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LTR-NRC-14-40

July 3, 2014

Subject: Submittal of Presentation "WCAP-17721-P WCOBRA/TRAC LOCA Mass and Energy Release Methodology Regulatory Guide 1.203 Compliance" (Proprietary) and Report WAAP-6205, "PIRT for Large Break LOCA Mass and Energy Release Calculations" (Non-Proprietary)

Enclosed is a copy of a proprietary presentation titled "WCAP-17721-P WCOBRA/TRAC LOCA Mass and Energy Release Methodology Regulatory Guide 1.203 Compliance" and a copy of a non-proprietary report, WAAP-6205, "PIRT for Large Break LOCA Mass and Energy Release Calculations"

Also enclosed is:

1. One (1) copy of the Application for Withholding Proprietary Information from Public Disclosure, AW-14-3987 (Non-Proprietary), with Proprietary Information Notice and Copyright Notice.
2. One (1) copy of 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 Proprietary Information 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.

The presentation document was prepared and classified as Westinghouse Proprietary Class 2. Westinghouse requests that the document be considered proprietary in its entirety. As such, a non-proprietary version will not be issued.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse Affidavit should reference AW-14-3987 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

John T. Crane for

James A. Gresham, Manager

Regulatory Compliance

Enclosures

T007
NRR

bcc: James A. Gresham
Cheryl Robinson
Anne M. Stegman

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AW-14-3987

July 3, 2014

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: Presentation LTR-NRC-14-40 P-Attachment "WCAP-17721-P WCOBRA/TRAC LOCA Mass and Energy Release Methodology Regulatory Guide 1.203 Compliance" (Proprietary)

Reference: Letter from James A. Gresham to Document Control Desk, LTR-NRC-14-40, dated July 3, 2014

The Application for Withholding Proprietary Information from Public Disclosure 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 customarily held in confidence.

The proprietary information 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-14-3987 accompanies this Application for Withholding Proprietary Information from Public Disclosure, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully 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 the proprietary aspects of the application for withholding or the accompanying Affidavit should reference AW-14-3987, and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Very truly yours,

John T. Crane for

James A. Gresham, Manager

Regulatory Compliance

Enclosures

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared Bradley F. Maurer, 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:

Bradley F. Maurer, Principal Engineer
Plant Licensing

Sworn to and subscribed before me
this 3rd day of July 2014

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Renee Giampole, Notary Public
Penn Twp., Westmoreland County
My Commission Expires Sept. 25, 2017
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

(1) I am Principal Engineer, Plant Licensing, 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 Proprietary Information from Public Disclosure 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 constitute Westinghouse policy and provide 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.

(iii) 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.

(vi) 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.

(v) 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.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in presentation LTR-NRC-14-40 P-Attachment, "WCAP-17721-P WCOBRA/TRAC LOCA Mass and Energy Release Methodology Regulatory Guide 1.203 Compliance" (Proprietary), for submittal to the Commission, being transmitted by Westinghouse letter, LTR-NRC-14-40, and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with Westinghouse's request for NRC approval of WCAP-17721, and may be used only for that purpose.

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

(i) Obtain NRC approval of WCAP-17721, "Westinghouse Containment Analysis Methodology – PWR LOCA Mass and Energy Release Calculation Methodology."

(b) Further this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of design basis containment licensing analyses.

(ii) Westinghouse can sell support and defense of design basis containment licensing analyses.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology 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 calculations 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

The reports transmitted herewith each bear a Westinghouse copyright notice. The NRC is permitted to make the number of copies of the information contained in these reports which are necessary for its internal use in connection with generic and plant-specific reviews and approvals as well as the issuance, denial, amendment, transfer, renewal, modification, suspension, revocation, or violation of a license, permit, order, or regulation subject to the requirements of 10 CFR 2.390 regarding restrictions on public disclosure to the extent such information has been identified as proprietary by Westinghouse, copyright protection notwithstanding. With respect to the non-proprietary versions of these reports, the NRC is permitted to make the number of copies beyond those necessary for its internal use which are necessary in order to have one copy available for public viewing in the appropriate docket files in the public document room in Washington, DC and in local public document rooms as may be required by NRC regulations if the number of copies submitted is insufficient for this purpose. Copies made by the NRC must include the copyright notice in all instances and the proprietary notice if the original was identified as proprietary.

