Docket File

52-003

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 9, 1997

APPLICANT: Westinghouse Electric Corporation

FACILITY: AP600

SUBJECT: SUMMARY OF APRIL 15, 1997, MEETING WITH WESTINGHOUSE TO DISCUSS ISSUES ASSOCIATED WITH THE LOWER HEAD INTEGRITY UNDER IN-VESSEL STEAM EXPLOSION LOADS FOR THE AP600

The subject meeting was held on April 15, 1997, in the Rockville, Maryland, offices of the Nuclear Regulatory Commission (NRC) between representatives of Westinghouse, and the NRC staff. Attachment 1 is a list of meeting attendees.

The purpose of the meeting was to discuss comments that were sent to Westinghouse from the staff in a March 25, 1997, letter concerning a report entitled "Lower Head Integrity Under In-Vessel Steam Explosion Loads," (DOE/ID-10541). Prior to the meeting Westinghouse provided Attachment 2 to the staff detailing the questions that they believed needed to be addressed as a result of the comments that were sent to Westinghouse. The staff agreed with Westinghouse that the questions in Attachment 2 captured all of the questions that were imbedded in the comments sent to Westinghouse in the March 25, 1997, letter. However, the staff did not agree with Westinghouse's assignment of the categories for the disposition of the questions. During the meeting the disposition of the questions was discussed. Therefore, the questions in Attachment 2 served as the agenda for the meeting and attachment 3 provides the disposition for the questions. The staff requests that Westinghouse enter the nine questions in attachment 2 into the Open Item Tracking System.

At the end of the meeting there was a brief discussion about the status of the peer review comments for the DOE report. Westinghouse stated that the peer review comments without the responses would be provided to the staff in the near term and that responses to the comments would be provided to the staff by the end of May. The staff stated that they were still in the process of reviewing the reports (DOE/ID-10489, DOE/ID-10503, and DOE/ID-10504) which form the basis of and/or supplement the findings in the main report. The staff further stated that any additional comments that it may have concerning the peer review comments and the additional reports would be provided to

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Westinghouse by the end of May. A draft of this meeting summary was provided to Westinghouse to allow them the opportunity to ensure that the representations of their comments and discussions were correct.

original signed by:

Joseph M. Sebrosky, Project Manager
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Docket No. 52-003

Attachments: As stated

cc w/attachments:
See next page

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WESTINGHOUSE AP600 IN-VESSEL STEAM EXPLOSION LOADS
MEETING ATTENDEES
April 15, 1997

NAME	ORGANIZATION
CINDY HAAG	WESTINGHOUSE
JIM SCOBEL	WESTINGHOUSE
BRIAN MCINTYRE (PART TIME)	WESTINGHOUSE
CHARLES THOMAS	DEPARTMENT OF ENERGY
THEO THEOFANOUS	UNIVERSITY OF CALIFORNIA, SANTA BARBARA
SUDHAMMAY BASU	NRC/RES
CHARLES TINKLER	NRC/RES
MICHAEL SNODDERLY	NRC/NRR/DSSA/SCSB
JOE SEBROSKY	NRC/NRR/DRPM/PDST

Attachment 1

Westinghouse comments provided to the staff prior to the meeting

Here is a summary of the potential RAIs that we have harvested from the NRC review of the In-Vessel Steam Explosion Report. Please Confirm with the NRC that this list covers all the topics that they wish to discuss at the 2 pm meeting on April 15. We have placed the comments into two categories: (A) comments for which we believe they should supply a written questions so we can supply a written response, and (B) comments we believe can be resolved with discussion in the meeting.

