Westinghouse

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U.S. Nuclear Regulatory Commission
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Washington, D.C. 20555

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Your ref: Docket No. 52-006
Our ref: DCP_NRC_002796

February 26, 2010

Subject: Transmittal of IRWST and CR Screen Related Documents

In support of Combined License application pre-application activities, Westinghouse is submitting the following RAI responses:

RAI-SRP6.2.2-SRSB-26 Proprietary
RAI-SRP6.2.2-SRSB-26 Non-Proprietary
RAI-SRP6.2.2-SRSB-27
RAI-SRP6.2.2-SRSB-28
RAI-SRP6.2.2-SRSB-29 Proprietary
RAI-SRP6.2.2-SRSB-29 Non-Proprietary
RAI-SRP6.2.2-SRSB-30
RAI-SRP6.2.2-SRSB-31 Proprietary
RAI-SRP6.2.2-SRSB-31 Non-Proprietary
RAI-SRP6.2.2-SPCV-25 Proprietary
RAI-SRP6.2.2-SPCV-25 Non-Proprietary
RAI-SRP6.2.2-SPCV-26 R1 Proprietary
RAI-SRP6.2.2-SPCV-26 R1 Non-Proprietary
RAI-SRP6.2.2-SPCV-28 R1

In addition, the AP1000 IRWST and CR Screen Related Technical Reports are provided:

APP-GW-GLR-079 Proprietary
APP-GW-GLR-086 Non-Proprietary
WCAP-16914-P Proprietary
WCAP-16914-NP Non-Proprietary
APP-PXS-GLR-001
APP-GW-GLR-092 Proprietary
APP-GW-GLR-093 Non-Proprietary
APP-GW-GLE-002
APP-GW-GLR-110 Proprietary
APP-GW-GLR-111 Non-Proprietary

This information is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). This information is provided to support the independent review of the IRWST and CR Screen models by the NRC. The information provided in this report is generic and is expected to apply to all Combined Operating License (COL) applicants referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Also enclosed is one copy of the Application for Withholding, AW-10-2759 (non-proprietary) with Proprietary Information Notice, and one copy of the associated Affidavit (non-proprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

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NRO

Correspondence with respect to the affidavit or Application for Withholding should reference AW-10-2759 and should be addressed to James A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Questions or requests for additional information related to the content and preparation of this report 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 / FOR

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

/Enclosures

1. AW-10-2759 "Application for Withholding Proprietary Information from Disclosure," dated February 26, 2010

2. AW-10-2759, Affidavit, Proprietary Information Notice, Copyright Notice dated February 26, 2010

3. RAI-SRP6.2.2-SRSB-26 Proprietary

4. RAI-SRP6.2.2-SRSB-26 Non-Proprietary

5. RAI-SRP6.2.2-SRSB-27

6. RAI-SRP6.2.2-SRSB-28

7. RAI-SRP6.2.2-SRSB-29 Proprietary

8. RAI-SRP6.2.2-SRSB-29 Non-Proprietary

9. RAI-SRP6.2.2-SRSB-30

10. RAI-SRP6.2.2-SRSB-31 Proprietary

11. RAI-SRP6.2.2-SRSB-31 Non-Proprietary

12. RAI-SRP6.2.2-SPCV-25 Proprietary

13. RAI-SRP6.2.2-SPCV-25 Non-Proprietary
14. RAI-SRP6.2.2-SPCV-26 R1 Proprietary
15. RAI-SRP6.2.2-SPCV-26 R1 Non-Proprietary
16. RAI-SRP6.2.2-SPCV-28 R1
17. APP-GW-GLR-079 Proprietary
18. APP-GW-GLR-086 Non-Proprietary
19. WCAP-16914-P Proprietary
20. WCAP-16914-NP Non-Proprietary
21. APP-PXS-GLR-001 Non-Proprietary
22. APP-GW-GLR-092 Proprietary
23. APP-GW-GLR-093 Non-Proprietary
24. APP-GW-GLE-002 Non-Proprietary
25. APP-GW-GLR-110 Proprietary
26. APP-GW-GLR-111 Non-Proprietary

cc:	D. Jaffe	-	U.S. NRC	26E
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	P. Jacobs	-	Florida Power & Light	26E
	C. Pierce	-	Southern Company	26E
	E. Schmiech	-	Westinghouse	26E
	G. Zinke	-	NuStart/Entergy	26E
	R. Grumbir	-	NuStart	26E

ENCLOSURE 1

AW-10-2759

APPLICATION FOR WITHHOLDING
PROPRIETARY INFORMATION FROM DISCLOSURE

Westinghouse

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Nuclear Services
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

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

Direct tel: 412-374-6306
Direct fax: 724-940-8505
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: AW-10-2759

February 26, 2010

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Transmittal of WCAP-16914 Revision 3 and WCAP-17028 Revision 3 Proprietary and Non-Proprietary Reports Related to Recirculation Screen Testing

The Application for Withholding is submitted by Westinghouse Electric Company, LLC (Westinghouse), pursuant to the provisions of Paragraph (b) (1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and is customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-10-2759 accompanies this Application for Withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectively requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this Application for Withholding or the accompanying affidavit should reference AW-10-2759 and should be addressed to James A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, LLC, P.O. Box 355, Pittsburgh, Pennsylvania, 15230-0355.

Very truly yours,

James W. Winters, Manager
Passive Plants Technology

cc: G. Bacuta - U.S. NRC

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ENCLOSURE 2

AFFIDAVIT

AW-10-2759
February 26, 20108

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared James W. Winters, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

James W. Winters, Manager
Passive Plants Technology

Sworn to and subscribed
before me this 26th day
of February 2010.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Linda J. Bugle, Notary Public
City of Pittsburgh, Allegheny County
My Commission Expires June 18, 2013
Member, Pennsylvania Association of Notaries

Linda J. Bugle
Notary Public

0355ljb.doc

(1) I am Manager, Passive Plan Technology, Westinghouse Electric Company, LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse "Application for Withholding" accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in attachment to DCP_NRC_002796, Transmittal of IRWST and CR Screen Related Documents and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse for the AP1000 Design Certification Amendment application is expected to be applicable in all license submittals referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application in response to certain NRC requirements for justification of compliance of the safety system to regulations.

This information is part of that which will enable Westinghouse to:

(a) Manufacture and deliver products to utilities based on proprietary designs.

(b) Advance the AP1000 Design and reduce the licensing risk for the application of the AP1000 Design Certification

(c) Determine compliance with regulations and standards

(d) Establish design requirements and specifications for the system.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of plant construction and operation.

