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Your ref: Docket No. 52-006
Our ref: DCP/NRC2502

May 27, 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-SPCV-02 R1
RAI-SRP6.2.2-SRSB-01 R2
RAI-SRP6.2.2-SRSB-02 R2
RAI-SRP6.2.2-SRSB-05 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,

Robert Sisk, Manager
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Regulatory Affairs and Standardization

/Enclosure

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

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NRO

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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-01
Revision: 2

Question (Revision 0):

In the AP1000 DCD Section 6.3.2.2.7.3, Westinghouse stated that:

> "When the recirculation lines initially open, the water level in the IRWST is higher than the containment water level and water flows from the IRWST backwards through the containment recirculation screen. This back flow tends to flush debris located close to the recirculation screens away from the screens."

The back flow of water through the recirculation screens may cause a significant amount of water to be injected into the sump cavity. Although this flow through both recirculation screens causes the materials to be flushed from the screens, the backflow could cause enough turbulence in the cavity to lift up the debris from the bottom of the cavity, which collects during the early part of the LOCA, and once the water flow reverses into the screens this debris is available to be collected on the screens.

a. Describe the potential for blockage with the addition of uplifted debris.
b. Identify whether or not the addition of the zinc coatings or the higher density epoxy coatings, that were assumed to be collected at the bottom of the cavity, provide a source of blockage to the screens.
c. Identify whether these coatings add to the chemical impurities that could enter the core region.

Additional Question (Revision 1):

The responses to SRP-6.2.2-SRSB-01 and SRP-6.2.2-SRSB-02 indicate that the back flow velocity through the containment recirculation screen to be 0.006 ft/sec and 0.0132 ft/sec, respectively. Explain the difference. What is the assumed flow area used in the calculation.

Additional Question (Revision 2):

Indicate the break type analyzed.

Westinghouse Response: (Revision 1 with Revision 2 markup)

a. The initial calculated reverse velocity is very low, ranging from approximately 1560 to 4600 gpm (3.48 to 10.25 ft^3/sec) depending on the conditions assumed. These maximum values are both based on the elevation corresponding to the IRWST switchover level of

112.56 ft and the containment water evaluation of 104.65 ft. at the time of switchover to containment recirculation. The 1560 gpm value is based on the conditions assumed in the DCD Chapter 15 long-term cooling analysis of one IRWST line injecting with maximum resistances corresponding to a DVI break in the PXS room. The 4600 gpm value assumes two lines injecting with minimum line resistances. The frontal face area of each recirculation screen is 105 ft^2 (ITAAC Table 2.2.3-4, item 8.C). These flow rates result in a velocity range of 0.0166 to 0.0488 ft/sec initially across the front face of the recirculation screens. Note that the reverse flow is elevated 2 feet above the floor due to the curb that is located in front of the recirculation screens. All of the resident debris that is involved with post accident flows is assumed to be transported to the screens; none of this debris is assumed to settle out. As a result, the only debris that may be on the floor in front of the recirculation screens is MRI and high density coatings. This high density debris will not be uplifted by the very low velocity / elevated reverse flow through the recirculation screens.

b. The zinc coating material is elemental zinc having a density of 457 lbm/ft3. Due to the high density of the zinc coating material and the low velocity of flows in the reactor containment building pool, the zinc coatings will not transport to the recirculation screens.

   By the requirements of the DCD, epoxy coatings have a density of 105 lbm/ft3. Calculations of paint debris chip transport have been performed and demonstrate that chips of the size necessary to block the recirculation screens will not transport to the screens. These calculations are available for NRC review.

   Therefore, these coatings are not considered a source of blockage to flow through the recirculation screens.

c. The zinc and epoxy coatings used inside the AP1000 reactor containment building are the same Design Basis Accident Qualified (DBA-Qualified) coatings materials currently used inside reactor containment buildings of operating PWR's. The dissolution and leaching of DBA-Qualified coatings resulting in chemical impurities in the post-accident recirculation fluid was evaluated by the PWR Industry in WCAP-16530-NP-A, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" and determined to not be subject to dissolution, and to be an insignificant source of chemical impurities .Therefore, these coatings are not a significant source of chemical impurities.

