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EPRI

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Washington, D.C. 20545

Dear Mr. Silberberg:

SUBJECT: REVIEW OF DRAFT NUREG-0956, "RADIONUCLIDE RELEASE UNDER LWR SPECIFIC ACCIDENT CONDITIONS"

We were pleased to review NUREG-0956 and congratulate you for embarking on the peer review process for this important document. We appreciate the NRC efforts towards a sound technical basis for the source term; NUREG-0956 is an effort in the right direction. We also appreciate the efforts of the staffs of the Battelle Columbus Laboratory and Sandia National Laboratory for performing this work.

GENERAL COMMENTS

The most limiting factor in our review effort was the limited time allotted. The draft document (first volume) was made available to us only one week before the review meeting on January 25 and 26, 1983. It reports results for the Surry PWR computed for several accident sequences with various codes. The numerical results presented could not be digested in the brief time before the peer review meeting. A thorough review will require more time to carefully examine the methodology and results and to compare them with earlier studies. Such an effort is difficult, since the draft document does not describe the methodology adequately. The computer codes employed are either considerably modified older codes, or new codes with no documentation. This lack of documentation should be corrected as soon as possible. It should provide, as a minimum, a description of (1) the physical basis of the models employed, (2) the relationship between the various models in a traceable manner, and (3) any model validation and/or benchmarking performed on a separate-effect or integral basis.

The methodology in NUREG-0956 is based on the MARCH 1.1 code. This version of the code, even as modified, has significant deficiencies, many of which have been documented by J. R. Rivard in NUREG/CR-2285. Employing the MARCH 1.1 code for the accident scenario studies throws doubt on the accuracy of the reported results.

The NUREG-0956 methodology is described as deterministic and best-estimate. However, at certain places in the analysis, very conservative (or non-deterministic) arguments are employed which radically affect the results of the analyses. A case in point is the catastrophic failure of the Surry PWR containment one minute after the molten corium is discharged into the containment cavity during the postulated TMLB' accident. The MARCH 1.1 calculations generate a steam spike of 85 psia when the molten corium interacts with water in the containment cavity. The Surry containment design pressure is 45 psig; the containment could hold for much higher pressure levels; for example, WASH-1400 assumes a failure pressure of 85+15 psig (100±15 psia), with failure defined as cracking of the concrete and breaching of the liner. According to WASH-1400, 0.03 inch cracks would form; enough for gas release at a catastrophic rate. (N.B. not catastrophic structural failure). Thus, the containment failing at 85 psia is neither a best-estimate nor a deterministic assumption. Even if it were to fail at this low pressure, the fine cracks through many feet of concrete would greatly attenuate any aerosol in the gas, an important mechanism shown in the CSE experiments but not reflected in the NUREG-0956 analysis.

The accident sequences analyzed in NUREG-0956 are the so-called "dry" sequences, where no water or water vapor in the transport path of . e fission products is assumed. Certainly the water initially contained in the primary system will be somewhere along the fission product path. The presence of steam greatly increases the retention of the aerosols as demonstrated in numerous experiments. Thus, the "dry pathway" assumption is not a valid assumption. We recommend that the location and state of water during the course of the accident be traced with the same attention that is given to the fission products.

Lastly, the NUREG-0956 methodology should be validated against the TMI-2 data obtained during and after the accident. Reasonably accurate predictions of the TMI-2 accident during the accident phases, where the codes are applicable, will generate confidence in the codes used in NUREG-0956.

<u>SPECIFIC COMMENTS</u>

1) High values of source term have been derived for some cases where the containment fails catastrophically. That this occurs is not clear; a mechanistic model for the containment failure should be employed. This model should predict the location and mode of containment failure, the leak rate to the atmosphere and the fission products and water vapor transport through the failed containment. Similar analyses should also be performed for the case of containment isolation failure, where the fluid and fission product transport through the open valves, piping or penetrations should be treated mechanistically. Such mechanistic descriptions could increase the predicted retention of fission products, for those cases where containment is assumed to fail or not isolate.

2) The calculated release from the primary system for the V sequence appears to be too high. The fission products must traverse long pipes and the steam generator. Supersaturation ratios for the predominant fission product species in the cold primary system are very high. The aerosols formed will rapidly agglomerate and settle at various points in the system. Thus, it does not seem reasonable to predict that only 60% of the CsOH and CsI formed will be retained. This prediction may be due to the modeling of the long pipes as a single "well-mixed" compartment, instead of a number of serially connected "well-mixed" compartments; with differential deposition of aerosols from one end of a pipe to the other.

3) The V sequence calculation does not assume retention of the fission products in the auxiliary building. The auxiliary building failure should be modeled mechanistically and leakage rates determined. The effect of the wet atmosphere prevalent in the auxiliary building on the scrubbing of the fission product has been ignored. We believe that very substantial reduction in the fission product source will occur, if mechanistic and realistic treatment of the transport of the fission product source in the auxiliary building is employed. An observation in this respect is that the Windscale accident (dry, oxidizing atmosphere) released only 12% of the iodine and 5% of cesium inventory in two days under forced flow conditions.

4) The hydrogen combustion pressures generated by the MARCH 1.1 code do not account for the mitigating effect of steam in the containment atmosphere. The Whiteshell tests (under EPRI sponsorship) showed a 30% decrease in the peak pressure at steam concentrations of 30%. The Accurex tests (also under EPRI sponsorship), with hydrogen injection rates corresponding to the MARCH code predictions, showed intermittent burns with pressure peaks of approximately 30 psi, when steam was present in the containment atmosphere. Thus, the current data does not support the failure of a PWR dry containment due to hydrogen combustion.

5) The fission product sources used in the various accident scenarios are based on the empirical models described in NUREG-0772. The magnitudes of the fission products appear to be reasonable; however, the core material source seems too high. A thermodynamics-based model would be preferable for vaporization of core materials and their transport, since various chemical compounds are being formed during this time.

6) There is evidence that, at the temperatures prevalent in the upper plenum, chemical reactions occur between stainless steel and CsOH, and stainless steel and tellurium compounds. Penetration of cesium into stainless steel has been observed in laboratory experiments (fast reactor fuel experiments). Analysis of the activity on the control-rod lead-screw from the TMI-2 vessel showed much cesium, some of which could be removed only after etching with nitric acid. This mode of fission product retention in the upper plenum was not considered in NUREG-0956. Fission products chemically fixed in the upper plenum will not appear in the containment even if the vessel ruptures.

7) The MERGE code does not consider natural convection flow patterns, in the upper plenum; such flow increases the residence time (in the TMLB' S_2D and V sequences) and the aerosol deposition rate on the cold surfaces by impaction. The probability of chemical reactions is also increased.

We appreciate the invitation to comment on NUREG-0956 and recognize the very significant efforts put forth by the BCL, Sandia, ORNL and the NRC staffs. If you have any further questions concerning our comments to NUREG-0956, please contact either one of us.

Sincerely yours,

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