(b) Westinghouse can sell support and defense of safety systems based on the technology in the reports.

(c) The information requested to be withheld reveals the distinguishing aspects of an approach and schedule which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar digital technology safety systems and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

ENCLOSURE 4

RAI-SRP6.2.2-SRSB-26 Non-Proprietary

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-26
Revision: 0

Question:

RAI-SRP 6.2.2-SRSB-26: WCAP-17028-P, Rev. 3

The fuel assembly debris head loss tests were performed with a 1/3-length scaled model with isothermal conditions without heat addition.

a) Provide an evaluation and justification on how the test results from this scaled model are applicable to the post-LOCA long-term cooling situation for a full-length assembly in which boiling occurs in the upper portion of the fuel assembly.

b) Are there any situations where two-phase flow behavior could challenge the single phase test results? Could a different liquid temperature or local boiling phenomenon affect the behavior of the debris plugging the core?

Westinghouse Response:

a. The majority of the AP1000 fuel assembly debris head loss tests were performed with a single fuel assembly and upflow of water. A fuel bottom nozzle, p-grid, and spacer grids were present, simulating the bottom one-third of a fuel assembly. The results from these tests have shown that the debris-induced pressure drop (DP) acceptance criteria is met. The up flow tests simulated DVI / CL LOCAs where the debris entered into the downcomer and then into the core. In these tests the vast majority of the DP was seen across the inlet nozzle / P-grid. As such the shorter length of the test fixture was not important.

Westinghouse performed additional fuel assembly head loss tests to address this RAI concerning boiling. Tests CIBAP36 and CIBAP37 were repeats of Test CIBAP30, with the difference that chemicals were added to the loop to simulate reactor coolant chemistry and the loop was heated. [

]a,c

Similar to previous tests, the fiber accumulated around the bottom of the p-grid prior to accumulating around the bottom nozzle. For Test CIBAP36, the accumulation of the debris on the bottom nozzle formed a thin bed but covered the entire surface.

The debris that was collected on the bottom of the p-grid collected mainly to one side and the debris clumped together. For Test CIBAP37, debris started to collect on the third grid from the bottom nozzle, which is unusual compared to the previous tests. For both tests, near the end of the flow sweeps, the debris bed was very thick and very smooth yet it did not cause an increase in the steady state dP. Overall, adding the chemicals to simulate reactor coolant chemistry and increasing the loop temperature to [ ]^{a,c} resulted in a lower dP compared to the previous tests. The pressure drop increase occurred almost exclusively at the bottom nozzle/p-grid location as in the other tests.

Test CIBAP39 was performed to observe the effects of adding debris to a model fuel assembly under simulated hot-leg break conditions. The conditions simulated in this test were upward flow of coolant with boiling. The debris loadings used were the same as Test CIBAP30. [

]^{a,c}

[

]^{a,c}

Flow profiling was performed at the beginning of the test before the debris was added (clean loop). Forty minutes after each debris addition, another flow sweep was performed. [

]^{a,c} This was done to determine if any debris blockage or flow resistance was present versus a clean fuel assembly. The profiling was done without air flow to increase the sensitivity of the measurement, since pressure readings during the air flow were highly variable. Flow sweeps were done instead of maintaining a constant flow with no air flow because measurement of the dP variation with flow is not sensitive to zero shift in the dP sensors. Air can be trapped in the dP tap lines, which if not completely removed, will cause an erroneous dP reading due to the change in static head. The change in pressure during a flow profile, however, will not be affected by trapped air.

There was a significant dP increase between the clean assembly profiling and assembly profiling after debris addition. The maximum dP increase in going from [

$]^{a,c}$ occurred during the first flow profiling after debris addition. [$]^{a,c}$ However, this change in pressure drop observed during profiling after debris is insignificant in comparison to our available head of [$]^{a,c}$

[$]^{a,c}$

b. As discussed in the response to Part a of this RAI, a higher coolant temperature was included as a test parameter in Tests CIBAP36 and CIBAP37. The resulting debris-induced pressure drops at the bottom of the fuel assembly were less than for other upflow tests.

An evaluation of the potential for plate-out of unbuffered boric acid or buffered boric acid (boric acid plus trisodium phosphate) was performed (Reference 1). This evaluation considered information resources such as phenomena identification and ranking tables (PIRT), Westinghouse bench-scale tests, open literature, and other docketed sources.

A series of bench-scale test were conducted by Westinghouse to investigate the nucleate boiling heat transfer characteristics of unbuffered and buffered (including TSP) boric acid solutions. The test article consisted of [$]^{a,c}$

However, the single heated rod testing does not fully address all the flow regimes found in a typical PWR core region during post-LOCA conditions. Additional PWR heated rod testing in the presence of boric acid solution with decay heat level heat input and low pressure was reviewed and can be applied to AP1000. Additional heated rod testing includes rod-bundle geometries and multi-rod full-height slab core geometry. [

][a,c]

Deposition of boric acid or boric acid buffered with trisodium phosphate is not expected to occur during post-LOCA conditions in the AP1000 since the heated core region has been shown to always be covered by a two-phase mixture.

References

1. APP-GW-GLR-110, Boric Acid Precipitation Tests During Post-LOCA Conditions, February 2010.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
New tests will be documented in WCAP-17028-P and -NP, Revision 4.

Preparation and submittal of a new report, APP-GW-GLR-110 discussing boric acid and TSP plate-out on fuel rods.

APP-GW-GLR-079, Revision 7 (TR26) will be updated with conclusions from boric acid and TSP plate-out report.

ENCLOSURE 5

RAI-SRP6.2.2-SRSB-27

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-27
Revision: 0

Question:

RAI-SRP 6.2.2-SRSB-27: WCAP-17028-P, Rev. 3

In addition to the acceptance criterion of 4.1 psid at a flow rate of 3.1 gpm/FA applied to each of the fuel assembly tests, page 5-3 (Section 5) of WCAP-17028-P adopts a second criterion of 3.5 psid at 5.3 gpm/FA which is based on long-term cooling sensitivity study case 3, for tests with concurrent debris additions.

Explain why the second criterion 3.5 psid at 5.3 gpm/FA is only applied to the concurrent debris addition tests. Also explain how the exponent, b, developed from the flow sweep and applied for extrapolation of the dP to 3.1 gpm in the first criterion, is also applicable to the second criterion.