Design Control Document (DCD) Revision: None

PRA Revision: None

Technical Report (TR) Revision: None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-02
Revision: 2

Question: (Revision 0)

In TR 26, Revision 3, on page 8, in the "Applicability to the AP1000 Design" subsection, Westinghouse states that:

> "The flow velocities have been reduced further by the increase in face area of the screens (approximately 55% larger for containment recirculation)."

Since Westinghouse credits the low flow velocities in minimizing the potential for a LOCA to generate debris challenging the recirculation flow path, the staff requests additional information to assess the velocities during every phase of the transient.

Identify the calculated flow velocities through the IRWST screens (leading to the intact and broken DVI lines, respectively), the containment recirculation screens, and the reactor vessel during all phases of the transient including the reverse flow through the recirculation screens when the IRWST is switched to recirculation. For example, when recirculation flow starts, identify the velocity of the initial reverse flow through the recirculation screens and the velocity variation across the screens once all water has filled the recirculation sump cavity.

Additional Question: (Revision 1)

The responses to SRP-6.2.2-SRSB-01 and SRP-6.2.2-SRSB-02 indicate that the back flow velocity through the containment recirculation screen to be 0.006 ft/sec and 0.0132 ft/sec, respectively. Explain the difference. What is the assumed flow area used in the calculation.

Additional Question: (Revision 2)

Provide the maximum volumetric flow in the IRWST injection line in the injection phase associated with the intact DVI line.

Westinghouse Response: (Revision 1 with Revision 2 markup)

The sensitivity study performed to evaluate effect of increased head loss caused by post-accident debris was based on the DCD Chapter 15.6.5.4C analysis. This DCD case is a double-ended DVI LOCA that results in flooding of PXS room B and reduces the final containment floodup level. The IRWST injection line associated with the faulted DVI line is assumed to open early in the event when the CMT connected to the faulted DVI line blows down to the ADS 4 actuation setpoint. This assumption is made to maximize the IRWST draindown flow rate and reduce the time when switch to recirculation occurs. When recirculation is actuated on a Low IRWST level signal, it is assumed that the recirculation squib valves located in the flooded PXS room fail because they are not qualified to operate under water; this assumption minimizes the number of recirculation lines in operation. The recirculation squib valves located in the unflooded PXS room provide for recirculation; the limiting single failure is that of one ADS 4 squib valve. Note that the operating recirculation line draws water from both recirculation screens because the screens are cross-connected. In the final long-term cooling configuration, water recirculates from the containment through one recirculation line and from PCS condensate that is collected and drained into the IRWST.

~~Each of~~ The two IRWST injection lines are separated from each other and are connected to opposite sides of the tank. ~~As described above~~ IRWST flow into the intact DVI line is zero until the RCS pressure is significantly reduced. The flow through the IRWST line associated with the faulted DVI line starts as soon as the IRWST squibs open.

In the injection phase, the volumetric flow in the IRWST injection line associated with the intact DVI line reaches a maximum of 1700 ~~1260~~ gpm (The technical basis for this number and detailed explanation for its derivation can be found in RAI-6.2.2-SPCV-016 Rev. 1 part (c)), and decreases to the long-term recirculation flow shown below as the IRWST drains. At this flow, the IRWST screen face velocity is ~~0.070~~ 0.14 ft/sec.

The IRWST spill flow (volumetric) through the broken DVI line reaches a maximum as soon as the IRWST injection valves open and decreases as the IRWST drains and the PXS valve room floods. The maximum initial flow in this line is 2700 gpm. This flow decreases quickly to 2220 gpm as the PXS valve room floods due to RCS blowdown and IRWST spill. The face velocities in the IRWST screen at these flow rates are 0.301 and 0.245 ft/sec respectively.

