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DCP/NRC1489
Project 711

November 5, 2001

Document Control Desk
U. S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

ATTENTION: Mr. Andrzej Drozd, NRC, MS 10H1

SUBJECT: Transmittal of Westinghouse Responses to Requests for Additional Information (RAIs) for AP1000 Pre-Certification Review

Dear Mr. Drozd:

Attached please find the Westinghouse responses to the following Requests for Additional Information (RAIs) related to the pre-certification review of the AP1000:

P40	P57
P43	P58
P44	P68
P55	P70
P56	P74

Please contact me if you have questions related to these responses.

Very truly yours,

Michael M. Corletti

M. M. Corletti
Passive Plant Projects & Development

/Attachments
1) Responses to NRC Request for Additional Information

DO63
Rec'd from NRR 02/27/02

2775alf.doc

Attachment 1

"Westinghouse Responses to Requests for Additional Information (RAIs)
for AP1000 Pre-Certification Review"

(Westinghouse Non-Proprietary Class 3)

REQUEST FOR ADDITIONAL INFORMATION

RAI: P40

Question:

Please provide current user input manuals for LOFTRAN, NOTRUMP, WCOBRA/TRAC, and WGOTHIC. We understand that Westinghouse has prepared "Safety Engineering Standards" and calculational notes describing input preparation for AP1000. Please provide these documents.

Westinghouse Response:

The applicable LOFTRAN, NOTRUMP and WCOBRA/TRAC user input manuals have been provided in References P40-1, P40-2, and P40-3 respectively. The GOTHIC users manual was provided to the staff as part of the AP600 Design Certification review. In addition, Westinghouse has committed to use an AP1000 WGOTHIC evaluation model consistent with the AP600 Evaluation Model (Reference P40-4). Therefore, an update of the GOTHIC user input manual or application report was not deemed necessary at this time. Westinghouse has committed to follow the same approach for AP1000 as was used for AP600 as described in Reference P40-4, and an update to reference P40-4 will be submitted to the staff as part of the AP1000 Design Certification review.

References:

P40-1 DCP/NRC1488, "Transmittal of Westinghouse Report, "AP1000 Analysis Methodology Summary for Events Using the LOFTRAN Code Family," dated 10/31/2001.

P40-2 DCP/NRC1485, "Transmittal of Westinghouse Report, "NOTRUMP Users Manual for AP600 and AP1000," dated 9/19/2001.

P40-3 DCP/NRC1483, "Transmittal of WCOBRA/TRAC Users Manual," dated 9/10/2001.

P40-4 WCAP-14407 Rev. 3, "WGOTHIC Application to AP600," April 1998.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P43

Question:

For each user input option used to describe AP1000 for LOFTRAN analysis, please provide the option used for each reactor system component and justify that the option used is appropriate.

Westinghouse Response:

Please see Reference P43-1 for options used in the AP1000 LOFTRAN transient analyses. Reference P43-1 includes LOFTRAN node diagrams and a LOFTRAN input description. Also included is a listing of the latest LOFTRAN reference input to be used in AP1000 analyses, as well as comprehensive review of events analyzed with LOFTRAN that identifies assumptions, options and input used for each transient analyses. A section is also included which summarizes noding and assumptions used for LOFTRAN analyses of SPES tests from WCAP-14307 Revision 1.

References:

P43-1 APP-GW-GSR-010 (Proprietary) and APP-GW-GSR-011 (Nonproprietary), "AP1000 Analysis Methodology Summary for Events Using the LOFTRAN Code Family", October 2001

REQUEST FOR ADDITIONAL INFORMATION

RAI: P44

Question:

Provide a comparison of user options described in RAI P43 for AP1000 with the LOFTRAN analyses of SPES described in WCAP-14307, Rev. 1. Provide a comparison of system noding between the LOFTRAN AP1000 input model and the SPES input models.

Westinghouse Response:

Please see Reference P44-1 for options used in the AP1000 LOFTRAN transient analyses. Reference P44-1 includes LOFTRAN node diagrams and a LOFTRAN input description. Also included is a listing of the latest LOFTRAN reference input to be used in AP1000 analyses, as well as comprehensive review of events analyzed with LOFTRAN that identifies assumptions, options and input used for each transient analyses. A section is also included which summarizes noding and assumptions used for LOFTRAN analyses of SPES tests from WCAP-14307 Revision 1.

References:

P44-1 APP-GW-GSR-010 (Proprietary) and APP-GW-GSR-011 (Nonproprietary), "AP1000 Analysis Methodology Summary for Events Using the LOFTRAN Code Family", October 2001

REQUEST FOR ADDITIONAL INFORMATION

RAI: P55

Question:

WCAP-15613 shows that APEX is not appropriately scaled for the Natural Circulation phase. Since the PRHR design has been modified to significantly reduce the flow resistance, the Π groups representing the ratios of inertia to buoyancy and resistance to buoyancy may change considerably. To fully justify the applicability of the SPES tests for this phase, provide numerical values for the Π groups listed in Table 3.2-8 and 3.2-9 of WCAP-14727, Rev. 2 and values for terms used within these Π groups such that they can be calculated for the AP1000.