Westinghouse Response:

Please refer to responses to RAI-SRP6.2.2-SRSB-29 and RAI-SRP6.2.2-SRSB-36.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

ENCLOSURE 6

RAI-SRP6.2.2-SRSB-28

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-28
Revision: 0

Question:

RAI-SRP 6.2.2-SRSB-28: WCAP-17028-P, Rev. 3

The repeat tests for tests CIBAP27, CIBAP29 and CIBAP30 with the same amount of debris and debris addition procedures described in Sections 8.26, 8.28 and 8.29, respectively, show a significant variation in the test results, including the peak dP, time, flow rate, and batches of chemical addition when the peak dP occurs, and the phenomenon of debris break-through. Section 9.1.5 concludes that all three tests have considerable margin to the current acceptance limit. However, Test #27 has significantly higher peak dP than test #29 even though test #27 has a much lower flow rate at the time of peak dP, and the peak dPs differ more than 81% when adjusted to the same flow rate (by the respective correlations). This shows that the tests have poor repeatability and potentially large uncertainties.

Provide an explanation of why the repeated tests are not repeatable and why the test results with large uncertainties are acceptable. Provide an evaluation of the confidence with which the test results with so much uncertainty can be used to assess the fuel assembly head loss with debris transported to the core.

Westinghouse Response:

Westinghouse has prepared APP-GW-GLR-092, Rev. 0 (proprietary), "Statistical Evaluation of AP1000 Fuel Assembly Debris-Loading Head-Loss Tests". The methodology employed to address variations and uncertainties in the test results is discussed in Section 3. Section 4 provides additional considerations for the statistical analysis. Determination of the probability to exceed the long term cooling acceptance criteria is addressed in Sections 3.3, 4.1.4, 4.2.4, 4.3.4, and 4.6. Specifically, the evaluation of the confidence associated with the standard deviation of the repeat test results is addressed in Sections 3.2.2 and 4.1.3. Section 6.0 summarizes the evaluation.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:

None

ENCLOSURE 8

RAI-SRP6.2.2-SRSB-29 Non-Proprietary

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: **RAI-SRP6.2.2-SRSB-29**
Revision: 0

Question:

With the majority of fuel assembly head loss tests performed at a flow rate higher than 3.1gpm, Section 5 describes the development of head-flow correlations to extrapolate the test results at higher flow down to the 3.1 gpm condition. Sections 8.30.1 through 8.30.3 provide an explanation of developing a correlation of the pressure differential once the debris bed has been formed.

a) The fuel assembly debris formation and dP are greatly affected by the decrease in flow rates during the tests. Explain and justify how the correlations, which are based on the debris bed fully formed, can be used to determine a maximum head loss of a developing bed by extrapolating the test results at higher flow rate down to 3.1 gpm.

b) Many tests were performed with constant flow rate and therefore, no data is available to determine the test-specific exponent of the correlation. Justify the use [of an average value]^{a,c} of the exponent of other tests with flow variations for the constant flow tests.

c) All fuel assembly head loss tests were run at a low flow rate above 5.2 gpm at peak core pressure differential. Since the fuel assembly head loss test acceptance criteria is based on the flow rate of 3.1 gpm, explain why these tests are sufficient in spite of large variability of the test results and the uncertainty associated with the application of the developed correlations.

RAI-SRP 6.2.2-SRSB-27: d) Explain why the second criterion (3.5 psid at 5.3 gpm/FA) is only applied to the concurrent debris addition tests. Also explain how the exponent, b, developed from the flow sweep and applied for extrapolation of the dP to 3.1 gpm in the first criterion, is also applicable to the second criterion.

Westinghouse Response:

Many of the AP1000 tests have been conducted with variable flow rates where the flow was changed during the test as the DP increased to simulate the actual behavior of the plant. The acceptability of the AP1000 FA tests is verified by a criterion based on the LTC sensitivity case #10. This first acceptance criterion allows a maximum head loss of 4.1 psi when the flow rate is 3.1 gpm/FA. Moreover, to simulate as far as possible what is expected to experience the AP1000 in the post LOCA long term core cooling, the later tests were performed by concurrent additions of [ ]^{a,c}. In order to verify the acceptability of concurrent [ ]^{a,c} tests two criteria are used. The first criterion is based on LTC case #10 as discussed above. The criterion applies to time [ ]^{a,c}. The second criterion is based on LTC sensitivity case #3 and applies to times [ ]a,c. This second criterion limits the FA DP to 3.5 psid at a flow of 5.3 gpm/FA. The use of both the criteria as well as the correlation adopted is discussed in the following.

As has been discussed previously, the later of the AP1000 tests have been conducted with variable flow rates where the flow was changed during the test. In order to compare the results against both the first and the second criteria, the experimental results need to be adjusted to a lower flow rate (3.1 gpm for the first criterion, 5.3 gpm for the second one).

a,c

When the debris bed is formed and stable, the pressure drop behavior of the debris bed will vary consistently with flow rate. In other words, [ ]a,c This also means that once the value of [ ]a,c, it is possible to evaluate the value of the loss of pressure at any flow rate.

a,c

[ ]^{a,c}

The applicability of the former correlation is separately discussed and justified in the following for the two acceptance criteria.

Applicability to the first acceptance criterion

To compare the test results against the first acceptance criterion, the following equation is used, deduced on the basis of eq. (3) [ ]^{a,c}

Where:

[ ]^{a,c}

Eq. (4) is deduced by eq. (3) and makes use of the experimental exponents deduced by the flow sweep at the end of the tests. Moreover, the stability of the debris bed is assumed. In order to compare the results against the first acceptance criteria (max DP allowed = 4.1 psi at 3.1 gpm) the results obtained by the AP1000 FA tests are adjusted by eq. (4) to determine the DP at the acceptance criteria flow rate.

Test CIBAP 34 was performed to investigate the nature of the flow / DP relationship throughout the test to allow comparison of the bed behavior for a fully formed and stable debris bed as well as for the initially formed debris bed.

Flow sweeps were performed throughout the duration of Test CIBAP 34 and the experimental results confirm that the dP and the flow are related by [ ]^{a,c} as shown in equation 1 even in the case of a debris bed not yet fully formed. In Figure 1 the DP vs Flow data from test CIBAP 34 are reported. Each series of data is referred to a flow sweep, and a best-fit curve for each series is shown too. As can be noted, equation 1 provides an adequate fit of the data. However, both the [ ]^{a,c} evolve as the debris bed evolves.

Figure 2 shows the calculated values for both the [ ]^{a,c} during test CIBAP 34. As can be noted, the results show a [ ]^{a,c} to the final bed performance. They also indicate that the bed [ ]^{a,c}.