PIRT for Large Break LOCA Mass and Energy Release Calculations [PIRT methods and results supporting BE analysis]

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INTRODUCTION

Pipe ruptures in the primary reactor coolant system are postulated as part of the design basis for containment integrity and equipment qualification validation for Nuclear Power Plants. The mass and energy (M&E) released from a postulated large break LOCA is the primary forcing function used as input for determining the containment response to a LOCA. The current Westinghouse LOCA M&E release calculation methodology was developed in the 1970's, when computing power was limited. The method is somewhat deterministic and includes several simplified, conservative modeling assumptions. Westinghouse is developing a mechanistic LOCA M&E release accident analysis calculation to more realistically, yet conservatively, model the containment response. A good definition of the key LOCA phenomena is needed as part of this development process. The purpose of this document is to discuss the development of the Phenomena Identification and Ranking Table (PIRT) for large break LOCA M&E release calculations.

PROCESS

Draft PIRT

The PIRT development process begins by dividing the event into several phases. The large LOCA event typically is broken into 3 phases: Blowdown, Refill, and Reflood. During the Blowdown phase, the high pressure/temperature water in the RCS is expelled through the break resulting in a rapid depressurization and flashing of the remaining fluid. The accumulators begin to inject as the system pressure continues to decrease. The Blowdown phase ends and Refill phase begins when the RCS pressure is equilibrated with the containment pressure. At the start of the Refill phase, the RCS is full of steam and the accumulators are beginning to refill the lower plenum and downcomer with water. The RCS metal surfaces are still very hot and the incoming water may begin to boil. The Refill phase ends and Reflood phase begins when the water level reaches the bottom of the fuel. A steam/water mixture begins to flow upward through the core as the water level rises. As the water level continues to increase, the upward flowing steam/water mixture removes core stored energy and decay heat, eventually resulting in a decrease in the fuel temperature. The Reflood phase is complete when the fuel is covered with enough water to maintain core cooling via nucleate boiling.

The NRC acceptance criteria for large dry containment designs to satisfy the GDC 38 requirement to rapidly reduce the containment pressure is that the calculated containment pressure should be less than 50% of the peak pressure within 24 hours after the postulated accident. The criterion for the sub-atmospheric containment design is that the containment pressure must be reduced below atmospheric pressure within 1 hour of accident initiation and maintained at a sub-atmospheric condition. Therefore, the LOCA mass and energy release input for the containment calculation must extend at least 24 hours (and even longer for EQ considerations). This is well past the end of the Reflood phase of a typical large LOCA event and covers both the cold and hot leg recirculation-cooling periods. So, an additional phase was considered for the LOCA M&E PIRT.

During the long-term cooling phase (which follows the Reflood phase), core decay heat is removed by nucleate boiling. Assuming the break is on the outlet side of the steam generator; a two-phase mixture exiting the upper plenum would enter the hot legs, and then pass through the steam generators. Water passing through the hot SG tubes could be vaporized (the SG secondary side would remain at or near operating temperature until a cooldown was started) and super-heated steam could potentially exit the steam generator. After the RWST empties (typically around 30 minutes after SI initiation) recirculation water would be drawn from the containment sump. The sump recirculation discharge flow path is typically changed from the cold legs to the hot legs at about 12 hours after event initiation, however, the time that this occurs and the associated recirculation flows, would be plant specific analysis inputs.

The NRC developed the first large LOCA PIRT as part of the best estimate (BE) LOCA program for ECCS design basis analysis [1]. Westinghouse subsequently developed a large LOCA PIRT for the WCOBRA-TRAC BE LOCA model development program [2]. The Westinghouse large LOCA PIRT was later updated to address new components as part of the AP600 [3] and AP1000 [4] plant development programs.

The phenomena in these large LOCA PIRTs were ranked with regard to their impact on the peak clad temperature (PCT) calculation. In some cases, phenomena that could cause the PCT to increase could have the opposite effect on the LOCA M&E release rate. This would be non-conservative with respect to maximizing the containment DBA pressure calculation. Therefore for the LOCA M&E PIRT, the phenomena were ranked with regard to the impact on the mass and energy release calculation.

