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DOCKET NUMBER
PETITION RULE PRM 50-76
(67FR51783)

Ms. Annette L. Vietti-Cook
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Rulemakings & Adjudications Staff

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Our ref: LTR-NRC-02-53

October 22, 2002

Reference:

1) Federal Register 51783, Vol. 67, No. 154, August 9, 2002

Dear Ms. Vietti-Cook:

A notice of receipt of a petition for rulemaking to 10 CFR Part 50 was published for comment in Reference 1. The petitioner requested an amendment to the NRC regulations concerning evaluation models for Emergency Core Cooling Systems (ECCS) and associated guidance documents. The petitioner believes that the amendments are necessary to correct technical deficiencies that do not consider the complex thermal-hydraulic conditions during a Loss-of-Coolant-Accident, including the potential for very high fluid temperatures.

The attachment contains the comments of the Westinghouse Electric Company regarding this petition for rulemaking. The petitioner's comments on the differences between the test conditions and the expected fluid conditions in a reactor core during a postulated LOCA accident do not prevent the current database from being applicable to LOCA analysis. Within the range considered, the flow condition is a secondary effect to the zirconium-water reaction because oxidation kinetics depend mostly on the temperature of the oxidizing material.

The consistency between the MaxiZWOK and MiniZWOK data together with more recent investigations conducted by Argonne National Labs (ANL) and Westinghouse support the conclusion that the particular flow conditions considered for the Cathcart-Pawel correlation did not introduce any bias due to hydrogen-blanketing, steam-starvation or other oxidation-limiting phenomena.

The conditions of FLECHT Run 9573 were extremely severe, and from a LOCA standpoint should be considered beyond design basis for the ECCS. Despite the severity of the conditions and the observed extensive zirconium water reaction, the oxidation was within the expected range and runaway oxidation occurred beyond 2300 F.

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SECY-02

Based on these considerations, it is concluded that the proposed revisions to NRC Regulatory Guide 1.157 and Appendix K to Part 50 are unnecessary.

The Westinghouse Electric Company appreciates the opportunity to comment on this petition for rulemaking. If there are any questions regarding these comments, please contact Cesare Frepoli at (412) 374-4156.

Very truly yours,

H. A. Sepp, Manager
Regulatory and Licensing Engineering

cc: G. Shukla

Attachment

ATTACHMENT

Comments of the Westinghouse Electric Company Regarding The Petition for Rulemaking Published in Federal Register 51783

Petitioner's Request

The petitioner requests that the U.S. Nuclear Regulatory Commission take actions to address the impact of the complex thermal hydraulic conditions during Loss-of-Coolant Accident (LOCA) on zirconium-water reactions. In particular the petition covers three distinct issues:

1) Amendment of Appendix K to Part 50 of the Commission's regulations.
2) Amendment of an NRC guidance document entitled Regulatory Guide 1.157, Best-Estimate Calculations of Emergency Core Cooling System (ECCS) Performance.
3) The need for further analysis of Part 50 backup data.

Zirconium-Water Reactions during LOCA

The effects of the exothermic zirconium-water reaction are considered in the emergency core cooling system design because of their potential influence on the thermal and mechanical behavior of the system.

Discussion in the literature concludes that the zirconium-water reaction is relatively slow and corrosion-like under most conditions However, at very high temperatures a self-sustained reaction can occur (runaway oxidation). The Baker-Just correlation is specified in Appendix K of 10CFR50.46 for the calculation of the energy release rate due to oxidation, hydrogen generation, and equivalent cladding reacted. One of the reasons for establishing 2200 F temperature limits during a LOCA, with Baker-Just correlation, was to avoid runaway oxidation

Baker-Just experiments considered the reaction occurring between finely dispersed zirconium specimens at the melting point and sub-cooled water. The Baker-Just correlation was obtained with a simple interpolation between zirconium melting point data and adjusted points from Lemmon. The correlation is known to be very conservative and subsequent tests demonstrated that the correlation over-predicts the zirconium-water reaction by as much as 30% at the limiting temperature (2200 F).

In 1989 the USNRC Regulatory Guide 1.157 allowed the use of a best-estimate correlation to calculate the zirconium-water reaction for temperatures greater than 1900 F, and recommended the use of the Cathcart-Pawel correlation (NUREG-17).

In these experiments the zirconium specimens were exposed to flowing steam environments. NUREG-17 describes two test series. The MaxiZWOK tests covered a temperature range from 1632 to 1832 F and the MiniZWOK test series extended up to 2732 F. Although both test series aimed to produce isothermal oxidation data, they operated under different conditions. In particular the MaxiZWOK was characterized by a higher steam flow and steam temperature than in MiniZWOK.

The Cathcart-Pawel correlation is based on data originated with the MiniZWOK test facility. The experimenters used the MaxiZWOK for scoping tests. Data obtained from the MiniZWOK were considered more precise and reliable. Also from the NUREG-17 report, it can be inferred that the MaxiZWOK tests were limited to a lower range of temperature because of limits in the apparatus.

One feature of the MaxiZWOK tests is that in the upper bound of the range of temperature considered, an overshoot of a few tens of degree F was observed before the specimen temperature reached the equilibrium value. This was the result of the exothermic zirconium-water reaction. Moreover, in order to heat the specimen at a given temperature, the vapor at the inlet needed to be superheated at a higher temperature than the target value for the specimen.