The results from test CIBAP 34 indicate that the relationship between the DP and the Flow is not affected by the decrease of flow rate during the test. Moreover, the exponent evaluated for the formed debris bed by the flow sweep in test CIBAP 34 is representative of a debris bed at its maximum resistance [ ]^{a,c}.

In general, the peak DP measured during the tests was expected to result in the [ ]^{a,c} (at 3.1 gpm). However, the analysis of the experimental data has revealed some cases where the peak DP occurred [earlier, when the bed resistance was not yet at its maximum]^{a,c}. This should never occur as long as the flow rate [ ]^{a,c}, however in a few tests there was some delay in [reducing the flow]^{a,c} such that the peak DP occurred at [ ]^{a,c} was eventually used in the test.

Figure 3 shows the DP measured during test CIBAP 34 and the DP adjusted at 3.1 gpm. The Peak DP occurred between [14 hours and 15 hours. Its value, adjusted to 3.1 gpm is 1.57 psi]^{a,c}. The debris bed reached its maximum resistance [ ]^{a,c}. The reason the adjusted DP is [ ]^{a,c} is that the flow rate in the test loop had been [ ]^{a,c}.

As a result, WCAP-17028-P, Rev. 4 has been updated to consider the DP [at the maximum bed resistance instead of the peak DP]^{a,c} of the test, in those tests like CIBAP 34. This results in using the highest [adjusted DP to compare against the current acceptance criterion.

In test CIBAP 34 it can be noted that the DP [ ]^{a,c} to 3.1 gpm remains constant when the flow rate [ ]^{a,b}, indicating that the debris bed was stable (the resistance and exponent in eq. (1) were constant).

Looking at the AP 1000 FA test results for which an experimental exponent was evaluated, it is possible to discriminate among two general types of tests. The first type of tests is where the adjusted DP reaches a maximum value, and then [ ]^{a,c}. This indicates that the bed resistance reached its maximum value and [did not change]^{a,c} during the rest of the test.

Tests CIBAP 20, CIBAP 21, CIBAP 22, CIBAP 23, CIBAP 24, CIBAP 28, CIBAP 29, CIBAP 31, CIBAP 32, CIBAP 34, CIBAP 36 and CIBAP 37 belong to this first type (see i.e. Figure 3). Test CIBAP 11 can be included in this first type too, because the resistance of the bed [ ]^{a,c}. The second type of tests shows a different behavior. After the debris bed reached its maximum resistance, [ ]^{a,c} the end of the test. Test CIBAP 08, CIBAP 09, CIBAP 10, CIBAP 18, CIBAP 19, CIBAP 25, CIBAP 26, CIBAP 27, CIBAP 30 and CIBAP 33 belong to this second type. This [ ]^{a,c} in the bed resistance can be caused by a [settlement of the bed (slow limited]^{a,c}, as in the case of test CIBAP 27, or by a [ ]^{a,c}, as in the case of test CIBAP 30 (see Figure 4).

For tests of the first type, the exponent evaluated at the end of the test by the flow sweep is representative of a fully-formed bed at its maximum resistance. The use of such an exponent in the correlation is suitable to [ ]^{a,c} to a DP at 3.1 gpm. On the other hand, the use of such an exponent to evaluate the results of the tests of the second type could result in an underestimation of the [ ]^{a,c}.

As said above, test CIBAP 34 belongs to the first type of test. However, in the end of the sweep interval a spike in the flow resulted in a change of the bed resistance, suggesting that a breakthrough was caused by the spike. Thus, the last sweeps performed were not considered for the estimation of the exponent for the maximum resistance debris bed. On the other hand, the last part of the sweep offered sufficient data to estimate an exponent for the reduced-resistance debris bed. This exponent was [ ]^{a,c} the exponent relevant to the maximum resistance bed. On this basis a sensitivity study was performed to evaluate the effect of a reduced exponent on the DP [ ]^{a,c} at 3.1 gpm for the tests of the second type. This study considered a reduction of the [ ]^{a,c} exponents.

Table 1 shows the results of this study. As can be noted, the effect of the assumed reduction of the exponent on the adjusted DP results in a small increase, [ ]^{a,c} in the worst case. Even with a [ ]^{a,c} at 3.1 gpm remain well below the limit of 4.1 psi and the difference in the results can be neglected. Thus, for the tests of the second type, the exponent evaluated by means of the flow sweep is suitable to be used in the correlation to calculate the [ ]^{a,c} at 3.1 gpm.

The impact of a 10% of reduction on the exponent for the tests of the second type was also evaluated in the AP1000 FA debris test statistical study (APP-GW-GLR-092, Rev. 0). The statistical results indicate that the probability to exceed the acceptance criteria increases less [ ]^{a,c} for both the pressure drop and the natural log DP, when the exponent is reduced by 10%. The results [ ]^{a,c} are summarized in the table below (Table 2). The impact of the possible uncertainties related to the exponent is then very limited on the overall probability to exceed the limits in the AP1000 core. This confirms the choice to use the exponent evaluated by means of the flow sweep (stable bed exponent) for both first type and second type of tests.

[ ]a,c

[ ]a,c

Applicability to the second acceptance criterion

Concerning the second acceptance criterion (adopted for the concurrent debris addition tests only), the use of the stable bed exponent would result in a greater underestimation of the [ ]a,c DP. Looking at the results of test CIBAP 34, the exponent at 9 hours (in plant time) is [ ]^{a,c} and the bed resistance is still increasing. This suggests that a reduction [ ]^{a,c} should be applied at the stable bed exponent to extrapolate the test results at higher flow rate [ ]^{a,c}. For conservatism, a reduction [ ]^{a,c} on the exponent has been then considered in WCAP-17028-P, Rev. 4 when the second criterion is applied. This reduction is based on the difference between the fully formed bed exponent and the lowest exponent estimated in test CIBAP 34. For the second acceptance criterion eq. (3) then becomes:

a,c

a,c

As previously discussed in the response to RAI-SRP6.2.2-SRSB-36, the first acceptance criterion is based on the LTC sensitivity case 10, and its limit (4.1 psi with 3.1 gpm/FA) is related to the decay heat at 8.6 hours after the LOCA. The second criterion is based on the LTC sensitivity case 3, which assumes the maximum blockage condition in the core at the beginning of the recirculation. It is related to a higher level of the decay heat. The second criterion is aimed to verify that during the recirculation, for any level of the decay heat between the start of the recirculation phase (LTC sensitivity case 3) and 8.6 hours (LTC sensitivity case 10), the core will be satisfactorily cooled, requiring that the loss of head through the core at 5.3 gpm/FA must be lower than 3.5 psi. Note that the concurrent debris addition FA tests were set up in order to model the plant timing of debris addition after the start of recirculation. Thus, the test time can be related to the plant time. In contrast, the sequential debris addition tests were set up to determine the maximum DP value that would be achieved under the test condition, with no reference to the time at which it would occur in the plant. For this reason the second acceptance criterion is not applicable to the sequential debris addition tests, but only to the concurrent debris addition tests.