A draft large LOCA M&E release PIRT was created using existing large LOCA PIRTs as the basis. A group of LOCA experts was selected to review the LOCA M&E release PIRT. They were selected based on their experience level and range of analysis capabilities since the new large LOCA M&E analysis methodology will be applied to both the Westinghouse PWR and ABB-Combustion Engineering PWR designs, including the advanced passive plant design. Initially the experts were asked individually to review and rank the phenomena with regard to the impact on the LOCA M&E release calculation. The experts were asked to rank the phenomena as HIGH, MEDIUM or LOW corresponding to the ranking definition in [1]. A HIGH would correspond to the ranking values of 7-9, a MEDIUM would correspond to ranking values 4-6, and a LOW would correspond to ranking values of 1-3. They were allowed to include/rank additional phenomena that were not listed in the table. They were requested to note phenomena that might be more important for one plant type than another. They were also requested to provide an indication of the quality and quantity of available test data for the HIGH ranked phenomena.

After collecting the results of the individual PIRT reviews, it was decided that a group discussion would be needed to develop the final PIRT. The participants were provided with a summary of the high ranked phenomena and an updated PIRT for the group to review together. Table 1 presents the PIRT supplied for the group review.

Group Review Process

The group decided to begin by ranking the phenomena for each event phase. The group decided to merge several of the fuel rod and core component phenomena under a single stored energy release phenomena for the fuel rod. This included the gap conductance, DNB, rewet/quench, nucleate boiling and flow reversal/stagnation phenomena. These items had been ranked relatively high in the individual PIRT reviews previously.

Everyone agreed that the break phenomena (critical flow/flashing) were important during Blowdown and the fuel rod decay heat was important during Reflood and long term phases. Upon further discussion it was decided that flashing at the break location was less important and actually more of a containment phenomenon.

During the Refill period the releases are minimal, and no phenomena were highly ranked. It was decided that a conservative treatment of the Refill period would be best. It should be biased to shorten the refill time (shorten the ECC bypass phase), start early, end early, etc.

The group also decided to merge several of the core component phenomena under the Core Reflood Heat Transfer phenomena. This encompasses the post-CHF, rewet/quench, entrainment/de-entrainment and nucleate boiling phenomena. The core entrainment/de-entrainment and the other phenomena were kept separate for the discussion, as they could be important during other phases.

Everyone agreed that the entrainment/de-entrainment phenomena was important in both the upper plenum and hot leg during the Reflood and long term phases. It was decided to merge the void distribution phenomena in the hot leg and call it Stratification/entrainment/de-entrainment. Hot leg condensation was included as an important phenomenon during the long-term, hot leg recirculation phase.

Steam generator heat transfer (both primary and secondary side) was agreed to be important during the Reflood and long-term phases. Because secondary stratification affects the heat transfer rate, it was merged into this phenomenon. It was decided that steam binding was simply a pressure drop issue. Pressure drop issues were not highly ranked, therefore, it was decided that this phenomenon should not be highly ranked.

Everyone agreed that condensation during cold leg/accumulator injection was important during the Reflood phase. The effect of accumulator nitrogen release was not highly ranked.

It was agreed that Hot Wall, saturated nucleate boiling, and quenching phenomena comprises the downcomer stored energy release modeling phenomena. Condensation in the downcomer was highly ranked during Reflood. Also, 3-D effects were important for system 80+ since the injection location is above the hot/cold leg nozzles. The 3-D effects phenomena was merged with the direct vessel injection phenomena (which was ranked high during the Reflood phase).

Finally, it was agreed that the loop flow split was important during both the Reflood and long term phases as this effects the amount of steam boiloff that exits directly out of the break without passing through the other loops, and therefore not coming in contact with the safety injection of the other loops (if applicable).

HIGHLY RANKED PHENOMENA

Following is a discussion of the highly ranked phenomena for each of the components in the RCS.

Break

During the Blowdown phase, the initial RCS fluid contents are released through the break. The critical flow at the break during the Blowdown phase is a highly ranked phenomenon and is equally important for all designs. The importance of the critical flow is higher during the early Blowdown phase of the transient since, it along with the loop resistance differences, determines the system and break flow during Blowdown.