Because of the different flow conditions between the two test series, the petitioner infers that the oxidation could be limited in the MiniZWOK tests The petitioner suggests that the low steam flow in the MiniZWOK caused hydrogen blanketing at the surface because of the reduced mass transfer. For a given temperature the hydrogen blanketing, which is claimed by the petitioner to occur in MiniZWIK and not in MaxiZWOK, could limit the amount of oxidation

However, MiniZWOK data points were overlapped with MaxiZWOK data points in the range of 1652 to 1832 F and the agreement was good. Moreover, the experimenters ran a series of 'mixed temperature' tests with the MaxiZWOK facility (pg. 102 NUREG-17). In one of these pseudo-isothermal tests the furnace temperature was held at 2030 F and the steam temperature controlled at 1821 F. The MaxiZWOK specimen experienced a temperature overshoot at 2012 F and reached an equilibrium value of 1935 F, but the amount of oxidation for this test was in agreement with values obtained with the MiniZWOK facility at the same equilibrium temperature.

It is believed that the temperature overshoot was not observed in the MiniZWOK tests because of the much lower thermal capacity of the apparatus where the temperature of the specimen was tightly controlled as shown in Fig. 9 and 10 of NUREG-17.

Hydrogen blanketing also requires the development of a stable hydrogen boundary layer which prevents the steam in the main stream from being in contact with the Zircaloy tubing. The specimens used in the MiniZWOK tests were relatively short (1.18 in) and most likely the boundary layer was still developing over the entire length of the specimen, and a high concentration of steam is expected to be present in proximity of the wall despite the low flow.

It is true that during a LOCA the expected steam flow conditions are more similar to the conditions of the MaxiZWOK tests rather than the MiniZWOK tests. However, the previous considerations and the good overlap between the two test data sets are clear indications that the effect of the steam flow was a secondary effect. The steam flow of the MiniZWOK provided a sufficient mass transfer to prevent steam starvation from occurring.

A number of scoping tests were conducted with MiniZWOK in which a small amount of potentially reactive gases had been added. Even for the case with 10 mole % oxygen addition, the comparison with the standard data base was very good. Had steam starvation occurred in the tests, the addition of oxygen would have been expected to increase the oxidation rate.

More recently, Westinghouse conducted tests with pure oxygen as the oxidant instead of steam. Results were very consistent with Cathcart-Pawel, and this provides further evidence that steam starvation did not occur in the Cathcart-Pawel experiments. Molen and Olander ran tests where they used a mixture of steam and helium. They showed that steam starvation did not occur even with helium concentration as high as 90%.

The high fluid temperature was a result of the exothermic reaction between the zirconium and the steam. This reaction would have occurred at hot spots on the heater rods, on the Zircaloy guide tubes, spacer grids, and steam probe.

From a LOCA perspective, the test conditions of Run 9573 were extremely severe and can be considered beyond design basis. Plant technical specifications limit the nominal peak power to about 17 kw/ft or less. At the beginning of reflood the power is reduced to about 4% of the nominal value. The initial power for Run 9573 was about twice that value. Also, core reflood is expected to start at significant lower clad temperature than in Run 9573.

Metallurgical analyses were performed on specimens extracted from heater rods of Run 9573. The heater rods were exposed to temperatures as high as 2500 F. The measured oxide thickness was in the expected range. Electrical failure of the heating elements began to occur when the clad temperature reached 2300 F.

Conclusions

The petitioner's comments on the differences between the test conditions and the expected fluid conditions in a reactor core during a postulated LOCA accident do not prevent the current database from being applicable to LOCA analysis. Within the range considered, the flow condition is a secondary effect to the zirconium-water reaction because oxidation kinetics depend mostly on the temperature of the oxidizing material.

The consistency between the MaxiZWOK and MiniZWOK data together with more recent investigations conducted by Argonne National Labs (ANL) and Westinghouse support the conclusion that the particular flow conditions considered for the Cathcart-Pawel correlation did not introduce any bias due to hydrogen-blanketing, steam-starvation or other oxidation-limiting phenomena.

The conditions of FLECHT Run 9573 were extremely severe and from a LOCA stand point should be considered beyond design basis for the ECCS. Despite the severity of the conditions and the observed extensive zirconium water reaction, the oxidation was within the expected range and runaway oxidation beyond 2300 F.

Based on these considerations, it is concluded that the proposed revisions to NRC Regulatory Guide 1.157 and Appendix K to Part 50 are unnecessary.

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The Federal Register Notice requested public comment on several specific questions. Those questions are repeated below, followed by the Westinghouse Electric Company's responses.

(1) Are the petitioner's three concerns with respect to ECCS cooling valid? If so, do these concerns constitute a significant safety concern?

Response:
In issues (1) and (2), the petitioner expressed concerns that test conditions do not include any allowance for the complex thermal-hydraulic conditions in a reactor core during a postulated LOCA. Westinghouse believes that the differences between the test conditions and the expected fluid conditions in a reactor core during a postulated LOCA do not prevent the current database from being applicable to a LOCA analysis

accident for the reasons stated above. Regarding issue (3), Westinghouse notes that the metallurgical analyses performed for FLECHT Run 9573 indicated that the measured oxide thickness was still within the expected range for specimens heated as high as 2500 F. Moreover, the thermal-hydraulic conditions of FLECHT Run 9573 should be regarded as beyond design basis for the ECCS.

Therefore, based on previous conclusions, petitioner's concerns do not constitute a significant safety concern.

(2) Are there actions available to the Commission other than rulemaking that would effectively address the concerns raised by the petitioner?

Response:
Based on our conclusions, proposed revisions to NRC regulations, regulatory guidance, or other actions are considered unnecessary.