The initial calculated reverse flow and velocity ranges from approximately 1560 to 4600 gpm (3.48 to 10.25 ft^3/sec) depending on the conditions assumed. These values are based on the elevation corresponding to the IRWST switchover level of 112.56 ft and the containment water elevation of 104.65 ft at the time of switchover to containment recirculation. The 1560 gpm value is based on the conditions assumed in the DCD Chapter 15 long-term cooling analysis of one IRWST line injecting with maximum resistances. The 4600 gpm value assumes two lines injecting with minimum line resistances. The frontal face area of each recirculation screen is 105 ft^2 (ITAAC Table 2.2.3-4, item 8.C). This flow rate results in a velocity range of 0.0166 to 0.0488 ft/sec initially across the front face of the recirculation screens.

During the long-term cooling analysis recirculation phase, flow from the IRWST maintains the water level in the PXS room such that it serves as a reservoir for the broken DVI line injection into the vessel. The IRWST level is maintained by steam condensate return from the IRWST gutter and back flow from the intact PXS recirculation line. The containment recirculation line connected to the intact DVI line provides flow to the reactor vessel through the intact DVI line as well as some flow back through the IRWST to the faulted DVI line.

The following table shows the calculated flow velocities through the IRWST screens, the containment recirculation screens, and the reactor vessel during the containment recirculation phase. Note that because of the cross-connection between the two containment recirculation screens, both of these screens share the flow, which reduces the velocity. The IRWST screen flows and velocities listed below are for the screen associated with the faulted DVI line; the other IRWST screen sees a lower flow rate. The reactor vessel velocity is calculated at the fuel assembly inlet.

	IRWST screen (one screen)	Recirculation screen (both screens)	Reactor Vessel
Time [sec]	6800 to 10,000	6800 to 10,000	6800 to 10,000
Flow Rate [gpm]	540	755	1042
Velocity [ft/s]	0.060	0.008	0.0313
Frontal Area [ft^2]	20	210	74.28

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-05
Revision: 2

Question:

In TR 26, Revision 3, on page 10, Westinghouse states that debris samples removed from operating plants and visual observations during plant walkdowns provide the basis for the debris composition as particulate material (85% by volume), coatings (5% by volume) and fiber (10% by volume).

a. Provide the references or sources of the operating plant walkdowns and debris samples. Confirm that the percentages of various debris types are based on total volume, as reported, and not total mass (NRC SE of NEI 04-07 recommends that fiber be 15% of total mass).
b. Explain why these references and data are representative of the AP1000.
c. Describe whether there could be other types of latent materials in the AP1000 that are different from the operating plants.
d. Explain how actual as-designed and operated AP1000 will be verified to be consistent with this data both prior to start-up and during the life of the plant? Propose appropriate surveillance testing and/or programmatic controls that will be necessary to ensure the actual plant is operated consistent with the analysis assumptions.

Additional Question:

The NRC staff reviewed the Westinghouse calculation files APP-PXS-M3C-053, "Latent Debris Calculation." Westinghouse identifies that only the Almaraz containment walkdown was used in the determination of the distribution of the containment latent debris types. Based on 'observations' at the Almaraz Unit 2 containment, visual identification of the debris types indicated that the debris volume appears to be made up of mostly particulate matter (85% assumed to be mostly dirt, welding slag, rust and grindings) with lesser amounts of coatings (5% paints) and fiber (10%, assumed to be composed of dust fabric and insulation). Therefore, the containment latent debris composition does not appear to have a sound basis.

Also, the debris contribution from vertical surfaces, small pipes and break jet impingement was essentially discounted. Only 10% of the dust on the vertical surfaces was considered and the debris on small bore pipes was ignored. There are a significant number of small pipes throughout the containment that collect debris such as dust. The total top-half surface area of these pipes could contain a substantial amount of debris mass, and adding it to the total could lead to a significant bump in the mass of the debris in the containment.

