Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6206
Direct fax: 412-374-5005
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP/NRC2516

June 4, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 6)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 6. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP6.2.2-SRSB-03 R2

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

D. A. Lindgren

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 6

DO63
NRO

cc:	D. Jaffe	-	U.S. NRC	1E
	E. McKenna	-	U.S. NRC	1E
	P. Donnelly	-	U.S. NRC	1E
	T. Spink	-	TVA	1E
	P. Hastings	-	Duke Power	1E
	R. Kitchen	-	Progress Energy	1E
	A. Monroe	-	SCANA	1E
	P. Jacobs	-	Florida Power & Light	1E
	C. Pierce	-	Southern Company	1E
	E. Schmiech	-	Westinghouse	1E
	G. Zinke	-	NuStart/Entergy	1E
	R. Grumbir	-	NuStart	1E
	D. Lindgren	-	Westinghouse	1E

ENCLOSURE 1

Response to Request for Additional Information on SRP Section 6

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-03
Revision: 21

Question:

In TR 26, Revision 3, on page 8 in "Applicability to the AP1000 Design" subsection, Westinghouse states that metal reflective insulation (MRI) is used on components that may be subjected to jet impingement loads; MRI is not transported to the AP1000 Containment Recirculation Screens with low flow rates; and as a result, there is no fibrous debris generated by the LOCA blowdown. On page 11 in "Break Selection Criteria" subsection, Westinghouse states that the density of the MRI material ensures that any debris generated by the damage of this insulation material to settle in the containment sump and not be transported onto the screens.

The staff notes there is a significant amount of MRI in the AP1000. In the SER for NEI 04--07, on page 7, the staff stated that MRI is assumed to degrade to 75 percent small fines and 25 percent large pieces.

a. Describe testing or evaluations that show that this type of insulation, once it has been damaged by the LOCA jet, will not become debris that will cause potential plugging of the screens.
b. Verify that the same degradation for the MRI as described in the NEI 04--07 SER exists in the AP1000 or identify what the degradation would be. Describe the impact of the degradation on the debris loading.
c. Was an evaluation performed showing that the MRI material under AP1000 break conditions will not migrate to the containment sump and screens? If so, provide the reference or detailed information in the reference.
d. Is there any chemical residual associated with the MRI that could impact the screen blockage or the downstream blockage in the core? If so, what is the impact to the screens and to the core blockage?
e. Are there any other objects in the zone of influence that can be damaged by jet impingement and contribute to the debris (e.g., cable insulation, instrumentation, hot/cold leg temperature instrumentation, nuclear instrumentation, signs, caulking…)?
f. Is there any fiber insulation encased in MRI that could contribute to the debris? If so, are the configurations qualified for jet impingement? Provide the qualification details.
g. How will lack of debris generating materials in the zone of influence be verified?

Additional Question:

a. Westinghouse's response implied that this RAI regarding MRI is satisfied since NEI 04--07 provides information on the transport of MRI and is accepted by the NRC SER on NEI 04--07. However, though NEI 04--07 indicates that small fines from MRI could be transported to the sump, in AP1000 the small fines from MRI could be transported directly to the open unfiltered flow going into the broken DVI pipe leading to the reactor vessel. This evaluation was not provided by Westinghouse.

b. The RAI response states that the thermal hydraulic conditions associated with a postulated break for the AP1000 are the same as those for current operating PWRs. However, the break conditions for AP1000 may be significantly different especially for a DVI break. What is the velocity of the break when water is flowing into the reactor vessel through the break? Will this be larger than .2 ft/sec, which is the velocity that Westinghouse referred to from NUREG/CR-6808?

