Response to NRC's Request for Additional Information by the Office of Nuclear Reactor Regulation for Topical Report WCAP-16608-P, "Westinghouse Containment Analysis Methodology" (TAC No. MD2953) (Non-Proprietary)

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REQUEST FOR ADDITIONAL INFORMATION
RELATED TO WCAP 16608-P
WESTINGHOUSE CONTAINMENT ANALYSIS METHODOLOGY

(Westinghouse response in ITALICS)

RAI 1. Section 4.1 of WCAP 16608P states that although the containment models and methods described in this report were developed using GOTHIC 7.2a, Westinghouse intends to use future versions of GOTHIC for plant specific containment analyses as they become available.

This, as stated, is not acceptable. (a) A new version of GOTHIC may contain models or yield results that would not be acceptable to the staff, at least without more justification than might be provided in the NAI documentation. On the other hand, the staff would prefer not to perform a complete review of the application of a new version of GOTHIC. Therefore, please propose a procedure that will allow Westinghouse flexibility but that still meets the staff's responsibility to review significant changes from one version of GOTHIC to another.

Response: The Westinghouse quality assurance program is implemented as described in the Quality Management System (QMS), which has been reviewed and approved by the USNRC. In accordance with the QMS, computer software changes are governed by established procedures and processes that define the requirements for development, testing, control, and maintenance of computer software used in engineering applications. As newer versions of GOTHIC are periodically released, such as may be needed to correct errors and/or to add new models or new functionality, Westinghouse will use the established procedures to evaluate these changes to ensure that they comply with the approved methodology and do not introduce unintended or adverse impacts on the past use of the code.

Updates which may require NRC review and approval prior to their use would include new models (for example, an improved condensation heat and mass transfer model) or a new functionality (for example, a new numerical solution technique) in an evaluation model, particularly if the calculated result produces more analysis margin.

Typically, the software changes made by NAI to implement new models and new functionality do not impact the end users; that is, they can expect to get the same (or nearly the same) results from the code when running their existing containment evaluation models without making any significant input changes. When updating GOTHIC versions, Westinghouse will use the 10 CFR 50.59 approach to changing "elements of a methodology" as defined in NEI 96-07, Rev. 1 and endorsed by USNRC Regulatory Guide 1.187. Prior to application of the new GOTHIC code version, the calculated results from an existing containment evaluation model (the benchmark) would be compared with results from the same containment model using the new GOTHIC code version to identify the differences caused by the change in code version. The new GOTHIC code version would be acceptable for the containment design basis analysis application if the calculated results are "essentially the same as, or more conservative than, either the previous revision of the same methodology or another methodology previously accepted by NRC through issuance of an SER". If either of these acceptance conditions is met, Westinghouse will document the results of the evaluation in accordance with the applicable procedure and the documentation would be retained for NRC review. If neither of these conditions is met, then NRC review and approval would be required prior to using the new GOTHIC code version for a containment design analysis.

(b) For the calculation of containment backpressure for the 10 CFR 50.46 LOCA analyses, the version of GOTHIC proposed in this topical report (7.2a) must be considered part of the LOCA evaluation model. Therefore, please describe the Westinghouse proposal for including GOTHIC 7.2a in the Westinghouse BWR ECCS evaluation model.

Response: Westinghouse is planning to submit a supplement or a revision to the existing BWR ECCS evaluation model topical report to document how GOTHIC 7.2a will be used for the containment minimum backpressure calculation.

(c) Describe how the Westinghouse use of GOTHIC 7.2a will comply with 10 CFR Part 50 Appendix B and 10 CFR Part 21.

Response: As described above, computer software used in engineering applications is governed by procedures and processes established in accordance with the Westinghouse Quality Management System (QMS). These procedures are in compliance with, and address the requirements of, 10 CFR Part 50 Appendix B and 10 CFR Part 21. According to the Westinghouse procedures, GOTHIC 7.2a is external software obtained from a qualified vendor. Westinghouse software QA procedures control the installation, configuration control, notification, and resolution of errors for software obtained from qualified software vendors.

(d) Please describe the Westinghouse procedure for responding to EPRI notifications of discovered errors in GOTHIC 7.2a so that licensing calculations done by Westinghouse with GOTHIC 7.2a remain valid.

Response: Westinghouse uses QA procedures to address software error reports. Upon receiving a GOTHIC error notification from NAI, the Westinghouse code-responsible engineer forwards a copy of it to the code users. Both the code-responsible engineer and the users review the NAI documentation to determine if any previous analyses results could have been impacted by the errors. The code-responsible engineer classifies the errors, documents the results of his review, and sends this information to the users for their review and concurrence. If the review process determines that an error could affect a licensing calculation, Westinghouse would notify the affected customer and a course of action would be developed.