Westinghouse Response:

Numerical values for the Π groups listed in Table 3.2-9 of WCAP-14727, Rev. 2 are provided in the table below. Reference values used to calculate the Π groups are based upon NOTRUMP calculations and are provided in Appendix E of WCAP-14727, Rev. 2 for AP600 and SPES. As the plant calculations and test facilities showed that there was not significant single-phase natural circulation when PRHR heat removal is important during a SBLOCA, only two-phase natural circulation Π groups are shown. As evidenced in the SPES facility, a typical SBLOCA proceeds from natural circulation with steam generator heat removal to two-phase natural circulation with PRHR heat removal.

Π Group	Ratio	AP600	AP1000	SPES	SPES / AP1000
Π_{S-1}	Inertia / Buoyancy	0.0018	0.0057	0.0005	Not Important (Π<<1)
Π_{S-2}	Resistance / Buoyancy	0.75	2.385	1.25	0.52
Π_{S-3}	Buoyancy / Buoyancy	1.0	1.0	1.0	1.0
Π_{S-4}	SensibleHeat / Core Power	0.356	0.75	0.388	0.52
Π_{S-6a}	Phase Change Momentum Flux / Buoyancy (Boiling)	0.00015	0.00076	0.00048	Not Important (Π<<1)
Π_{S-6b}	Phase Change Momentum Flux / Buoyancy (Condensation)	3.01E-06	7.27E-06	5.08E-06	Not Important (Π<<1)
Π_{S-7}	Boiling Heat / Core Power	1.967	1.453	1.249	0.86
Π_{S-8}	Convective Heat / Core Power	0.224	0.45	0.259	0.58

From the scaling ratios in the table above, it can be seen that SPES is sufficiently scaled to AP1000 for the important Π groups as the Π ratios are within the acceptance criteria ($0.5<\Pi_{Ratio}<2.0$). It can also be seen from the Π values above, that inertial (Π_{S-1}) and momentum flux (Π_{S-6a} and Π_{S-6b}) terms are not important ($\Pi<<1$) for AP1000 during this phase of a SBLOCA transient consistent with AP600 scaling results.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P56

Question:

The scaling groups for the ADS Blowdown phase depend on the core power, which is substantially higher in the AP1000 than AP600. This will reduce the value of the Π group and in some cases such as for Π_{S-4} , the ratio of sensible heat rate to core power, may cause the AP1000 value to fall outside the range supported by APEX and SPES. Provide numerical values for the Π groups listed in Table 3.2-10 of WCAP-14727, Rev. 2 and values for the terms used within these Π groups such that they can be calculated for the AP1000.

Westinghouse Response:

Numerical values for the Π groups listed in Table 3.2-10 of WCAP-14727, Rev. 2 are provided in the tables below. Reference values are based upon NOTRUMP calculations for a SBLOCA and are provided in Appendix E of WCAP-14727, Rev. 2 for AP600, SPES, and OSU.

SYSTEM LEVEL SINGLE-LOOP Π GROUPS FOR SBLOCA
ADS Blowdown (ADS-1)

Π Group	Ratio	AP600	AP1000	SPES	OSU	SPES / AP1000	OSU / AP1000
Π_{S-4}	Sensible Heat / Core Power	0.54	0.36	0.45	0.09	1.26	0.25
Π_{S-7}	Boiling Heat / Core Power	0.94	0.80	1.94	0.97	2.43	1.21
Π_{S-8}	Convective Heat / Core Power	0.10	0.08	0.16	0.06	1.97	0.78
Π_{S-9}	1ϕ Pressure Compliance / Core Power	0.0056	0.0036	0.0064	0.0016	Not Important (Π<<1)	Not Important (Π<<1)
Π_{S-10}	2ϕ Pressure Compliance / Core Power	0.62	0.44	0.86	0.27	1.96	0.62
Π_{S-11}	1ϕ Mechanical Compliance / Core Power	1.97	1.36	3.65	1.79	2.68	1.31
Π_{S-12}	2ϕ Mechanical Compliance / Core Power	0.05	0.04	0.05	0.01	Not Important (Π<<1)	Not Important (Π<<1)
Π_{S-14}	Flow Energy / Core Power	0.62	0.44	0.86	0.27	1.96	0.62

From the scaling ratios in the tables above, it can be seen that SPES and OSU are sufficiently scaled to AP1000 for most of the Π groups. For OSU, Π_{S-4} is distorted for both AP600 and AP1000. However, the SPES facility is well-scaled for this non-dimensional group, and can be relied upon for code validation for this phase of a SBLOCA transient. For SPES, Π_{S-7} and Π_{S-11} are slightly distorted for AP600 and AP1000 as the scaling ratios are just outside of the

Westinghouse acceptance criteria. Although these scaling groups are slightly distorted, this did not preclude the use of SPES for code validation purposes for AP600. The distortion is not too large and is within the acceptance criteria used by NRC scaling consultants for AP600 that important scaling ratios be within a factor of 3.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P57

Question:

For IRWST injection, the Π groups ($\Pi_{S\text{-}1}$, ...- $\Pi_{S.8}$) identified by Westinghouse in WCAP-14727, Rev. 2 as being important were as listed in table 3.2-11. Since several of the areas, lengths and thermal conditions of the ADS-4 and IRWST have changed, provide revised values for

$$W_0^2, L_{gr}, A_0, \left(\frac{L}{A}\right)_{ML}, and \sum R_{ML}$$

Also, provide an estimate of the core power and RCS pressure at the start of the ADS-4 phase.