Flashing at the break plane could cause a reduction in the break flow, but is considered to be less important than the critical flow calculation. Since containment pressure at the end of Blowdown is typically less than 50 psig, the flow will be choked and containment pressure will have a limited effect on the Blowdown. Any effect would be to reduce the break flow near the end of the Blowdown phase. The Automatic Depressurization System (ADS) utilized on the passive containment designs does not come into play before the Reflood part of the transient.

Fuel

The release of the stored energy in the fuel which is affected by the gap conductance in the fuel, DNB, rewet/quench, nucleate boiling, and flow reversal/stagnation in the core is a highly ranked phenomenon during the Blowdown phase. In the Westinghouse analysis, items such as gas gap conductance, fuel conductivity, effects of pellet radial power, pellet cracking, etc., are part of the initial stored energy used in the plant calculation. The stored energy released during Blowdown is greater than the decay heat energy released during Blowdown. The release of the decay heat energy however is a highly ranked phenomenon during the Reflood and Long-Term phases.

Core

Core heat transfer is the most important mechanism during the Reflood phase and is therefore a highly ranked phenomenon. Lumped into this phenomena are post-CHF, (which is the dominant heat transfer regime during Reflood), nucleate boiling, (which occurs during the final quench of the fuel cladding), and entrainment/de-entrainment, (which can result in increased flooding rates and hence enhance Reflood heat transfer and quench front propagation). Also, the core heat transfer is a direct function of the local void fraction during Reflood. Void generation and distribution are also part of this process. Rewet is will have a small effect during Reflood calculations.

Upper Plenum

The entrainment/ de-entrainment which occurs during Reflood, and in the Long Term, is a highly ranked phenomenon. Entrained liquid from the core can be carried to the upper plenum and de-entrained on the structural members there. This liquid can then form a pool in the upper plenum and provide water to drain back into the upper portions of the core and cool the fuel rods, or provide water to be swept into the steam generator inlet plenums where the de-entrainment process starts again.

Phase separation in the upper plenum is ranked as moderately important. The phase separation phenomenon is related to the entrainment and de-entrainment in the upper plenum. Usually, what is found is that the mass in the upper plenum will increase to a constant value as the liquid de-entrains on the upper plenum structures and the liquid pools on the core plate as a low void fraction mixture. Since there is mostly steam coming from the core, there is very little phase separation.

Hot Leg

Condensation of the steam during hot leg recirculation was considered to be an important phenomenon during the Long Term phase.

Stratification/Entrainment/ de-entrain ment, which occur during Reflood, and in the Long Term, will influence the void distribution in the hot leg and the amount of fluid reaching the steam generators. This was considered a highly ranked phenomenon during both the Reflood and Long Term phases.

Pressurizer

No pressurizer related phenomena were ranked high for LOCA M&E calculations.

Steam Generator

The steam generators will transfer energy to the fluid passing through the tubes. The heat transfer, both primary and secondary (including secondary stratification), is highly ranked during the Reflood, and the Long-term phases.

Pump

No pump related phenomena were ranked high for LOCA M&E calculations.

Cold Leg Accumulator

Condensation effects are the most important item for the accumulator behavior during the refill period. Most of the ECC water is bypassed early in the refill period, but the condensation process at the top of the downcomer helps to induce downflow through the core promoting cooling. To maximize the LOCA M&E releases, the refill period will be biased to start early and end early.

The condensation effects are diminished during the reflood period as accumulator injection ends and the lower flow pumped injection continues. However, since the Reflood period will be mechanistically calculated, it was concluded that accumulator condensation effects should be highly ranked for Reflood.

Downcomer

Condensation in the downcomer region, stored energy release (comprised of hot wall, saturated nucleate boiling, and quenching), and direct vessel injection (including 3-D effects) were ranked high during Reflood.

Most of the phenomena are important during the Refill phase, such as entrainment and de-entrainment, as well as condensation. ECC bypass and downcomer penetration phenomena are most important during the Refill period when the accumulator water is flowing into the downcomer annulus. These phenomena are similar for two-, three- and four-loop plants. As the transient progresses into the reflood phase, the importance of the phenomena decreases since the downflow is more easily predicted after the upflow of steam in the downcomer annulus has ended and the water penetrates more easily.