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

Please note the original response provided below relates to the previously proposed debris composition in containment. It has been retained for historical purposes only. The debris and fiber content has been modified as described in the "Additional Response" section.

a. A debris composition of 85% particulates, 14% coatings and 1% fiber by mass is used in the calculation note (APP-PXS-M3C-053, Revision 0) that documents the AP1000 resident debris loadings. This data is based on walkdowns performed at three plants. The walkdown data is proprietary; the calculation note is available for review by the NRC. It is noted that rounding the fiber debris upward to 1% fiber by mass added conservatism to the assumed amount of fibrous debris considered in the calculations.

b. The three plants whose latent containment debris walkdown data was used to assess latent debris loading for the AP1000 were evaluated to have containment cleanliness programs that might serve as a model for the AP1000 containment cleanliness program. The AP1000 DCD section 6.3.8.1 requires that the AP1000 cleanliness program be consistent with cleanliness programs used in the evaluation of debris loadings for the AP1000. Given this requirement, the walkdown data from the three plants is applicable to the AP1000 design. It is the responsibility of the AP1000 licensee to define and implement the COL containment cleanliness program to assure that the actual latent containment debris loads are less than or equal to those determined by evaluation and used in testing the recirculation screens.

c. The total amount of latent debris is limited by the COL cleanliness program. So the only question is whether the types of debris that might be found in an AP1000 containment could be different such that the resulting head loss across AP1000 screens would be increased.

   Some of the resident debris found in the walkdowns was transported into the containment by people that enter the containment during shutdown activities. This source of debris is expected to be reduced because the simplifications in the AP1000, and the reduced maintenance resulting from the use of canned motor reactor coolant pumps, will result in fewer people entering the containment during shutdowns.

   The materials used in the AP1000 containment are similar or less likely to create resident debris than those used in the plants where the walkdowns were performed. An example of an improved material is the use of MRI instead of fiberglass insulation; removing and re-installing fiberglass insulation can create small amounts of latent debris.

   One area where AP1000 might have an increase in a specific type of resident debris is in the area of coatings. The AP1000 uses qualified coatings inside containment; however, they are not applied, inspected, and maintained as safety coatings. As a result, the latent debris found in an AP1000 could have a greater percentage of coatings debris. Since these coatings are required to be high-density, they could not be transported to the screens.

In summary, the AP1000 latent debris is expected to be made up of similar materials; if anything it would form a mixture that would result in less pressure loss (less fiber and more [high density] coatings).

d. The AP1000 DCD contains a COL item (6.3.8.1) that requires the COLA to provide a cleanliness program that is consistent with the assumptions used in determining the AP1000 latent debris amounts. In addition, sensitivity studies have been performed that demonstrate that the AP1000 long-term cooling operation can tolerate much higher head loss than was shown to occur in the debris testing performed for the AP1000 screens and core.

Additional Response:

The data provided in NUREG/CR-6877, 'Characterization and Head-Loss Testing of Latent Debris from Pressurized-Water-Reactor Containment Buildings', supports the position that the amount of latent fiber that is found in operating plants that have performed latent debris walkdowns is small, as opposed to the generic 15% provided in the SER on NEI 04-07. Both NUREG/CR-6877, and the data in the Generic Letter 2004-02, 'Supplemental Responses and Close-Out', support the fact that the mass of latent debris calculated for the AP1000 (APP-PXS-M3C-053, Revision 0) is in line with debris masses found and reported in operating plants.

Using the data provided in Table 2 of NUREG/CR-6877, it is seen that 3 of the 4 plants evaluated in the manner described in the NEI 04-07 SER have less than 7.5 percent fiber in their latent debris totals. The data in table 2 of NUREG/CR-6877 illustrates that the average fibrous debris load of the four plants is 7 % and two of the four plants had less than 4 % fiber. Of 28 plants sampled for the Generic Letter 2004-02, 'Supplemental Responses and Close-Out', responses, only one has proposed a fiber content less than 15%. This plant performed a debris characterization per the NEI 04-07 SER and, concluded that an appropriate latent fiber fraction should be 2.7%. Observations from other plant walkdowns included statements such as ''dust with no fiber', 'visual inspection showed very little fiber content', and 'visual [examination of the debris] showed very little fiber', further indicating that the assumption of 15% latent fiber is extremely conservative.