Westinghouse Response:

Numerical values for the Π groups listed in Table 3.2-11 of WCAP-14727, Rev. 2 are provided in the table below. Reference values are based upon NOTRUMP calculations and are provided in Appendix E of WCAP-14727, Rev 2., for AP600, SPES, and OSU. The calculated values are for the 2-inch cold leg break event.

SYSTEM LEVEL SINGLE-LOOP Π GROUPS FOR SBLOCA IRWST Injection							
Π Group	**Ratio**	**AP600**	**AP1000**	**SPES**	**OSU**	**SPES / AP1000**	**OSU / AP1000**
$\Pi_{S\text{-}1}$	**Inertia / Buoyancy**	**0.0015**	**0.0011**	**0.0012**	**0.0028**	**Not Important (Π<<1)**	**Not Important (Π<<1)**
$\Pi_{S\text{-}2}$	**Resistance / Buoyancy**	**1.02**	**0.49**	**1.49**	**1.50**	**3.05**	**3.07**
$\Pi_{S\text{-}3}$	**Buoyancy / Buoyancy**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
$\Pi_{S\text{-}4}$	**SensibleHeat / Core Power**	**0.44**	**0.58**	**0.44**	**0.40**	**0.76**	**0.69**
$\Pi_{S\text{-}5}$	**Momentum Flux for Area Change / Buoyancy**	**1.59E-05**	**6.98E-06**	**3.77E-05**	**2.92E-05**	**Not Important (Π<<1)**	**Not Important (Π<<1)**
$\Pi_{S\text{-}6a}$	**Momentum Flux For Boiling / Buoyancy**	**3.99E-05**	**1.75E-05**	**4.78E-05**	**1.01E-05**	**Not Important (Π<<1)**	**Not Important (Π<<1)**
$\Pi_{S\text{-}7}$	**Boiling Heat / Core Power**	**8.49**	**5.88**	**11.77**	**13.5**	**2.02**	**2.32**
$\Pi_{S\text{-}8}$	**Convective Heat / Core Power**	**1.96**	**1.49**	**2.71**	**3.11**	**1.82**	**2.09**

From the scaling ratios in the tables above, it can be seen that SPES and OSU are sufficiently scaled to AP1000 with the exception of scaling ratios Π_{S-2} and Π_{S-7}. It can also be seen from the Π values above, that inertial and momentum flux terms are not important during this phase of a SBLOCA transient.

Scaling ratio Π_{S-7} is slightly beyond the Westinghouse acceptance criteria, however, it is well within the acceptance criteria (important scaling ratios should be within a factor of 3) used by NRC scaling consultants for AP600. Scaling ratio Π_{S-2} however is outside the Westinghouse acceptance criteria and that used by NRC scaling consultants for AP600. This scaling ratio represents the ratio of resistance to buoyancy during the IRWST injection phase. The formulation of this scaling group was derived for the AP600 program and was based upon the single phase contribution to resistance of the DVI and ADS paths. While this approach is appropriate for the DVI flow path it significantly understates the two-phase resistance associated with the ADS flow path. Therefore, for AP1000, the scaling of this phase was reformulated to account for the two-phase resistance associated with the ADS flow path. Referring to the AP1000 scaling in section 4 of WCAP-15613, when the two-phase contribution to resistance is accounted for, OSU is well scaled to AP1000 while SPES is distorted. The scaling provided in WCAP-15613 is considered to more completely reflect the influence of resistance and buoyancy during the IRWST injection phase.

The core power is approximately 48,000 BTU/s and the pressure is approximately 100 psia at the initiation of ADS-4.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P58

Question:

Several of the scaling groups for the Sump Injection phase depend on resistances through the ADS-4 and active systems, and on the core power. Provide numerical values for the Π groups listed in Table 3.2-12 of WCAP-14727, Rev. 2 and values for the terms used within these Π groups such that they can be calculated for the AP1000.

Westinghouse Response:

Numerical values for the Π groups listed in Table 3.2-12 of WCAP-14727, Rev. 2 are provided in the tables below. Reference values are based upon WCOBRA/TRAC calculations and are provided in Appendix E of WCAP-14727, Rev. 2 for AP600 and OSU. Note that SPES did not simulate sump injection.