Westinghouse Response: < The original response has been revised as shown below to address the additional questions. >

a. Information regarding the generation of debris from MRI is given in NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance." Information regarding the transport of MRI is given in NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology" and has been accepted in the associated NRC Safety Evaluation on NEI 04-07. The liquid velocities evaluated for the AP1000 recirculation flows are lower that the values listed for MRI in Section 4.0 of NEI 04-07.

b. NEI 04-07 and its associated NRC Safety Evaluation are applicable to current operating PWR's. The thermal hydraulic conditions associated with a postulated break for the AP1000 are the same as those for current operating PWR's. Therefore, the degradation or damage characteristics for MRI described in NEI 04-07 and its associated Safety Evaluation for current operating plants are also applicable to the AP1000.

c. MRI is constructed of stainless steel. Tests reported in NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance," have been performed that demonstrate that MRI damaged by LOCA tests will settle and require more velocity to transport than will occur in AP1000. These tests indicate that a velocity of 0.2 ft/s is required to move ½" x ½" crumpled foil MRI debris; larger velocities are required to move larger MRI debris. The AP1000 will have a liquid velocity less than 0.072 ft/s available to move MRI toward the containment recirculation screens.

d. MRI is constructed of stainless steel and contains no substances that would contribute to the post accident chemical precipitants.

e. Damage due to jet impingement is dependant upon the material of interest. Based on a review of the AP1000 design, there are no other materials that that would be affected by jet impingement loads associated with a high energy pipe break that would become debris.

f. As stated in TR 26, on page 8, MRI contains no fibrous material.

g. Tier I ITAAC Table 2.2.3-4, item ix, addresses this issue. The ITAAC requires the inspection of the "insulation used inside the containment on ASME Class 1 lines and on the reactor vessel, reactor coolant pumps, pressurizer and steam generators". The acceptance criteria are that "the type of insulation used on these lines and equipment is a metal reflective type or a suitable equivalent". Also note that the DCD (Section 6.3.2.2.7.1, item 3) also requires metal reflective insulation or a suitable equivalent be used where LOCA jet impingement damage insulation and generate debris.

Additional Reponse:

a. The density of MRI (stainless steel) is much greater (about 8 times) than water density, such that it will settle out readily when the water flows / turbulence due to RCS blowdown has decreased. Small fines from MRI would be moved around the room during the initial blowdown, however once ADS 1/2/3 has been actuated the RCS pressure will decrease substantially and allow the MRI fines to settle out. After the flooding level has increased over the break and after RCS pressure is overcome by the static head of flood water, water starts flowing back into the RCS through the break.

   The figure on the following page provides potential break location elevations in comparison with the room floor elevation. Please note that the lowest of these elevations, designated as the accumulator check valve will not exhibit the flow back into the RCS through the break because the IRWST flow will be either spilling or entering the RCS through this line. This can be seen in the Passive Core Cooling sketch provided.

   The AP1000 DCD long-term core cooling analysis reports the following total flow rates into the core

   - At 10,000 seconds in the LOCA transient, average flow rate into the core is calculated as 1068 gpm (2.3795 ft^3/s) and the peak flow rate into the core is calculated as 1325 gpm (2.9521 ft^3/s)
   - At 14 days into the LOCA transient, average flow rate into the core is calculated as 736 gpm (1.6398 ft^3/s) and the peak flow rate into the core is calculated as 957 gpm (2.1322 ft^3/s)

The associated velocities on the floor can be calculated using the break elevation with a flow area associated with a hemisphere of radius R that corresponds to the distance from the break centerline to the floor, and the maximum core flow rate (60% through the break and 40% through the intact line). Response to RAI-SRP6.2.2-SRSB-10, Revision 1 provides the justification for the flow split through the break DVI line and the intact DVI line. Item 4 in Table 1 displays the calculated flow velocity for a CL

Table 1: Calculated Floor Velocities for Max recirculation flow rates.