Thus, the tests performed are sufficient to demonstrate that the AP1000 core will achieve post-LOCA long term core cooling.

a,c

a,c

a,c

a,c

Several tests in the AP 1000 FA test program were performed with [ ]^{a,c} and therefore, no data is available to determine the [ ]^{a,c}. For those tests the use of an [ ]^{a,c} has been adopted. Note that these tests are less important to the final determination of the acceptance of the AP1000 FA debris in that they are not considered in the statistical analysis of the AP1000 FA debris DPs.

Figure 5 shows the exponents for a fully formed debris bed, estimated in the tests where the flow sweeps where performed. The values are divided in three series representing the exponents obtained for [ ]^{a,c}.

Several test parameters were different among those tests (e.g, [ ]^{a,c}, etc.). The exponent values are in the range [between 1.49 (test CIBAP 18) and 1.83 (test CIBAP 34)]^{a,c}. The range of variability is [practically the same]^{a,c} for the three series, and in spite of the sample not being very large, the values seem to be consistent with [ ]^{a,c} (see Figure 6). This suggests that the exponent relevant to the fully formed bed is [ ]^{a,c}. In other words, the exponent is [ ]^{a,c}. On the other hand, the coefficient R (as well as its variability) seems to be in some way related to [the flow rate management during the bed formation]^{a,c} and to the way the debris [ ]^{a,c} (see Figure 7). The distribution of the resistance coefficient for the same sample is [ ]^{a,c} (see Figure 8).

This indicates that the use of an [ ]^{a,c} is acceptable for the tests performed with constant flow rate, for which no data is available to determine [ ]^{a,c}. In fact, [ ]^{a,c}.

a,c

a,c

[ ] a,c

[ ] a,c

Conclusions

a) The evaluation of the results obtained by the AP1000 FA tests to verify if they meet or not the first acceptance criterion (max DP allowed = 4.1 psi at 3.1 gpm) is based on the following correlation:

[ ]a,c

The results from test CIBAP 34 indicates that the mathematical structure of the relationship between the DP and the Flow is unaffected by the decrease of flow rate during the test.

To adjust the results obtained at higher flow rate down to 3.1 gpm, the DP at the maximum debris bed resistance is the proper input to use, instead of the measured peak DP, because it results in a higher [ ]a,c for those tests where the peak occurred before than the maximum bed resistance was reached.

The exponent used in the correlation can affect the results at 3.1 gpm: the lower the exponent, the higher is [ ]a,c. However, the analysis performed showed that the proper exponent to be used has to be related to the maximum resistance of the bed. For tests of the type 1, the resistance [ ]a,c after its maximum is reached, and the debris bed remains stable. The exponent evaluated by the sweep at the end of the test is representative of a [ ]a,c, thus it is the proper exponent to use in the correlation to verify if the results meet the first acceptance criterion.

For tests of the type 2 the resistance of the debris bed when the sweeps were performed was lower than the maximum resistance. The exponent for these tests may be [ ]a,c less than the value it would have if the [ ]a,c. The effect of this [reduced]a,c exponent has been evaluated by a sensitivity analysis and the results indicate that it can be neglected. Thus the exponent estimated by the flow sweep at the end of the test will be used to extrapolate the results from higher flow rate down to 3.1 gpm.

b) The use of an average value of the exponent for those tests where an experimental exponent is not available has been discussed and justified. The experimental results suggest that the exponent relevant to the fully formed bed is independent from the way the debris were added, as well as from the way the flow rate was changed during the debris bed formation. In other words, the exponent is independent from the way the bed was formed, and its variability is small. Moreover, from the point of view of the acceptability of the test results, it should be noted that even with an extremely [ ]^{a,c}, all the test results would still meet the acceptance criterion (DP at 3.1gpm is less than 4.1 psi). This is true even when the second acceptance criterion (DP at 5.3 gpm is less than 3.5 psi) is applied to the max DP measured by 9 hours plant time in the concurrent debris addition tests.

c) From a physical point of view, the relationship that relates the DP and the flow must be [ ]^{a,c} (consider that in the Darcy formula the exponent is 2) This is consistent with the experimental evidences; even when the debris bed is not fully formed, the lowest value estimated for the exponent [ ]^{a,c} (see Figure 1). Then, in spite of the possible uncertainty related to the use of the stable bed exponent, as well as to the use of an average exponent, the DP limits are never exceeded for either criterion 1 or 2. Finally, it should be remarked that both the acceptance criteria are based on sensitivity cases performed in the LTC analysis (on case 10 per the first, case 3 per the second) and both are extremely conservative. The fact that the test results would meet the acceptance criterion means that these tests are sufficient, in spite of the variability of the test results and the uncertainty associated with the application of the developed correlations. Finally the AP1000 debris test statistical study (APP-GW-GLR-092 Rev.0) calculates a core average DP at 3.1 gpm assuming a distribution of FA resistances; this DP is only 1.35 psi which demonstrates large margin to the current acceptance limit of 4.1 psi.

d) The second acceptance criterion applies to only the concurrent debris addition tests: 3.5 psi at 5.3 gpm. The use of the stable bed exponent in the correlation has been discussed: for conservatism a [ ] ^{a,c} on the stable bed exponent is applied when the correlation used to adjust the experimental results to 5.3 gpm. The correlation for the second criterion is then:

$$\left[\qquad \qquad \qquad \right]^{a,c}$$

The [ ]^{a,c} on the exponent is based on the experimental results obtained by test CIBAP 34.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
WCAP-17028-P, Rev. 4 will be updated with discussion on the exponent and test results.

ENCLOSURE 9

RAI-SRP6.2.2-SRSB-30

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-30
Revision: 0

Question:

RAI-SRP 6.2.2-SRSB-30: WCAP-17028-P, Rev. 3

The FA test results indicated large uncertainties where the peak differential pressure can be significantly different for similar flow cases with the same amount of fiber, e.g., sequential debris addition tests #16 (2.47 psi, 5.49 gpm) and #23 (4.49 psi, 5.31 gpm), and concurrent debris addition tests #27 (5.1 psi, 5.27 gpm) and #30 (3.13 psi, 5.2 gpm).

a) Explain how these variations and uncertainties in the test results are accounted for in your final evaluations.

b) Provide an evaluation of the confidence that the test results demonstrate that the design basis AP1000 containment debris does not induce a head loss through the fuel assembly that would impede or reduce flow into the reactor core so as to jeopardize adequate post-LOCA long-term core cooling.