SYSTEM LEVEL SINGLE-LOOP Π GROUPS FOR SBLOCA Sump Injection							
Π Group	**Ratio**	**AP600**	**AP1000**	**SPES**	**OSU**	**SPES / AP1000**	**OSU / AP1000**
Π_{S-1}	**Inertia / Buoyancy**	**2.25E-05**	**5.57E-05**	**NA**	**1.16E-05**	**NA**	**Not Important (Π<<1)**
Π_{S-2}	**Resistance / Buoyancy**	**0.30**	**0.734**	**NA**	**0.43**	**NA**	**0.59**
Π_{S-3}	**Buoyancy / Buoyancy**	**1.0**	**1.0**	**NA**	**1.0**	**NA**	**1.0**
Π_{S-4}	**SensibleHeat / Core Power**	**0.95**	**1.05**	**NA**	**0.73**	**NA**	**0.70**
Π_{S-5}	**Momentum Flux for Area Change / Buoyancy**	**1.74E-06**	**1.62E-06**	**NA**	**2.81E-06**	**NA**	**Not Important (Π<<1)**
Π_{S-6a}	**Momentum Flux For Boiling / Buoyancy**	**7.14E-05**	**1.02E-02**	**NA**	**2.61E-05**	**NA**	**Not Important (Π<<1)**
Π_{S-7}	**Boiling Heat / Core Power**	**3.27**	**2.68**	**NA**	**6.03**	**NA**	**2.2**
Π_{S-8}	**Convective Heat / Core Power**	**0.19**	**0.276**	**NA**	**0.15**	**NA**	**0.54**

From the scaling ratios in the tables above, it can be seen that OSU is sufficiently scaled to AP1000 with the exception of Π_{S-7}. The ratio of boiling heat to core power is just outside the Westinghouse acceptance criteria but is well within the acceptance criteria used by NRC scaling

consultants for AP600 (scaling ratios within a factor of 3 are considered acceptable). It can also be seen from the Π values above, that inertial and momentum flux terms are not important during this phase of a SBLOCA transient.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P68

Question:

The NRC staff has completed a preliminary analysis of small break LOCA at AP1000 using RELAP5. For a postulated 2-inch cold leg break we calculate core void fractions at the top of the core to be in excess of 90%. These results will be compared to the analysis of the same break size by Westinghouse in WCAP-15612 using the NOTRUMP code. One ADS4 valve was assumed to fail closed as in the NOTRUMP analysis. Decay heat at 1.2 times the 1973 ANS standard was assumed. The containment pressure was set to atmospheric. So that we may continue to compare the results between the two computer codes, please provide the NOTRUMP prediction of core voiding for the 2-inch cold leg break size including the top of the core and intermediate locations. Provide the calculated reactor vessel steam plus water mass as a function of time. Provide the calculated core void fractions and reactor vessel steam plus water mass for the inadvertent ADS opening and double ended DVI line break analyzed using NOTRUMP in WCAP-15612.

Westinghouse Response:

As requested, the core void profiles and reactor vessel masses for the 2-inch cold leg break, Inadvertent ADS actuation, DVI line break (w/ containment pressure = 14.7 psia) and the DVI line break (w/ containment pressure =25.0 psia) documented in WCAP-15612 (Reference RAI P68-1) are provided in the attached figures. The top core node void fraction (Core node 14) observed for the NOTRUMP 2-inch cold leg break simulation approached but did not exceed 90%. In addition to the top core node, void fractions are also provided for Core node 13, the core mid-plane (Core node 7) and the core bottom (Core node 1).