Lower Plenum

There were no high ranked phenomena for the lower plenum.

Loop

The flow split phenomenon was ranked high during Reflood and Long Term because of the importance of the flow proportioning to each loop, the benefit of condensation in each loop, and the eventual effect on the time history mass and energy exiting the break. It is anticipated that sensitivities will be conducted to validate the importance of this phenomenon.

RESULTS

Table 2 lists the high ranked phenomena from the PIRT, along with the Transient Phase, & Projected Source of Validating Data. This table is the expert opinion of the selected team and is based upon and is an extension of NRC large LOCA PIRT, which was developed as part of the best estimate (BE) LOCA program for ECCS design basis analysis [1], the Westinghouse large LOCA PIRT developed for the WCOBRA-TRAC BE LOCA model development program [2], and the Westinghouse large LOCA PIRT, which was developed to address new components as part of the AP600 [3] and AP1000 [4] plant development programs.

REFERENCES

1. NUREG-1230,"Compendium of ECCS Research for Realistic LOCA Analysis", December 1988.
2. WCAP-12945-P-A, Volume 1, Revision 2, "Code Qualification Document For Best Estimate LOCA Analysis", Bajorek, S. M., et al, 1998.
3. WCAP-14171, "WCOBRA/TRAC Applicability to AP600 Large Break Loss of Coolant Accident", March 1998.
4. WCAP-15613, "AP1000 PIRT and Scaling Assessment", March 2001.

Table 1
Draft Large LOCA M&E Release PIRT

Component	**Phenomena**	**Event Phase**			
		Blowdown	Refill	Reflood	Long Term
Fuel Rod					
	Stored Energy	High	Medium	Medium	Low
	Oxidation	Medium	Medium	Medium	Low
	Decay Heat	Medium	Medium	High	High
	Reactivity-Void	Medium	Low	Low	Low
	Reactivity- Boron	Medium	Low	Low	Low
	Gap Conductance	Medium	Medium	Medium	Low
Core					
	DNB	Medium	Low	Low	Low
	Post-CHF	Medium	Low	Medium	Low
	Rewet	Medium	Low	Medium	Low
	Reflood Heat Transfer	N/A	N/A	High	Medium
	Nucleate Boiling	Medium	Medium	Medium	Medium
	Vapor Natural Circulation	Low	Low	Medium	Medium
	Medium-D Flow	Medium	Low	Medium	Low
	Void generation/distribution	Low	Low	Medium	Medium
	Entrainment/De-entrainment	Low	Low	High	Medium
	Flow Reversal/Stagnation	Medium	Low	Low	Low
	Radiation Heat Transfer	Low	Medium	Medium	Low
	Level	Low	Medium	Medium	Medium
Upper Head					
	Initial Water Temperature	Medium	Low	Low	Low
	Flow Path Area	Medium	Low	Low	Low
	Blowdown Flow	Medium	Low	Low	Low
Upper Plenum					
	Hot Assembly Location	Low	Low	Low	Low
	Entrainment/De-entrainment	Low	Medium	High	High
	Phase Separation	Medium	Low	Medium	Medium
	Counter Current Flooding	Low	Medium	Medium	Low
	Low-Phase Convection	Low	Low	Medium	Medium
Hot Leg					
	Condensation	N/A	N/A	N/A	High
	Entrainment/De-entrainment	Medium	Low	High	High
	Flow Reversal	Low	Low	Low	Medium
	Void Distribution	Low	Low	Medium	Medium
	Low-Phase Convection	Low	Low	Medium	Low
Pressurizer					
	Early Quench/Flow	Low	Medium	Medium	Low
	Critical Flow in Surge Line	Low	Medium	Medium	Low
	Flashing	Low	Low	Low	Low
	ADS Interaction*	N/A	N/A	Low	Medium