	Break Location	Max. Flow Rate	Flow Area	Distance from floor to break centerline	Velocity at Floor
1	DVI nozzle	1325 gpm * 60% (for One Line) = 795 gpm = 1.771 ft^3/s	917.38 ft^2	12.1 ft	0.00193 ft/s
2	Squib Valve	1.771 ft^3/s	50.44 ft^2	2.83 ft	0.0351 ft/s
3	Check Valve	1.771 ft^3/s	14.14 ft^2	1.5 ft	0.125 ft/s
4	CL Break	2600[1] gpm = 5.69 ft^3/s	2440.5 ft^2	19.71 ft	0.00233 ft/s

Note 1. The maximum bounding core flow from a large CL break is calculated to be 340 lbm/sec or (2600 gpm, rounded up). This is a maximum bounding core flow that is based on the following conservative assumptions:

- The water in the containment is saturated. This is a good assumption for a large cold leg break where all the PXS injection passes through the RCS before it enters the containment.
- Pressure losses due to flow through the injection paths (break and PXS) as well as through the ADS vent paths are ignored. This assumption maximizes the water flow through the core. A minimum ADS stage 4 vent quality is then calculated based on a simple hydrodynamic pressure balance between the saturated water supply from the containment and the steam/water mixture venting through the ADS stage 4 path.

For a CL break, the height from the containment flood up level (108.66') to the bottom of the active fuel (80.22 ft) is 28.44 ft, and the height from the ADS 4 discharge (113.39 ft) to the bottom of the active fuel is 33.17 ft. Since the ADS stage 4 discharge elevation is above the containment water level, some steam will be generated in the core to reduce the average density of the steam / water mixture that is vented from ADS stage 4.

From hydrodynamic pressure balance:

$$\gamma_{(l)@212F}h_1 = \gamma_{(l)@212F}h_2(1-Q) + \gamma_{(g)@212F}h_2(Q)$$

Where:
h_1 = height from the containment flood level to the bottom of the active fuel = 28.44 ft
h_2 = height from the ADS 4 discharge to the bottom of the active fuel = 33.17 ft.
γ = density of saturated water and steam at 14.7 psia.
Q = quality of steam required in the ADS vent path to balance head created by the containment water elevation.

Solving for Q yields a value of 0.14; the ADS vent path needs to be at least 14% steam to allow venting of ADS stage 4 at a distance of 4.7 feet above the containment water level.

Next, the maximum core flow is calculated. During recirculation operation for the DEDVI break (in a PXS room) the maximum core flow is 177 lbm/sec, of which 27% or 47.7 lbm/sec is steam. It is assumed that the same mass of steam will be produced to remove core decay heat for a cold leg break; this is considered conservative because recirculation will occur later in a cold leg break case because there is no spill of IRWST fluid directly to the containment which slows down the draining of the IRWST. Decay heat would then be less at the time recirculation started and less steam would be generated to remove decay heat.

The water that flows through the ADS stage 4 discharge is then calculated from:

$$M_T = M_w(1-Q) + M_s(Q)$$

Where:
M_T = Total Mass Flow Rate $M_T = M_w + M_s$
M_w = Mass flow rate of the liquid component
M_s = Mass flow rate of the steam component
Q = Steam Quality

Substitution of the relationship $M_T = M_w + M_s$ into the above equation and solving for M_w yields:

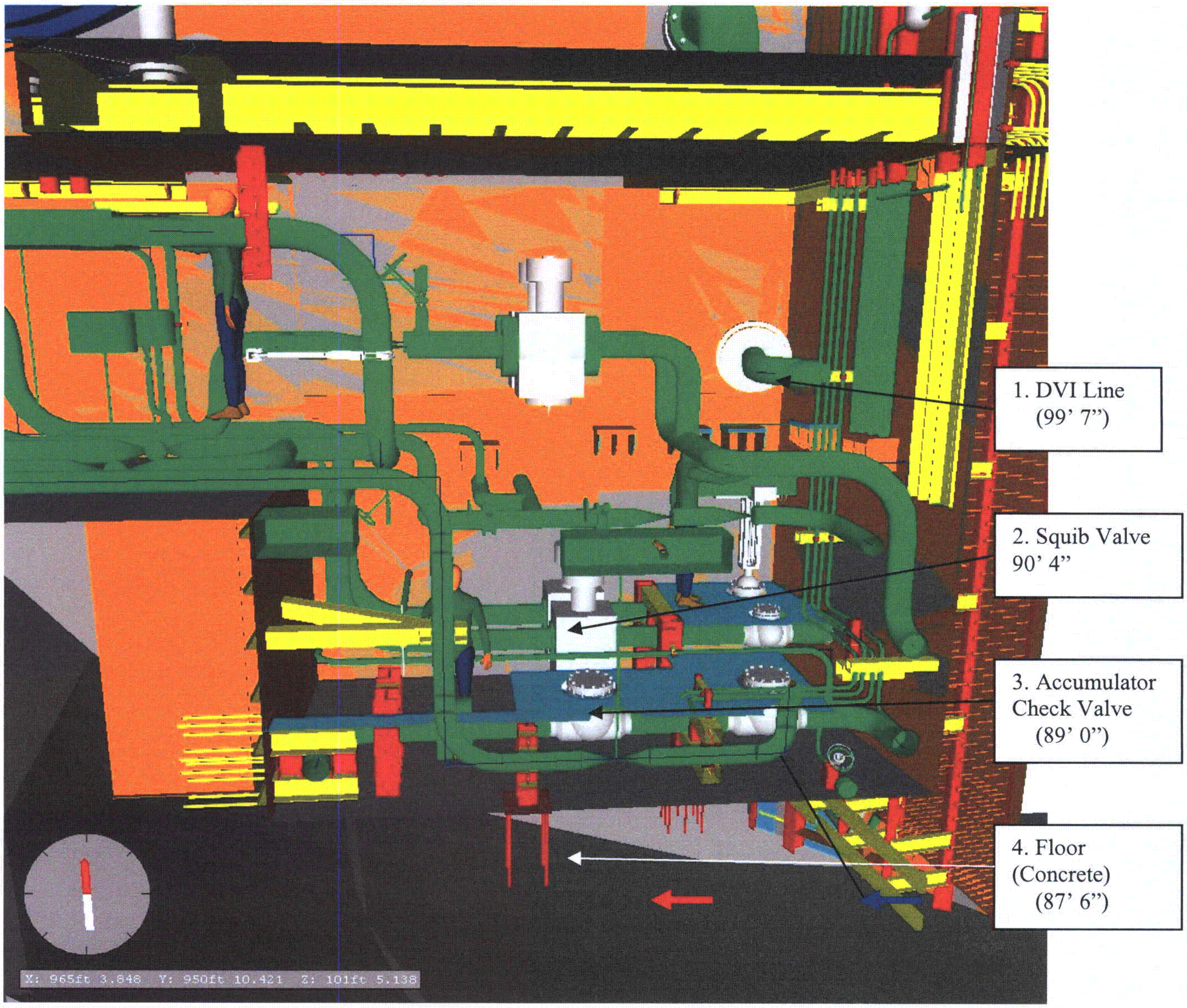
$$M_w = M_s(1-Q)/(Q)$$

The steam quality (Q) for a large cold leg break was calculated above (14%) based on a hydrodynamic balance. The mass flow of steam (M_s) was determined above based on a cold leg LOCA requiring the same steam flow as a DEDVI LOCA (47.7 lbm/sec).

The resulting water flow is then 293 lbm/sec and total flow is 340 lbm/sec. The volumetric total flow is 2,555 gpm (based on saturated water density).