Westinghouse Response:

Westinghouse has prepared APP-GW-GLR-092, Rev. 0 (proprietary), "Statistical Evaluation of AP1000 Fuel Assembly Debris-Loading Head-Loss Tests". The methodology employed to address variations and uncertainties in the test results is discussed in Section 3. Section 4 provides additional considerations for the statistical analysis. Determination of the probability to exceed the long term cooling acceptance criteria is addressed in Sections 3.3, 4.1.4, 4.2.4, 4.3.4 (individual assembly), and 4.6 (across core inlet). Section 6.0 summarizes the evaluation.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

ENCLOSURE 11

RAI-SRP6.2.2-SRSB-31 Non-Proprietary

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SRSB-31
Revision: 0

Question:

RAI-SRP 6.2.2-SRSB-31: WCAP-17028-P, Rev. 3

On page 17 of TR 26, APP-GW-GLR-079, Revision 6, Westinghouse discusses several reasons why the DEHLB is not the most limiting break with respect to debris plugging the core and causing a fuel heat-up. These include: (1) the HL break location not resulting in the spill of the IRWST injection thus the start of recirculation being later with lower decay heat than a DVI break, (2) potential counter-current flow due to inflow from the break and outflow from the core resulting in the debris brought in through the HL break being deposited in the top portion of the core.

a) Provide a comparison of the times of start of recirculation for a DVI break versus a DEHLB, and the corresponding decay heat values and the required flows to match boiloff at the respective times.

b) For a DEHLB, the reverse flow from the loop compartment through the break represents the percentage of total flow into the reactor vessel. How much of the flow that goes into the reactor vessel is unfiltered for the DEHLB?

c) The fuel assembly debris load head loss testing provided evidence that significant plugging would occur at the core inlet. The P-grid on top of a debris-filtering bottom nozzle appears to trap much of the debris causing a local dP increase for the bottom up flow testing that represents a DVI or CL break. The top of the core is more open, which could allow debris to enter the reactor vessel during the DEHLB and to flow into the core region unimpeded. For debris entering the top of the core for a DEHLB, is there enough counter-current flow to carry debris into the core? If so, how much debris enters the core from the upper plenum?

d) For a DEHLB, what effect does the two phase flow have on the debris entering the upper part of the core? Does the presence of two-phase liquid enhance or reduce the probability of debris sticking on the spacers and top grids?

e) The FA tests were based on the limiting break being cold leg break or DVI line breaks in which significant amount of debris enters the core directly, bypassing the containment recirculation screen. Since a hot leg break would result in the debris entering the top of the core, how are the FA head loss tests with debris entering from the bottom of the core applied to the flow conditions pertaining to hot leg breaks?

Westinghouse Response:

a) APP-GW-GLR-079, Revision 7 includes an updated discussion on why a double-ended hot leg (DEHL) LOCA is not limiting for debris transport. The original intent of the portions of the report listed in the RAI was to show that the DEHL LOCA is not limiting for debris transport into the core compared to a double-ended direct vessel injection line (DEDVI) LOCA in the loop compartment. This section will be updated to address a DEDVI LOCA, a double-ended cold leg (DECL) LOCA and a DEHL. The conclusion is that the DECL LOCA is the most limiting for the transport of debris into the core. A DEHL LOCA is less limiting because:

- For a DEHL LOCA, all of the flow that enters the core through the downcomer will come from the DVI injection lines and will have been filtered and will contain essentially no fiber. [ ]^{a,c} With the small amount of fiber in the AP1000, this would result in insignificant fiber transport through the PXS to the core inlet.
- Water can enter the RV through the flooded HL break. Some of this water is expected to leave the RCS through the HL break as a result of counter-current flow in the HL as the RCS pressure fluctuates up and down. Some of this water is expected to leave the RCS through discharge through the ADS stage 4 lines. These discharges would limit the amount of debris able to be transported into the core.
- Debris that does enter through the HL and is not discharged from the RCS can enter the upper portion of the core via recirculation that flows down through outer FAs then crosses over and up through central FAs. FA debris tests have been conducted for the AP1000 that demonstrate [ ]^{a,c} In any case, the PXS injection flow path is available to support core cooling
- Down-flow testing demonstrates that a debris bed can form, temporarily, on the top most grid. If there is an extended period of time of down flow of water without up flow of steam. This location is in an axial region that is above the top of active fuel such that even if blocked by down-flow debris, the peripheral FAs will be cooled satisfactorily by PXS flow from below the debris bed.

A DEDVI LOCA will result in the shortest time for the start of containment recirculation because the break results in the spill of the IRWST which causes the IRWST to drain faster and the containment to flood up faster. Revision 7 of APP-GW-GLR-079 now contains the following times for start of recirculation for a DEDVI LOCA and for a DECL LOCA:

	DEDVI	DECL
[		]a,c

A DEHL LOCA will perform like a DECL LOCA with respect to the recirculation start times since in both cases the IRWST will not spill into the containment.

b) An additional fuel assembly head loss test was conducted for the AP1000. Test CIBAP38 simulated the outer FAs where down flow may transport debris that entered the RCS through a DEHL LOCA into the upper part of the core. It was assumed that all the debris that enters the RCS through the break is transported into the core through the outer FAs; the debris is assumed to be evenly distributed radially amongst [

]a,c The debris loadings for this test were based on the assumption that 100% of all particulate, fiber, and chemical precipitate available in the containment transports into the reactor vessel through the flooded broken hot leg; none settles out or is trapped on the screens Note that the test added one seventh of this amount which was equilivant to the first hour's worth of debris transport. During this hour of down flow operation a debris bed formed on the upper portion of the fuel assembly. Then the test flow was switched to up flow of water with air, to simulate up flow with boiling. The upflow of air and water broke up the debris bed in a matter of seconds. This test is bounding because plant analysis indicates that the down flow will cycle every 3 minutes or so such that the flow rate will vary from a high down flow rate to essentially zero. During the brief (10-15 sec) zero flow time, the steam generated flows upward. Based on the test results, this brief up flow of steam would be sufficient to break up / prevent bed formation.]a,c Debris that breaks loose from the top of a FA is likely discharged through ADS 4 and subsequently filtered by the CR screens. The implication is that fibrous debris that enters through a HLB will be purged and captured by the screens, thus cleansing the core region over time. [Note that in Test #38, the debris discharged from the FA returned directly to the FA but a debris bed did not re-form while air flow continued.]a,c

c) The top nozzle is more open than the bottom nozzle such that it would pass debris. In the down flow HL testing discussed in item b, [most of the debris was trapped on the top most grid. Even with this bed accumulating debris for an hour without any up flow of air, the bed broke up in a matter of seconds when the up flow of air (simulating) steam was started.][a,c] The amount of debris that might enter the upper part of the core in a DEHL LOCA is discussed in item b.