Table 1 (Cont.) Draft Large LOCA M&E Release PIRT					
Component	**Phenomena**	**Event Phase**			
		Blowdown	Refill	Reflood	Long Term
Steam Generator					
	Heat Transfer	Medium	Medium	High	High
	Steam Binding	Low	Low	High	Medium
	Delta-P, Form Losses	Medium	Low	Medium	Medium
	PRHR*	N/A	N/A	Medium	Medium
	Secondary Stratification	Medium	Low	Medium	Medium
Pump					
	Low-Phase Performance	Medium	Low	Low	Low
	Delta-P, Form Losses	Medium	Low	Medium	Medium
Cold Leg/Accum					
	Condensation	Medium	Medium	High	Medium
	Non-condensable Gases	Medium	Low	Medium	Medium
	Discharge	Medium	Medium	Medium	Low
	Flow Asymmetries	Low	Low	Medium	Low
	High Pressure Injection Mix	Low	Low	Medium	Medium
	CMT Mixing/Interaction*	N/A	N/A	Medium	Medium
Downcomer					
	Entrainment/De-entrainment	Medium	Medium	Medium	Medium
	Condensation	Medium	Medium	High	Medium
	Countercurrent, slug, noneq.	Low	Medium	Medium	Low
	Hot Wall (vessel/barrel)	Medium	Medium	High	Medium
	Hot Wall (radial reflector)	Medium	Medium	Medium	Low
	Low-Phase Convection	Medium	Medium	Medium	Low
	Saturated Nucleate Boiling	Medium	Medium	Medium	Medium
	Medium-D Effects	Medium	Medium	Medium	Low
	Flashing	Medium	Low	Low	Low
	Liquid Level Oscillations	Medium	Medium	Medium	Medium
	Direct Vessel Injection - Acc*	Medium	Medium	High	Low
	IRWST Mixing*	N/A	N/A	N/A	Medium
	CMT Mixing/Interaction*	N/A	N/A	Medium	Medium
Lower Plenum					
	Sweep-out	Medium	Low	Low	Low
	Hot Wall	Medium	Medium	Medium	Low
	Multidimensional Effects	Medium	Low	Low	Low
Break					
	Critical Flow	High	Medium	Medium	Low
	Flashing	High	Medium	Medium	Medium
	Containment Pressure	Low	Medium	Medium	Medium
	ADS Flow*	N/A	N/A	Medium	Medium
Loop					
	2-Phase Delta-P	Medium	Low	Medium	Medium
	Oscillations	Low	Medium	Medium	Medium
	Flow Split	Medium	Medium	High	Medium
* - Only applicable to the passive plant design					

Table 2
Summary of High Ranked Phenomena and Associated Data

Phenomena	Transient Phase	Source of Data
Break: Critical Flow	Blowdown	Marviken, LOFT
Fuel Rod: Stored Energy Release (includes gap conductance, DNB, rewet/quench, nucleate boiling, and flow reversal/stagnation)	Blowdown	Initial Stored Energy -Fuel Related Input Parameter; Transient Aspects – LOFT, ORNL,G-1,G-2
Fuel Rod: Decay Heat	Reflood/Long Term	ANS 1979 Decay Heat Standard
Core: Reflood Heat Transfer (includes post-CHF, nucleate boiling, Entrainment/De-entrainment and rewet/quench)	Reflood	FLECHT, FLECHT SEASET, Semi-scale, SCTF, CCTF,
Upper Plenum: Entrainment/De-entrainment	Reflood/Long Term	CCTF, SCTF, UPTF
Hot Leg:Condensation	Long Term	UPTF (German tests, although the piping is different than ours)
Hot Leg: Stratification/Entrainment/De-entrainment	Reflood/Long Term	CCTF, UPTF
Steam Generator: Heat Transfer (both primary and secondary, includes secondary stratification)	Reflood/Long Term	FLECHT SEASET, CCTF, UPTF
Cold Leg/Accum: Condensation	Reflood	W/EPRI 1/3 scale test, COSI
Downcomer: Condensation	Reflood	UPTF
Downcomer: Stored Energy Release (includes Hot Wall, saturated nucleate boiling, quenching)	Reflood	LOFT, CREARE, UPTF
Downcomer: Direct Vessel Injection (includes 3-D effects)	Reflood	UPTF, CCTF, Ed Lee also has a paper that may be appropriate
Loop: Flow Split	Reflood, Long term	FLECHT, CCTF