Of the 28 plants sampled from the Generic Letter 2004-02 'Supplemental Responses and Close-Out' responses (s~~S~~ee Table 1), 17 have reported latent debris loads less than 100 pounds. Of those 17 plants reporting latent debris loads less than 100 pounds, seven report latent debris loads less than 50 pounds. It should also be noted that of the 28 plants sampled, ten used latent debris loads of 150 pounds or less when performing their ~~downstream~~ evaluations. The column "Dominant Insulation" in Table 1 refers to the primary type of insulation used on in-containment piping. The term RMI refers to reflective metal insulation, and the high fiber designation refers to insulation systems composed of jacketed Nukon™ or similarly equivalent.- Trending based on the containment inside diameter is shown in Figure 1. There is a small trend for more debris for a larger containment inside diameter; however, there is a large amount of scatter. This indicates that other factors are more important, such as the utilities cleanliness programs.

Using the data in NUREG/CR-6877 and the Generic Letter 2004-02 'Supplemental Responses and Close-Out' responses, it is proposed that the AP1000 will assume 150 pounds of resident debris of which eight~~six~~ pounds are fiber which has the potential to transport to the screens. This resident debris mix is supported by both the plant responses in the Generic Letter 2004-02 'Supplemental Responses and Close-Out' (resident debris mass) and NUREG/CR-6877 (fiber content).

Westinghouse will provide updates to the Design Control Document (DCD) Section 6.3 (including COL item) which will provide the total latent debris limited to 150 lb and the total latent fiber debris limited to 8~~6~~ lb. These updates will be provided in APP-GW-GLE-002, Revision 2, by May 8, 2009.

Westinghouse Response: < The Revision 1 response has been revised as shown below to address the comments received from the NRC via teleconference on 5/1/2009. >

1. The amount of allowable fibrous debris was amended to 8 pounds, which is bounded by current test data.
2. Discussion was added in the 3rd paragraph of the Additional Response to discuss physical definition of "Dominant Insulation" referred to in Column 2 of Table 1.