a,c

Figure C-1 Fuel Assembly

d) Based on Test CIBAP38, two-phase liquid flow was shown [

][a,c]

e) Westinghouse ran [

]a,c

- [

  ]a,c

- Center FAs; these FA will experience up flow of water and steam. [

  ]a,c

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:

1. APP-GW-GLR-079 (TR26) will be revised to include a discussion on why a DEHL LOCA is not limiting for debris transport.
2. WCAP-17028-P, Rev. 4 will include discussion on the FA debris tests that have been performed to simulate hot leg LOCAs.

ENCLOSURE 13

RAI-SRP6.2.2-SPCV-25 Non-Proprietary

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP 6.2.2-SPCV-25
Revision: 0

Question:

RAI-SRP 6.2.2-SPCV-25: ZOI Coatings Debris

The DCD limits the amount of coatings debris fines that can be generated by a LOCA jet to less than 50 pounds. This requirement is assumed to apply to both hot and cold leg breaks, which is inconsistent with the discussion on the bottom of page 17 of APP-GW-GLR-079, which states that the containment screen could see extra ZOI-generated particle debris resulting from a hot leg break. Please explain this discrepancy, being sure to include the following:

a) Does the DCD requirement limiting ZOI coating to 50 pounds apply to both hot and cold leg breaks?
b) If ZOI coatings associated with a hot leg break are greater than 50 lbs, what quantity is assumed, how was this determined and how will it be controlled?
c) If ZOI coatings associated with a hot leg break are greater than 50 lbs, what percentage are assumed to transport to the IRWST and CR screens? Provide justification if the hot leg break uses different values than the 100% transport assumptions stated in the DCD.
d) In APP-GW-GLR-079, the epoxy coated surface area is assumed to equal 3 times the inside surface area of a sphere with a diameter equal to 4 times the ID of the CL ID of 22 inches. Per the response to RAI-SRP6.2.2-CIB1-24, Westinghouse considers this approach conservative with respect to operating plants. Please explain how this is conservative, because it was not apparent in the staff's sampling of Generic Letter 2004-02 responses.
e) If the ZOI coatings associated with a hot leg break are also limited to 50 pounds, explain what correlation is used and why this is appropriate.

Westinghouse Response:

a) The 50 lb ZOI coating limit only applies to DECL and DEDVI LOCAs as was discussed in response to RAI-SRP6.2.2-CIB1-24; item b) addressed the AP1000 ZOI coatings debris. APP-GW-GLR-079 was revised to be consistent with the response to this RAI. In the RAI response it was recognized that a HL LOCA in the AP1000 may create a larger amount of coating debris and allow that debris to enter the RCS through the break and to be transported into the top portion of the core. However, the RAI response discussed why the HL LOCA was not limiting. The reasons that the HL LOCA is not limiting have become even stronger due to additional FA debris testing performed for the AP1000 that has demonstrated that debris in the upper part of the core [will not result in DP (Refer to WCAP-17028, Rev 4). The presence of steam in this part of the core prevents the formation of debris beds and their associated DP.][a,c]

b) The is no need to control the ZOI coating debris for the following reasons:
   - The amount of ZOI coatings that could be generated by a HL LOCA has been estimated to be 80 lb using the same approach used to determine the design limit for a CL LOCA (50 lb). In the AP1000, debris (including these additional particles) can transport into the RCS through a flooded HL and possibly into the upper parts of the core. However, AP1000 FA testing has shown (Reference 1) that such fiber [is not able to form a bed in the upper part of the central portion of the core because of the presence of steam flow (which will exist in this area of the core in the AP1000). In addition, it might be possible for a bed to form in the upper part of the outer FAs because they could experience down flow circulation. In this case the debris bed would dissolve as soon as the up flow of steam occurred, as was shown AP1000 FA testing (Reference 1). Steam up flow will occur before a debris bed can significantly restrict core cooling. Note that without a debris bed, additional particles will have no effect on core DP.]^{a,c}
   - For AP1000 there is no mechanism to transport fiber to the core inlet in a HL LOCA. All of the water that enters the core through the down comer will come from PXS injection which is screened in a HL LOCA. With the AP1000 flows/velocities and screen design (hole size) the fiber bypass through screen is 1%. With the small amount of fiber in the AP1000, the bypass of fiber through the screen would result in insignificant fiber transporting to the core inlet through the PXS. As a result, there would be insufficient fiber to form a debris bed in the core inlet.

c) The DP observed in the screen tests was [~0]^{a,c} at the maximum flow during screen tests -4W and -5W. Since the DP was [~0 in the test, it is concluded that there was no contiguous debris bed on the screen. Therefore, the screen DP would not increase even if all of the additional particles generated within the ZOI on a HL LOCA were added to the screen debris load since there would be no fiber bed for the particles to build up on and create DP.]^{a,c}

d) In evaluating GL 2004-02 responses, it is important to consider that there are differences between the AP1000 and the operating plants that will reduce the amount of coated surfaces inside containment. These differences include:
   - A simplified plant that reduces the amount of coated surfaces on valves, pipes, pipe supports, and snubbers.
   - Severe restrictions of the use of inorganic zinc inside containment; these restrictions require that epoxy be used where ever possible.
   - Use of a ZOI of 4 for epoxy rather a ZOI of 10 which was used by some of the operating plants.

   Based on the above 3 bulleted points, the AP1000 design limit on ZOI coatings does not have to bound all of the responses from operating plants to GL 2004-02.

e) For the AP1000, the ZOI coatings are not limited to 50 lb for HL LOCAs. As explained in the response to item b), a HL LOCA might result in somewhat more particulate debris however based on AP1000 FA and screen testing this would be acceptable.

Design Control Document (DCD) Revision:
DCD section 6.3.2.2.7.1, item 12, second bullet, will be changed to clarify that the 50 lb of ZOI coatings only applies to CL and DVI LOCA locations.