RAI 2. <u>Introduction</u> WCAP 16608P lists 9 applications of the methodology for both BWRs and PWRs. However, only BWR Mark I containment applications are described in detail in the report in Appendices A and B. Therefore, the staff SER will only discuss application to BWR Mark I containments.

Response: Westinghouse agrees. Addendums to WCAP-16608 describing the PWR LOCA M&E release methodology and PWR containment models are forthcoming.

RAI 3. What steps are taken to verify that all relevant GOTHIC 7.2a empirical correlations will be used within their range of applicability?

Response: The relevant correlations for the BWR Mark I containment model applications are related to the Direct/DLM heat and mass transfer option and the liquid/drop surface interface heat and mass transfer. The validation comparison with test data and range of applicability for the DLM heat and mass transfer correlation is presented in Section 5.11 of the GOTHIC Qualification Report. The drop interface heat and mass transfer validation is described in Section 6.6 of the Qualification Report. GOTHIC containment DBA applications containing these *same empirical correlations have been previously approved. The GOTHIC BWR Mark I containment model applications for which Westinghouse is seeking approval are expected to remain within the validity range of these empirical correlations.*

RAI 4. What characteristic length is used in the heat transfer correlations applied to BWR Mark I containment heat transfer?

Response: The cell hydraulic diameter is used for the characteristic length in the BWR Mark I containment model. This is the GOTHIC code default input value.

RAI 5. Subcompartment analysis (Standard Review Plan Section 6.2.1.2 is not listed as one of the applications of this methodology. Please verify that the methods of WCAP 16608-P (i.e., GOTHIC) will not be applied to BWR Mark I subcompartment analysis.

Response: Westinghouse does not intend to use the GOTHIC BWR Mark I containment model documented in WCAP-16608 for subcompartment analyses. It is understood that an extension of this generic methodology to cover that application would require NRC review and approval.

RAI 6. For the applications considered in WCAP 16608P, is surface-to-surface radiation heat transfer considered? If so, please describe and provide the source of the emissivities and shape factors used. For which, if any, of the BWR Mark I containment safety analyses is thermal radiation heat transfer significant?

Response: Westinghouse does not model surface-to-surface radiation heat transfer for any of the BWR Mark I containment model applications listed in WCAP-16608. The radiation heat transfer option between the vapor space and the thermal conductor surface is used, but it is not a significant source of heat transfer because the wall surface and vapor temperatures are nearly the same in all cases.

RAI 7. Please verify that the GOTHIC height scaling factor is not included in the calculation of heat transfer to structures.

Response: The GOTHIC height scaling factor is not included in the calculation of heat transfer to structures in the BWR Mark I containment model.

RAI 8. Discuss how suppression pool level and/or volume changes during postulated events are calculated. If level and/or volume change is not included in the calculation, why is this acceptable, especially for the available NPSH calculation?

Response: Currently, the ECCS pump NPSHa is expected to be calculated outside of GOTHIC using the code calculated transient containment pressure, suppression pool temperature, and suppression pool level (or water volume), along with the pump flow rate and line resistance as inputs. GOTHIC calculates the transient water volume based on the flow rates into and out of the lumped parameter node representing the suppression pool. The suppression pool water level is calculated by dividing the transient water volume by the total volume of the node and multiplying by the node height.

RAI 9. Do any of the calculations of WCAP 16608P use the GOTHIC jet and drop breakup model? If yes, which calculations. If yes, please reference qualification studies or other references to demonstrate that the model is conservative.

Response: The GOTHIC jet and drop breakup model is not used in the BWR Mark I containment model.

RAI 10. Standard Review Plan 6.2.1.1.A.II.5.b states that to satisfy the requirements of GDC 38 the containment pressure should be reduced to less than 50% of the peak calculated pressure for the design basis loss-of-coolant accident within 24 hours after the postulated accident. Demonstrating that the containment pressure is reduced by 50% in 24 hours permits the containment leakage rate to be reduced by 50% after 24 hours. This guidance was intended for PWRs. However, the NRC staff has approved the reduction in leakage with a reduction in pressure for BWRs also. Does Westinghouse intend to perform this type of calculation for BWR Mark I containments? If so, please provide information on how the calculation would be done.

Response: Yes, Westinghouse intends to perform a long-term pressure and temperature calculation with the BWR Mark I containment model to provide input for long-term equipment qualification and to determine the containment pressure at 24 hours. The long-term mass and energy input is calculated by the GOTHIC vessel model. The GOTHIC vessel model is described in Section A.2.2 and the vessel thermal conductors (including the fuel rods) are described in Section A.2.4. The transition from GOBLIN to the GOTHIC long-term mass and energy release calculation is described in Section A.2.10.

A sample RSLB long-term containment response calculation is provided in Section A.4.4. This case was only run out 50000 seconds; however, the case has been extended to 100000 seconds in response to this RAI. The revised figures for WCAP-16608 are attached to RAI 13.