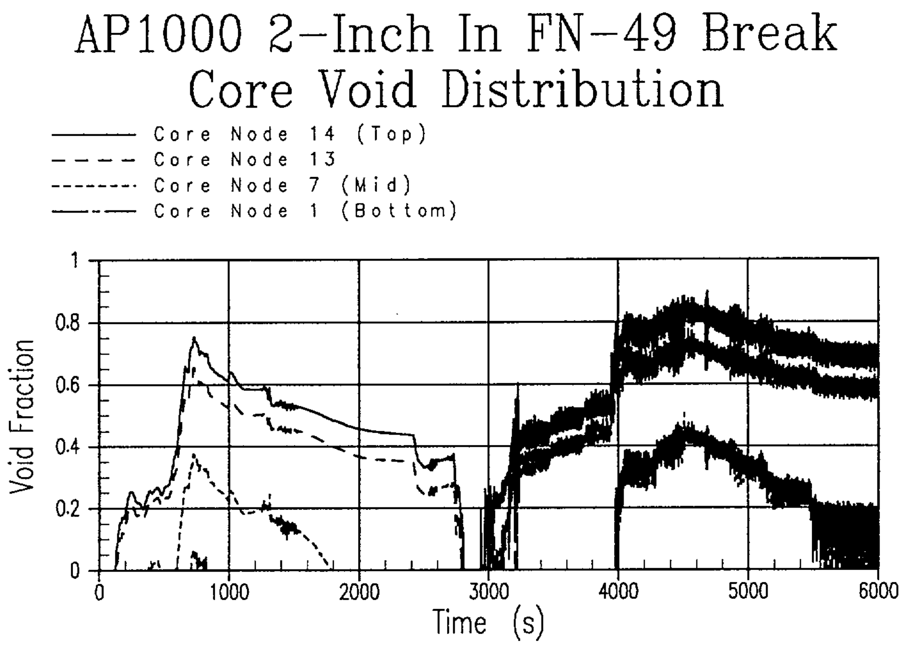

Figure RAI P68-1 - 2-Inch Cold Leg Break: Core Void Profile

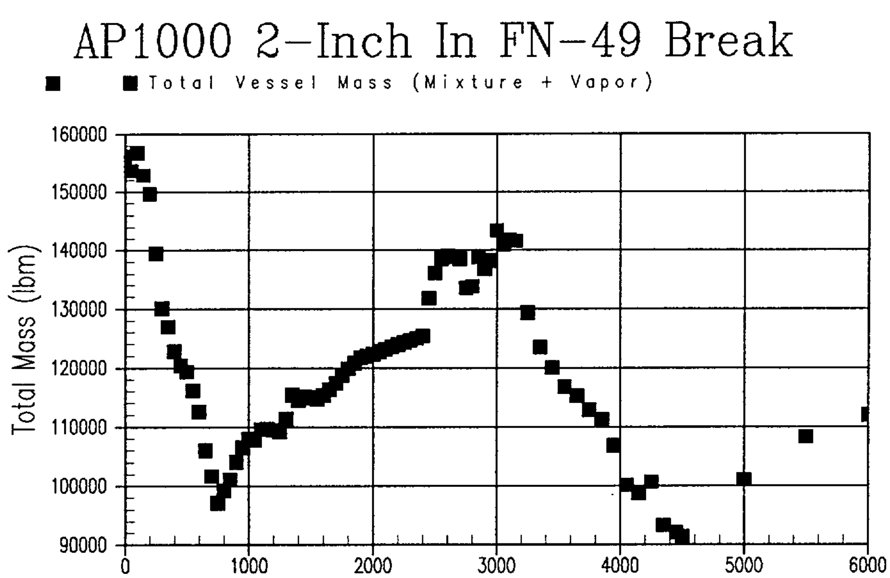

Figure RAI P68-2 - 2-Inch Cold Leg Break: Total Vessel Mass

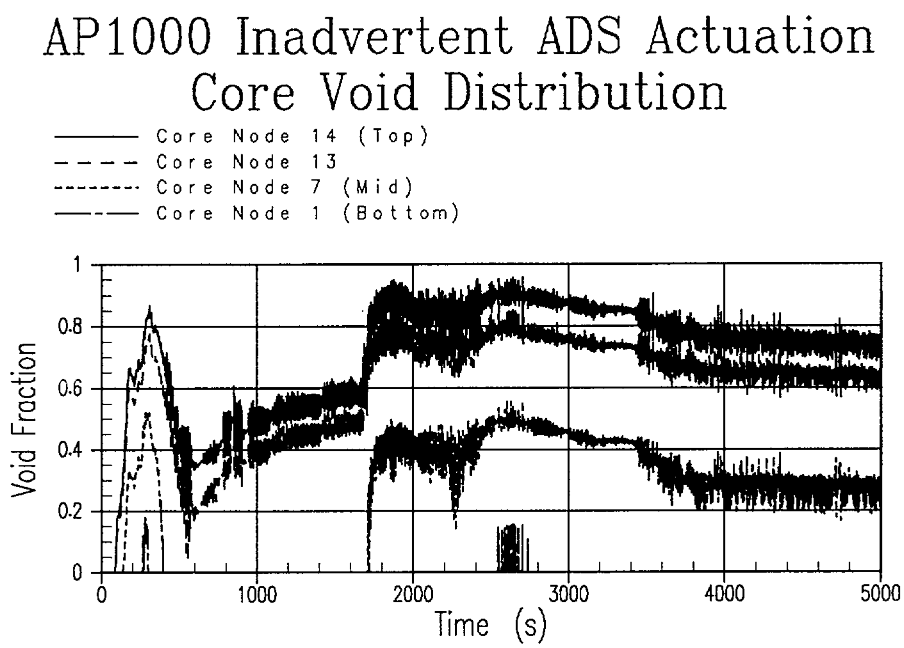

Figure RAI P68-3 - Inadvertent ADS Actuation: Core Void Profile

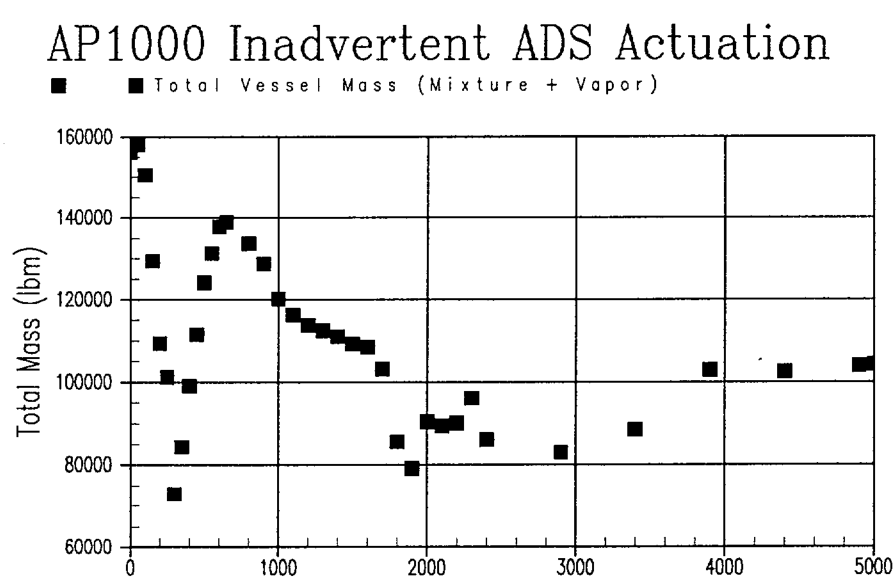

Figure RAI P68-4 - Inadvertent ADS Actuation: Total Vessel Mass

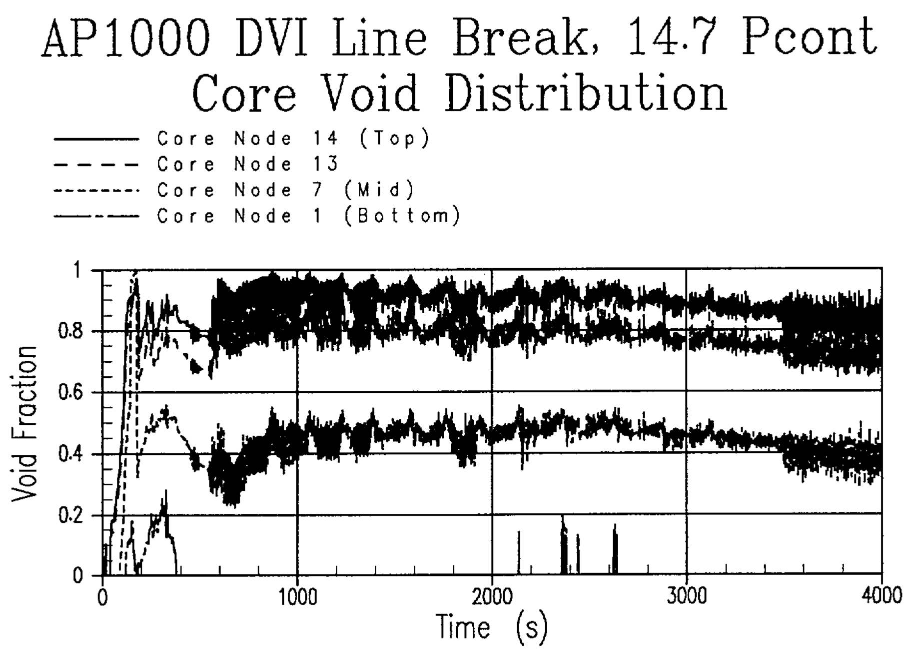

Figure RAI P68-5 - DVI @ 14.7 Containment Pressure: Core Void Profile

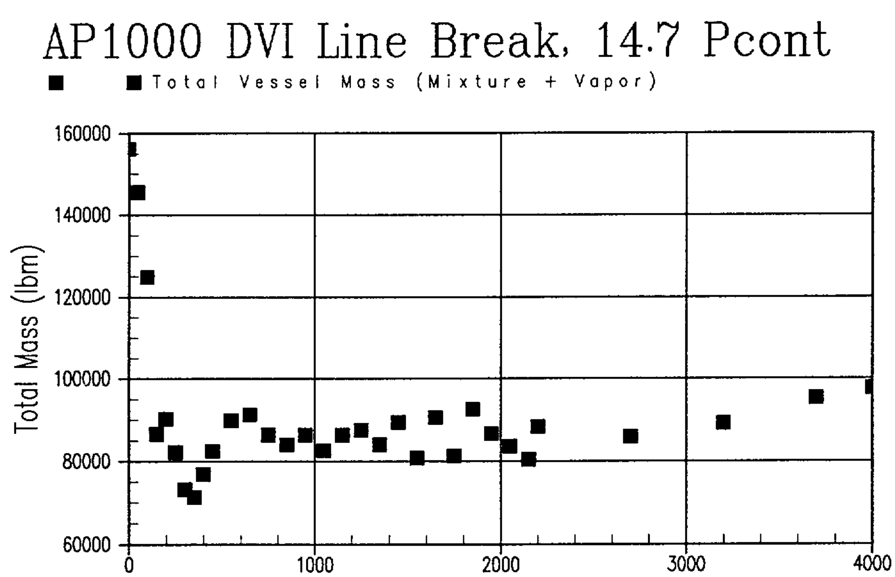

Figure RAI P68-6 - DVI @ 14.7 Containment Pressure: Total Vessel Mass

