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SEP 29 1982

Docket No.: 50-245

MEMORANDUM FOR: Dennis Crutchfield, Chief
Operating Reactors Branch #3
Division of Licensing, NRR

FROM: L. G. Hulman, Chief
Accident Evaluation Branch
Division of Systems Integration

SUBJECT: QUANTITY OF IODINE RELEASED TO COOLANT FOLLOWING A LOCA, FOR RADIOLYSIS OF COMBUSTIBLE GAS AT MILLSTONE 1 CONSIDERATION (TAC. #48293)

The Accident Evaluation Branch (AEB) was requested by the Millstone 1 project manager, Jim Shea, to provide an estimate of the amount of iodine, both stable and radioactive, that would be released to the coolant following a LOCA at the Millstone 1 plant.

The total core inventory of iodine, both stable and radioactive isotopes for a typical equilibrium core with the Millstone power level of 205[illegible] MWt is on the order of 10 Kilograms, with some variation depending on fuel burnup. For an upper limit of burnup level of about 40,000 MWd/MTu the inventory is 13.7 kilograms of iodine.

The fraction of this inventory that could be released depends on the type of accident postulated. The design basis accident postulated for site acceptability, containment systems (fission product retention) and mitigative engineered safety features is described in Regulatory Guides 1.3 and 1.4. The design basis accident with respect to combustible gas control is described in Regulatory Guide 1.7, which specifies a release of 50% of the core iodine inventory to the sump water as the appropriate assumption for radiolysis calculations.

The above described iodine releases are consistent with substantial overheating of fuel which would result in the oxidation of a large fraction of the zirconium in the fuel cladding. For BWRs with inerted atmospheres like Millstone 1, the extra hydrogen produced from this reaction will serve to retard the formation of a combustible gas mixture in the containment atmosphere. The large releases of iodine accompanying clad oxidation, therefore, are not expected to be the worst case with respect to the approach to a combustible gas mixture in the containment.

The licensee has provided estimates of the iodine release for a successfully terminated LOCA, analyzed according to Appendix K criteria. For this accident, there is little clad oxidation (<1%), and a limited number of clad perforations. The licensee's analysis includes an assumed iodine release based on the gap activity release measured at ORNL (R. Lorenz, et. al) for fuel from the Robinson (PWR) plant.

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Since the gap inventory is a strong function of the heat rating of the fuel, as well as burnup, enrichment, etc., the application of the ORNL measurement to Millstone 1 is of questionable utility. In the September 1982 meeting with the licensee, the staff suggested that gap inventories be calculated specifically for the limiting conditions of the Millstone reactor, using assumptions and methods acceptable to the Core Performance Branch.

In addition to the established conservative criteria and assumptions for the two defined design basis accidents (i.e., characterized by Appendix K and 10 CFR Part 100, respectively) AEB has been asked to provide iodine release estimates on a more "realistic" basis, particulary in light of recent findings concerning fission product source terms. In this regard it should be noted that current research information indicates that iodine release from the fuel is larger, not smaller, than that envisioned at the time of the generation of the "TID source term." For fuel undergoing a substantial degree of melting (as assumed in TID-14844), current data shows that essentially 100% of the iodine would have left the fuel long before melting temperatures are reached. (See NUREG-0772). The much talked about reductions in source term results from more accurate modelling of iodine attenuation after it has left the fuel, not lower estimates of release from fuel. Most of the attenuation mechanisms (e.g., plate-out on wet walls, washout by sp[illegible]rubbing in suppression pools, etc.) involve a removal of iodine from the [illegible] phase, and results in accumulation of iodine in the liquid phase, i.e., the sump and torus water, so that a lower iodine concentration in the water cannot be expected on the basis of these considerations. It should also be noted that this condition would prevail independent of the postulated chemical form (I_2 or CsI) of iodine in the gas phase.

Provided that the licensee has demonstrated an adequate margin between calculated combustible gas concentrations and the appropriate flammability limits for Appendix K and Regulatory Guide 1.7 accidents, the question of potentially combustible gas mixtures for a LOCA falling somewhere in between these two extremes remains. We do not believe that a combination of the iodine release assumption of R.G. 1.7 and the clad oxidation estimates of Appendix K - type accidents is appropriate. Rather than postulating additional combinations of degraded ECCS performance and iodine releases as design basis events, it appears appropriate for the licensee to demonstrate that his proposed solution provides protection against the formation of combustible mixtures for the spectrum of accident severity ranging from Appendix K assumption to R. G. 1.7 assumptions. For this approach it becomes necessary, however, to coorelate the iodine release and the degree of clad oxidation for various core conditions. Recent experimental measurements of iodine release in temperature range 1300-1500 C at ORNL (Lorentz, et. al.) provide an appropriate basis for such correlations. Although the measured iodine releases are a function of a number of variables, AEB would find an upper bound defined by the following points acceptable:

1300 C - Release of gap activity, as calculated by ANS 5.4, or other models acceptable to CPB.

1400 C - Release of an additional 10% of fuel inventory of iodine

1600 C - Release of an additional 30% of fuel inventory of iodine

1700 C (or higher) - Release of 50% of fuel inventory of iodine, i.e.

Regulatory Guides 1.3, 1.4, and 1.7 assumptions.

Because of the chemically reactive nature of iodine, and the difficulty of fission product measurement at high temperatures, a high degree of uncertainty is associated with the above fission product release estimates. Therefore, we recommend that a substantive safety margin be maintained between the estimated iodine releases described above and the maximum iodine release values tolerable with respect to radiolysis rates resulting in potentially flammable gas mixtures.

References:

NUREG-0772, Technical Bases for Estimating Fission Product Behavior During LWR accidents, June 1981.

R. A. Lorenz, et. al., Fission Product Release from High Irradiated LWR Fuel Heated to 1300 - 1600 C in Steam, NUREG/CR-1386, ORNL, November 1980.

Original signed by:

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*See Previous Concurrence Sheet

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