excess of the SLCS storage tank temperature, the boron in the ECCS injection water is significantly diluted; therefore, the BWROG believes a significant amount of boron precipitation is unlikely..

RAI 5 Response (cont.)

To fully address the NRC's concern, the BWROG ECCS Suction Strainer program will address the effects of boron interaction with coolant as originally expressed in the program plan. The effects of boron injection in the core on pH will be explored in the fuel test program in 2012. Results of the testing program will be reported to the NRC, but will also be forwarded to the BWROG Licensing Committee for future interaction with the NRC Staff regarding the effects of boron precipitation.