1. Provide the values or set of values used for the crust growth constant, λ used in the freezing time calculation for the lower core blockage. (A)

2. Provide assessment of the effect of uncertainties in conductivity of the blockage material and the power density in the crust on the heat flux used to calculate the water contact time for the lower core blockage. (A)

3. Provide evidence to support the claim that the range of sizes of the sideward failure in the reflector represents a reasonable range for the calculation of the melt release rate. (B)

4. Provide an extreme parametric case to investigate the bounding melt release rate that can produce lower head failure. (B)

5. Provide the basis for the 20 mm melt length scale used in the analysis. (B)

6. Discuss how the results of [NRC Review Letter] Table 2 relate to the conclusion that the impulses do not depend strongly on the size of the mixing zone. (B)

7. What value of the melt participation factor was used in the ROAAM calculations? (B)

8. It is recommended that the report discuss how the case of intersecting load and fragility curves would be treated within the ROAAM framework. (B)

9. Why is the 11 percent plastic strain criterion not used in the case of the reflood FCI? (A)

Attachment 2

Disposition of Comments on the In-vessel Steam Explosion Report

1. Provide the values or set of values used for the crust growth constant, λ used in the freezing time calculation for the lower core blockage. (A)

   Disposition: Westinghouse will provide a written response to this question.

2. Provide assessment of the effect of uncertainties in conductivity of the blockage material and the power density in the crust on the heat flux used to calculate the water contact time for the lower core blockage.

   Disposition: During the discussion of this question, Westinghouse stated that the downward heat flux would remain the same even if the blockage thermal conductivity and/or power density was varied. As a result, the water evaporation time would not change. Consequently, it would be more appropriate to assess the effect of uncertainties in the conductivity and the power density of the blockage crust thickness. Therefore, at the meeting it was decided that Westinghouse would provide a written response to Item 2 in terms of the effect on the blockage crust thickness instead of in terms of the effect on water contact time for the lower core blockage.

   Subsequent to the meeting, the staff further evaluated the issues and has concluded that unless there is an extreme change in crust thickness as a result of the parametric studies, the result is not likely to shed additional light into the melt relocation scenario considered in the report. In fact, the staff is of the view that it is necessary rather to document the basis for the Westinghouse position that downward heat flux would not change as a result of parametric variation. Therefore, the staff wishes to reformulate the question and ask Westinghouse to demonstrate that the downward heat flux will remain the same as will the relative partitioning of downward, upward and sideward heat fluxes.

Attachment 3

3. Provide evidence to support the claim that the range of sizes of the sideward failure in the reflector represents a reasonable range for the calculation of the melt release rate.

   Disposition: See item 4 below.

4. Provide an extreme parametric case to investigate the bounding melt release rate that can produce lower head failure.

   Disposition: During the discussion of questions 3 and 4 Westinghouse provided additional background information. Specifically, Westinghouse stated that the release rate is an intangible parameter that was difficult to bound. In addition to the release rate, Westinghouse considered the trigger time and breakup size to be intangible parameters. Westinghouse believed that they used conservative numbers for these parameters and that with the conservative treatment of these parameters there was still sufficient margin in the calculations to demonstrate that the reactor vessel would not fail.

   The staff noted that the peak impulse loads calculated in the DOE report were close, at least in one case, to the fragility limit. Consequently, the staff was concerned about the implication of higher melt release rates than the ones considered in the report on the likelihood of lower head failure. Westinghouse responded that the peak impulse loads should not be considered by themselves, instead they should be combined with the effect of the area reduction factor. The staff agreed to reassess questions number 3 and 4 based on the information on area reduction factor in the report. (See question #6 for a related discussion)

   The staff has since reviewed Chapter 3 of the report with particular focus on the area reduction factor argument. The argument, simply, is that when the load is localized, part of it is transformed into bending energy. Consequently, the effective impulse corresponding to a localized load is smaller than the impulse corresponding to a uniform load. Likewise, the effective plastic strain for a localized load is smaller than that for a uniform load. The report assumes that the fractional impulse, I_b/I, dissipated in bending is directly proportional to the total impulse, I, and inversely proportional to the fractional area loaded - the latter meaning, the smaller the area loaded the higher the bending energy dissipated and vice versa. The proportionality constant, β, in equation (3.8) is identified as a material and geometric constant implying that the value of β depends on the lower head material and the geometry. Even though no value is specified in the report, an examination of equivalent plastic strain plots in Figure 3.9 leads us to conclude that a value of 0.2 is chosen for ß. Westinghouse needs to confirm the value of ß and provide justification for the chosen value.