Table 1: Operating PWR Debris Amounts

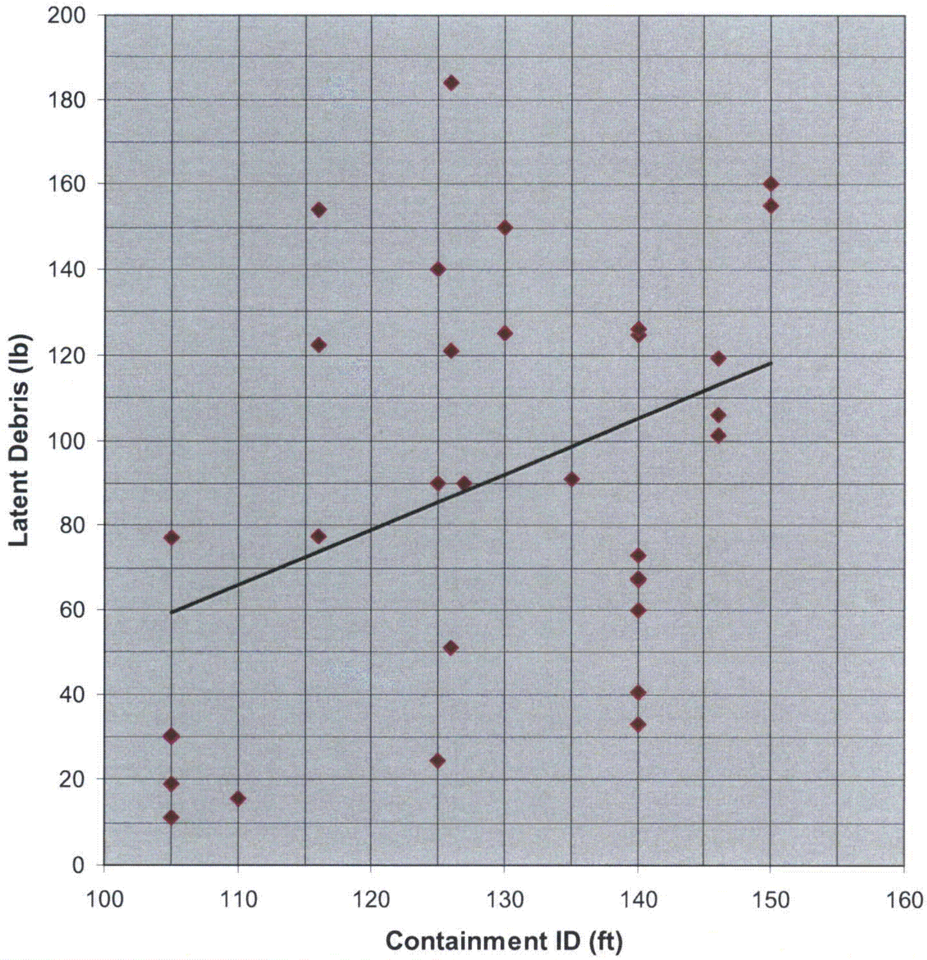
Plant	Dominant Insulation	Containment ID (ft)	Total Latent Debris (lb)	
			Walkdown	Analysis
ANO	RMI	116	122.4	150.0
BVPS 1/2	?	126	184.0	200.0
		126	184.0	200.0
Byron 1/2	RMI	140	67.2	150.0
		140	124.6	150.0
Braidwood 1/2	RMI	140	126.0	150.0
		140	72.8	150.0
Calvert Cliffs	?	130	150.0	150.0
Catawba	High fiber	127	90.0	200.0
Comanche	?	135	91.0	200.0
DCPP	Low fiber /RMI	140	60.0	100.0
Farley	Low fiber	130	125.0	200.0
Ginna	High fiber	105	77.0	100.0
Kewaunee	Low fiber /RMI	105	11.3	100.0
McGuire 1/2	High fiber	125	140.0	200.0
		125	90.0	200.0
Palo Verde 1/2/3	RMI	146	101.2	200.0
		146	119.2	200.0
		146	105.8	200.0
Point Beach 1/2	High fiber	105	19.0	150.0
		105	30.0	150.0
Prairie Island	Low fiber /RMI	105	30.2	?
Salem	High fiber	140	33.0	200.0
San Onofre	RMI	150	155.0	200.0
Seabrook	High fiber	140	40.7	200.0
Sequoyah	RMI	125	24.5	200.0
South Texas	RMI	150	160.0	200.0
St Lucie	High fiber	140	67.4	134.7
Surrey 1/2	?	126	121.0	121.0
		126	51.0	121.0
Turkey Point 3/4	High fiber	116	77.2	77.2
		116	154.0	154.4
Vogtle	High fiber	140	60.0	200.0
Fort Calhoun	?	110	15.7	159.0
		Averages	90.6	165.7

Table 2 from NUREG/CR-6877

	Plant A		Plant B		Plant C		Plant D	
NUREG/CR-6877								
Particles	5.06 g	83.0%	2479 g	90.8%	14.77 g	95.0%	151.20 g	93.3%
Fiber	1.04 g	17.0%	252 g	9.2%	0.77 g	5.0%	10.88 g	6.7%
Total	6.1 g	100.0%	2731 g	100.0%	15.54 g	100.0%	162.08 g	100.0%
NUREG/CR-6877								
Particles	5.06 g	68.8%	2479 g	74.2%	14.77 g	52.2%	151.20 g	55.2%
Fiber	1.04 g	14.1%	252 g	7.5%	0.77 g	2.7%	10.88 g	4.0%
Other*	1.25 g	17.0%	611 g	18.3%	12.74 g	45.0%	111.93 g	40.8%
Total	7.35 g	100.0%	3342 g	100.0%	28.28 g	100.0%	274.01 g	100.0%

NOTE: * Los Alamos removed larger / heavier particles from the plant samples in their work for NUREG/CR-6877 because they thought they would not transport. This debris ("Other") is shown added back in in the lower set of values. Separating out such debris is not anticipated to be done by utilities; it also does not reduce the amount of fibers, just the percentage.

Figure 1: Containment ID Trends



Design Control Document (DCD) Revision:

Westinghouse will provide updates to the Design Control Document (DCD) Section 6.3 (including COL item) which will provide the total latent debris limited to 150 lb and the total latent fiber debris limited to 8~~6~~ lb. These updates will be provided in APP-GW-GLE-002, Revision 2 by May 8, 2009.

PRA Revision:

None

Technical Report (TR) Revision:

None