PRA Revision:
None

Technical Report (TR) Revision:
APP-GW-GLE-002, Impacts to the AP1000 DCD to Address Generic Safety Issue GSI-191 will be revised to show the DCD changes discussed above.

DCP_NRC_002796
February 26, 2010

ENCLOSURE 15

RAI-SRP6.2.2-SPCV-26 R1 Non-Proprietary

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP 6.2.2-SPCV-26
Revision: 1

Question:

Screen Head Loss

a) The DCD states that the limiting head loss for the containment recirculation and IRWST screens is .25 psi at a maximum flow of 242 gpm, which is the flow rate from Case 10 of APP-PSX-GLR-001. The screen head loss modeled in Case 10 is zero, so please explain how Case 10 can be used to justify a screen head loss greater than zero.
b) WCAP-16914 states that pressure drop is calculated from the resistances used in APP-PXS-GLR-001 as a function of velocity squared. It is not obvious how this was done for any of the tests, so please provide details of this calculation that relate the pressure drop to a specific APP-PXS-GLR-001 case resistance.
c) WCAP-16914 Section 5.2 calculates the minimum IRWST flow using the core flow and ADS#4 water quality from sensitivity cases run in APP-PXS-GLR-001. Explain why this approach is more appropriate or conservative than using the flows reported for PSX A and B lines to represent the containment recirculation and IRWST flows.

Westinghouse Response:

a) The following changes are offered to clarify the description of the design flow and allowable head losses of the AP1000 containment recirculation and IRWST screens.

   Change the minimum screen flows to flows consistent with the long-term cooling analysis Case 3 from APP-PSX-GLR-001. This case is being used for the design of the screens because head loss across the screens was assumed in the analysis. Note that Case 10 is still bounding for the core DP because it maximizes the fiber that transports to the core; since so much of the fiber in the containment transports to the core (90%) there will not be enough to form a bed on the screens and therefore the screens will have no DP in this case. There are other situations where more debris can transport to the screen (and less to the core) and Case 3 is used to bound those cases.

   For the containment recirculation (CR) screens, [

   ][a,c]

The CR screen head loss modeled in Case 3 is 14 inches of water head loss at a flow of 77 lb/sec. In the analysis for Case 3 the actual CR screen flow is 56 lb/sec because the added resistance reduces the flow. The mass flow results in [

]^{a,c}

For the IRWST screens, change the minimum flow to 464 gpm. [

]^{a,c}

The screen head loss modeled in Case 3 is 14 inches of water head loss at a flow of 75 lb/sec. In the analysis for Case 3 the actual IRWST screen flow is 55 lb/sec because the added resistance reduces the flow. [

]^{a,c}

For the maximum screen flows [

]^{a,c}

The following table shows that the flow loading that was tested bounds all of the increased flows [

]^{a,c}

- [
-
-

]a,c

This change will impact the DCD but that change is addressed in RAI-SRP6.2.2-SPCV-28. In addition, the reports for the screen debris tests and TR26 will be impacted. The main impact on the screen test WCAP will be on Section 5.2 and Table 5-2. The revised Table 5-2 is shown below. As shown in this table, the conditions tested bound the increased flow rates and as a result no additional testing is required.

Table 5-2 (in WCAP-16914)
AP1000CR vs IRWST Screen Debris Loadings

	CR Screens	IRWST Screens	Test Screen
Screens Operating			
Screen Area Oper.			
Face Area Oper.			
Fibers			
Particles			
Chemicals			
Flow Rate, Max			
Flow Rate, Min			

a c

The paragraphs following this table will be revised based on the discussion preceding this table. In addition a note will be added to this table stating that the IRWST minimum flow loading is based on reverse flow through one of the IRWST screens.

b) The response to item a) addresses this question.

c) With the changes made to the IRWST screen cross connections as well as to the squib valve operability while submerged, the only flow through the IRWST screens during passive system operation will be the steam condensate return from the containment.

Design Control Document (DCD) Revision:
DCD will be revised (refer to RAI-SRP6.2.2-SPCV-28).

PRA Revision:
None

Technical Report (TR) Revision:
1. WCAP-16914, screen debris test report will be revised based on the response to item a).
2. APP-GW-GLR-079 (TR-26), the AP1000 GSI-191 summary report will be revised based on the response to item a).

ENCLOSURE 16

RAI-SRP6.2.2-SPCV-28 R1

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.2-SPCV-28
Revision: 1

Question:

RAI-SRP 6.2.2-SPCV-28: Design changes

DCD, 6.3.2.2.7.1, Item 12 discusses why RNS is not considered when determining maximum flow rates. It notes that no credit is taken for RNS operation in the PRA of a DVI LOCA, and non-DVI LOCAs will have less head loss because both PXS recirculation lines will be operating. However, the recent design changes to cross connect the IRWST screens and to qualify operation of the IRWST injection and containment recirculation squib valves while submerged means that both PXS recirculation lines now operate during a DVI LOCA, so non-DVI LOCAs no longer have more screen area.

a) Please explain the DCD statements discussed above regarding RNS operation with respect to the latest design changes.

b) Explain why RNS operation will not have an adverse reaction on safety systems

Westinghouse Response:

a. Please also refer to the RAI Response RAI-SRP6.2.2-SPCV-26, Revision 1 for additional discussion on the screen flow rates regarding operation of RNS.

~~a.~~ Section 6.3.2.2.7.1, Item 12, of the DCD will be revised in accordance with the following information.

The range of flow rates during post-LOCA injection and recirculation are as follows:

- CR screens: 2320~~1548~~ to 622 gpm,
- IRWST screens: 2320~~1548~~ to 464~~310~~ gpm,
- Core: 2012 to 484 gpm.

These flows bound operation of the PXS and the RNS. Note that if the RNS operates during post-LOCA injection or recirculation, the RNS flow is limited to ~~1548~~ 2320 gpm. This limit ensures that the operation of the plant is consistent with screen head loss testing ~~results bound the operation of the plant~~. In addition, the screens will be designed structurally to withstand much higher flow rates and pressure losses to provide appropriate margin during PXS and RNS operation.

b. As discussed in ~~the~~ response ~~to~~ RAI-SRP 6.2.2-SPCV-26, Revision 1 the screens are currently designed to include RNS operation. Therefore there is no adverse reaction on safety systems from RNS operation.

Design Control Document (DCD) Revision:
Tier 2, Section 6.3.2.2.7.1. Clarify discussion about RNS operation as described above.

PRA Revision:
None

Technical Report (TR) Revision:
The DCD changes described above will be reflected in the next revision of APP-GW-GLE-002.