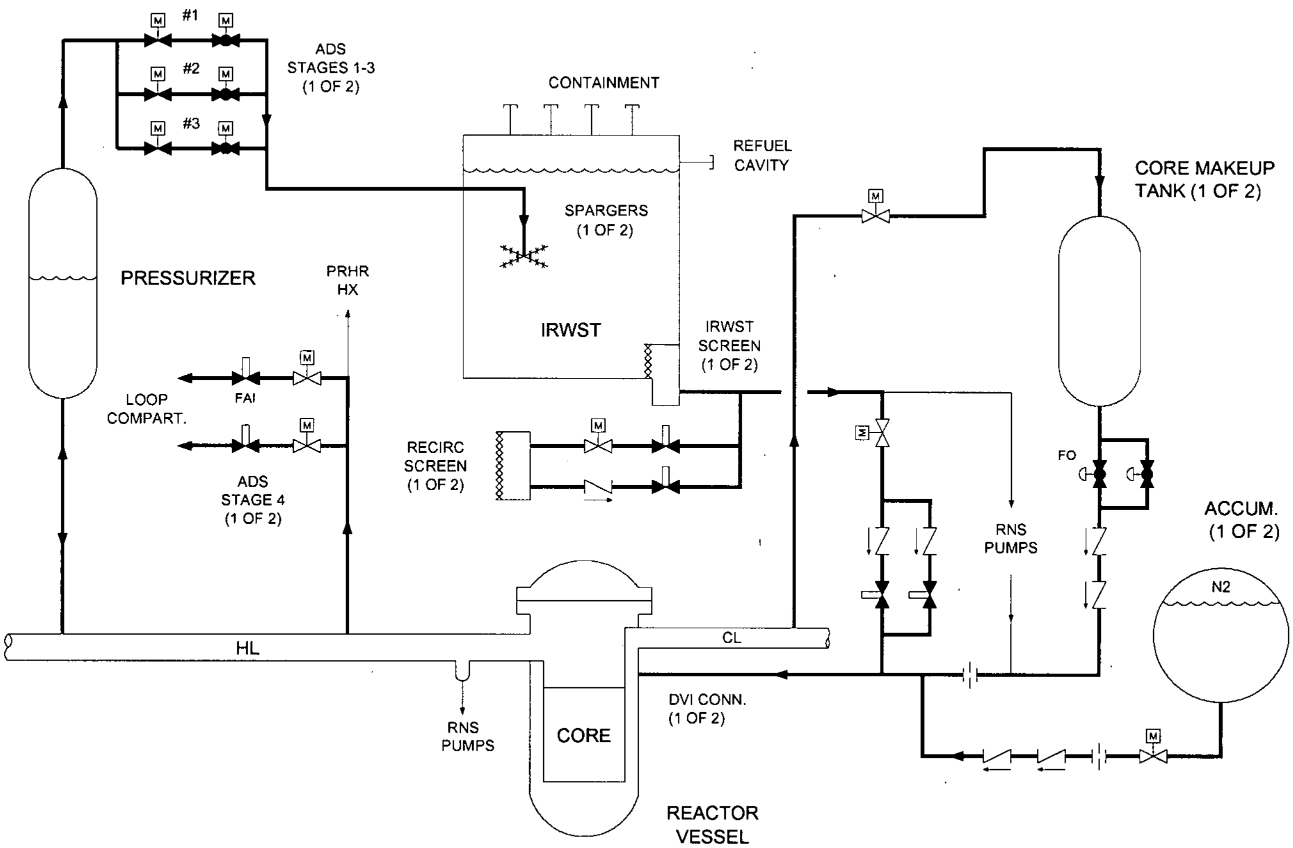
Table 1 depicts the flow velocities at the floor for the CL break. Table 1 conservatively assumes all flow that enters the core is from the CL; this ignores the fact that some of this flow would get to the core through the PXS recirculation lines. This is extremely conservative and performed to show that even if all core flow were to come from the broken CL there would still not be sufficient flow to transport debris, and furthermore prove that the DVI break at the check valve is most limiting with regards to debris transport. From Table 1 it can be discerned that the DEDVI at the check valve is the most limiting break with regards to debris transport to the core by comparison of velocity at the floor for various break locations.

b. Tests reported in NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance," have been performed that demonstrate that MRI damaged by LOCA tests will settle and require more velocity to transport than will occur in AP1000. These tests indicate that a velocity of 0.2 ft/s is required to move ½" x ½" crumpled foil MRI debris; larger velocities are required to move larger MRI debris. The response to item a. above shows that there is insufficient water flow to transport MRI fines from the floor location into the break even from the lowest potential break locations.



View of PXS Room Potential Break Elevations

Passive Core Cooling Sketch



Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None