With ß=0.2 assumed, calculations were carried out to determine the effect of load localization on effective impulse, I_{eff} (= $I-I_b$), and on equivalent plastic strain (with strain rate included), ϵ_{3D}. The results indicate that for the three loading patterns considered in the report (see Table 3.2), the local plastic strain is 23 percent for an impulse load of 300 kPa-s with least load localization. In fact, the plastic strain is limited to 40 percent or less for impulse loads up to 400 kPa-s with least load localization. Note that this impulse load is 2 times the maximum impulse (~ 200 kPa-s) calculated in the report for a parametric run with 400 kg/s melt release rate. Assuming that the impulse is proportional to the release rate, it means that a 800 kg/s release rate is likely to produce 400 kPa-s impulse and equivalently, 40 percent plastic strain when the load is least localized. Therefore, Westinghouse's assertion of the area reduction factor argument has a basis; however, it is contingent upon the assumed value of ß.

In the staff review, two cases were found when the plastic strain exceeded 40 percent (see Figure 3.8 of the report). The cases are 450 kPa-s (corresponding strain of 52 percent) and 570 kPa-s (corresponding strain of 87 percent) impulse loads, the first one with least load localization and the second with intermediate load localization. Following the proportionality assumption between the melt release rate and the impulse as above, these cases correspond to melt release rates of 900 kg/s and 1150 kg/s, respectively. Westinghouse should demonstrate, based on geometry and other arguments, why these cases are not considered in the framework of ROAAM.

In its previous review, the staff noted that the melt release rates (100, 200, and 400 kg/s) considered in the subject report are comparable to the TMI-2 scenario (~ 160 kg/s). However, the hole sizes (10 cm x 10 cm, 10 cm x 20 cm, and 10 cm x 40 cm, respectively, corresponding to the three release rates) are much smaller than the TMI-2 hole size (60 cm x 150 cm). The implication is that if the TMI-2 hole size is considered, the release rate will be much larger and the steam explosion load will likely be much larger. This concern formed the basis of the staff comment (see item 3 in Attachment 1) dealing with the reasonableness of the hole sizes considered in the report.

For its part Westinghouse agreed to address why the hole size seen at TMI-2 which was much larger (60 cm x 150 cm) than the hole sizes used in the DOE report was not considered. (The reference to the TMI-2 hole size can be found in the comments of the March 25, 1997, letter.) Westinghouse agreed to provide this assessment in a revision to the DOE report.

5. Provide the basis for the 20 mm melt length scale used in the analysis.

   <u>**Disposition**</u>: Westinghouse will revise the DOE report to provide a discussion as to why consideration of a larger value of initial melt length scale does not affect the conclusions of the report.

6. Discuss how the results of [NRC Review Letter] Table 2 relate to the conclusion that the impulses do not depend strongly on the size of the mixing zone.

   <u>**Disposition**</u>: See disposition of item 4 above for a related discussion. Westinghouse agreed with the staff that there were calculated values of the peak local impulses on the lower head that should be reinvestigated. Specifically, Westinghouse referred to Table 6.1 of the DOE report for the C2 case where beta equaled 20 and the trigger time was 0.120. This case resulted in a peak pressure of about 1000 MPa. Westinghouse stated that they were concerned about this case because it exceeded 800 MPa. Westinghouse stated that it would reinvestigate this calculation.

7. What value of the melt participation factor was used in the ROAAM?

   <u>**Disposition**</u>: Westinghouse stated that 1 was used as the melt participation factor. The staff agreed with Westinghouse that this was a conservative treatment of this parameter. Therefore, the staff considers this question resolved.

8. It is recommended that the report discuss how the case of intersecting load and fragility curves would be treated within the ROAAM framework.

   <u>**Disposition**</u>: Westinghouse will revise the DOE report to address this issue.

9. Why is the 11 percent plastic strain criterion not used in the case of the reflood FCI?

   <u>**Disposition**</u>: Westinghouse will revise the DOE report to provide an explanation for why 20 percent was chosen for the plastic strain criteria in the reflood case instead of 11 percent as in the baseline case.