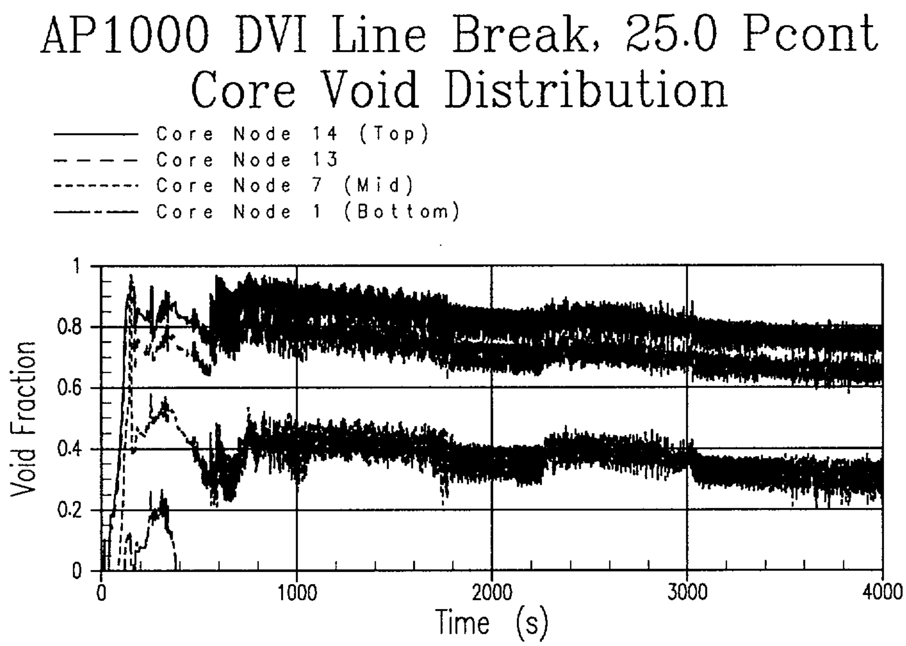

Figure RAI P68-7 - DVI @ 25.0 Containment Pressure: Core Void Profile

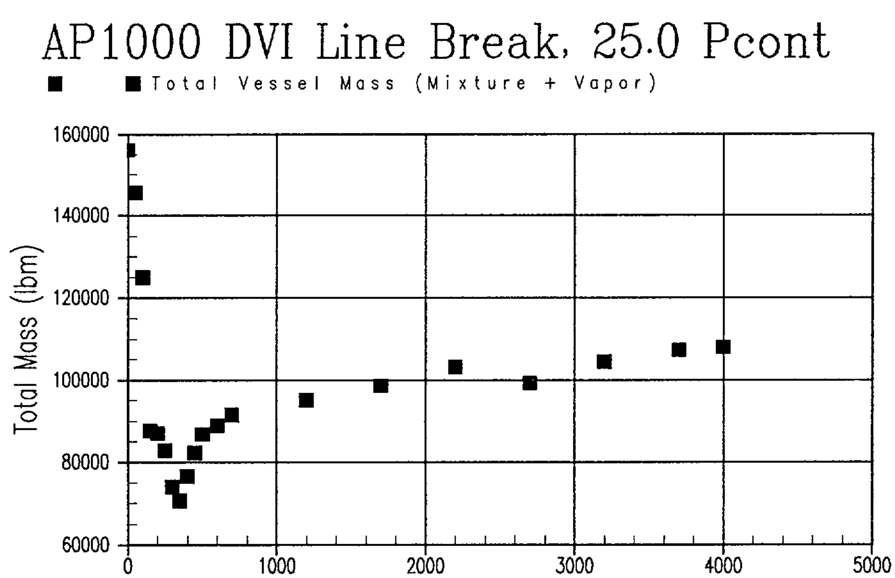

Figure RAI P68-8 - DVI @ 25.0 Containment Pressure: Total Vessel Mass

REQUEST FOR ADDITIONAL INFORMATION

References:

RAI P68-1 WCAP-15612, "AP1000 Plant Description and Analysis Report," December 2000.

RAI: P70

Question:

The AP1000 small break loss-of-coolant accident (SBLOCA) Phenomena Identification and Ranking Table (PIRT) does not include a potential phenomenon of condensation-induced water hammer (CIWH) in the Direct Vessel Injection (DVI) line during early part of the Automatic Depressurization System (ADS) stages 1-2-3 blowdown. A CIWH could occur when cold Core Makeup Tank (CMT) or Accumulator water contacts a low-velocity, stratified steam-water mixture in the DVI line.

A. Provide a revised SBLOCA PIRT with the addition of, among others, the CIWH phenomenon and associated importance ranking. Provide the basis of its ranking.

B. If the CIWH in the DVI lines is determined to be an important phenomenon, provide an evaluation of available test data, test facility scaling assessment, and the modeling of the phenomenon in the analysis code and its validation.

Westinghouse Response:

Westinghouse performed a comprehensive assessment for the potential for water hammer to occur in the AP600 for all "leak-before-break" piping in the AP600 based on the guidelines provided in NUREG-CR-6519 "Screening Reactor Steam/Water Piping Systems for Water Hammer," November 1996. This document provides criteria for piping configurations and thermal hydraulic conditions that can result in steam bubble collapse induced water hammer occurrences. Our assessment included the direct vessel injection (DVI) piping and found that the water hammer potential was low. Since the AP1000 and AP600 DVI piping and the thermal-hydraulic conditions during recovery from design basis events are almost identical and piping configuration assessments performed for the AP600 apply; the water hammer evaluations are also applicable.

Westinghouse also performed evaluations for water hammer for the tests performed at the Oregon State University (OSU) APEX test facility and the SIET SPES2 test facility to identify CIWH events. No significant CIWH events were evident at the SPES2 facility. CIWH events were heard and indicated by the test data at the APEX facility during recovery following simulated small LOCA's. In order to better understand and evaluate these events, fast-response instrumentation was installed in the APEX facility, and the evaluation of this data identified the most severe CIWH events to be occurring in the reactor vessel downcomer, when the accumulator injection flow rate was high. Based on this evaluation of the APEX water hammer events, the RELAP computer code was used to model the events observed at APEX. This model was then used to determine the water slug velocity for water in the AP600 reactor vessel downcomer resulting from the condensation event and to extend the peak pressures observed at the APEX facility to the AP600. This analysis estimated the peak pressure in the

AP600 to be ≤150 psi, which is significantly less than the 400 psid differential pressure for which the affected reactor vessel components are designed. On this basis, no structural damage would result from the APEX type condensation events.

Because observed occurrences of CIWH did not occur in the DVI piping of the APEX or SPES2 test facilities, and would not be predicted to occur as a result of the specific piping configuration or thermal-hydraulic conditions; it was not deemed necessary to add this phenomena to the SBLOCA PIRT.

Based on our assessments for the potential for water hammer occurrences using the approach outlined in NUREG-CR-6519, and based on our observations and evaluations of the AP600 test facilities, it was not deemed necessary to add this phenomena to the SBLOCA PIRT.

REQUEST FOR ADDITIONAL INFORMATION

RAI: P74

Question:

Since the boron concentration of the coolant injected into the RCS in the AP1000 is higher than that for AP600 (2600 vs. 2200 ppm), the potential for boric acid precipitation is greater in the AP1000. Current plants are equipped with hot and cold side injection capabilities, which enable the core and lower plenum to be flushed of excess boron. Please describe how excess boron build-up and precipitation will be prevented in the AP1000. In addition, provide information showing that boric acid crystals from boric acid entrained in droplets from the core and hot legs will not sufficiently collect on the ADS valves and piping structures to compromise their intended functions.

Westinghouse Response:

The AP1000 boron concentrations are the same as the AP600 with the bulk of the boron coming from the IRWST with a boron concentration of 2600 to 2900 ppm. The means by which the AP600 prevents excessive boron buildup has been extensively discussed with the NRC staff (refer to AP600 RAI 440.663).

The AP600 provides a flow path through the core during post-LOCA long-term cooling that prevents significant boron concentration increase due to boiloff. Injection of containment liquid through the DVI lines and the discharge of liquid and vapor through the ADS stage 4 valves flushes the core and precludes a stagnant situation which could lead to boron precipitation in the core region. A quantitative assessment of the effectiveness of the AP600 features to flush boron from the core during post-LOCA conditions was performed using WCOBRA/TRAC calculated results. These results show that the ADS vent quality is 35% when containment recirculation begins about 2 hours after a DVI LOCA. The vent quality is less for other LOCAs. In addition, the vent quality decreases over time, reaching 12% in 28 days.

With a vent quality of 35% the maximum core boron concentration in the AP600 is calculated to be 4600 ppm as compared to the initial post LOCA boron concentration of 3007 ppm. The containment boron concentration decreases only slightly to 2999 ppm as a result of the core boron increase.

A concentration of 4600 ppm is far below the boron solubility limit, which is 50,000 ppm at 212 F. In order for the core boron concentration to reach such a high level, the vent quality would have to remain at 95% for more than a day. The AP600 post-LOCA boron concentrations provide significant margin with respect to boron precipitation.

The AP1000 is expected to behave like the AP600 with operation of the ADS 4 vent path automatically flushing boron from the core. The performance of the AP1000 will be quantified for the Design Certification application submittal including long term core cooling and core boron concentration. It is anticipated that the ADS 4 vent quality will be a little higher in the AP1000

which will cause the core boron concentration to be a little higher. However, the resulting core boron concentration is expected to retain a large margin to the precipitation limit.

Boric acid crystals can not form inside the ADS 4 line and valves. First, there will be a significant flow of liquid and steam in this line. Second, there are no hot surfaces in this line to evaporate water and leave behind dry boric acid crystals. Boric acid crystals can form in cases where borated water is slowly dripped onto a hot surface that can cause the water to evaporate, leaving behind dry boric acid crystals. Such events have occurred in PWRs where borated water leaked out of the RCS and onto the outside surface of hot RCS components. In these situations, the formation of dry boric acid crystals has occurred. This situation is not like the situation inside the ADS 4 piping and valves.