RAI 11. Section 2. Table 2-1 Item 1 What assurance is there that the **[**
]^{a,c} if analyzed with GOTHIC?

Response: As demonstrated in various benchmark comparison cases, GOTHIC produces similar results to the existing containment analysis codes. Therefore, there is no significant change in the predicted containment response when switching from a currently approved methodology to GOTHIC. **[**

]^{a,c}

RAI 12. Section 4.2.4 Page 4-7 Item 4. Licensing calculations maximizing BWR suppression pool temperature typically assume the torus outside surface is adiabatic, i.e., no heat transfer from the torus outer surface to the reactor building atmosphere. The staff requests that, for added conservatism, you reconsider including this heat transfer.

Response: Item 4 has been deleted. This item **[**
]^{a,c} *should be listed in the Appendices describing those types of containment models. The Westinghouse BWR Mark I containment model treats the torus exterior surface as adiabatic but allows heat transfer to the interior surface.*

RAI 13. <u>WCAP 16608P Table A.3-1</u> This table gives values of **[** **]**^{a,c} for Model 1, Model 2 and the Generic Model. There is a large discrepancy between the values for Model 1 and Model 2 and the Generic Model. The large values for Model 1 and Model 2, according to the description on Page A-40, were chosen to match the benchmark data. The value [ ][a,c] for the Generic Model appears to be more consistent with values used in other BWR modeling.

Figures A.3-3 and A.3-8 for Models 1 and 2, respectively, give peak drywell pressures of approximately 46 psig and 42 psig, respectively, while the peak drywell pressure for the Generic Model is approximately 44 psia or 29.3 psig - considerably less than either Model 1 or Model 2.

It therefore appears that when attempting to reproduce other BWR calculations, a high [ ][a,c] is necessary. When using a [ ][a,c] GOTHIC calculates a pressure much less than the other cases.

One explanation for this could be the modeling of droplets in the drywell and the downcomer flow. If a large fraction of the droplets are removed in the drywell, this would account for the need to [ ][a,c] in Models 1 and 2 and also account for the low drywell pressure calculated by the Generic Model. This might also explain the lack of agreement with the wetwell pressure in Figure A.3-4.

It has been the NRC position that 100% entrainment should be assumed [ ][a,c] [1] This is consistent with comparisons with Humboldt Bay and Bodega Bay data.[2]

Please verify that GOTHIC is not removing droplets from the drywell atmosphere prior to flowing through the vents.

If removal of droplets is not the cause of the discrepancy between the [ ][a,c] in Models 1 and 2 and the Generic Model, please explain why [ ][a,c] are necessary.

Response: [

][a,c]

[

][a,c].

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1 CONTAIN Code Qualification Report/User Guide for Auditing Design basis BWR Calculations, Table 2.1, SMSAB-03-02, USNRC , March 2003 (ML030700335)

2 The General Electric Pressure Suppression Containment Analytical model, NEDO 10320 Supplement 1, Section 3.2, General Electric Company, May 1971

A comparison of the resulting drywell and wetwell pressure response with the NRC CONTAIN model is shown in Figures 1 and 2. **[**

]^{a,c}

Next, the compressibility option was turned on in the vent flow paths. This option allowed the density of the flow to be adjusted based on changes in velocity and pressure and this will affect the calculated pressure drop in the flow path.

A comparison of the resulting drywell pressure response with this input change is also shown in Figure 1. **[**
]^{a,c}

All of the blowdown liquid break flow is released in the form of small (100 micron) drops in the current generic GOTHIC BWR Mark I containment model. Some of these drops (about 15%) fall out of the vapor region and form liquid pools on the floor of the drywell and ring header volumes before being deposited in the suppression pool.

The drop-to-liquid conversion option in the GOTHIC Run menu was set to IGNORE to prevent the drops from falling out of the vapor region; this effectively modeled 100% drop entrainment as suggested by the NRC. **[**

]^{a,c}

A comparison of the resulting drywell pressure response with these changes is also shown in Figure 1. The difference in the drywell pressure response due to these input changes is small **[**
]^{a,c} *since the code calculates only a small fraction of the drops to collect on the floors during blowdown.*

[**]**^{a,c} *the GOTHIC calculated peak drywell pressure with 100% entrainment is still* **[** **]**^{a,c} *less than the value calculated by the NRC. The wetwell pressure is approximately the same in both cases, so the difference in the calculated drywell pressure is due to some other difference in the vent path pressure drop calculation.*

A higher vent path pressure drop could be calculated with GOTHIC if the droplet and vapor phases could be forced to have the same velocity. In this case the drop volume fraction and average downcomer density would also have to be lower to conserve mass. **[** **]**^{a,c}

[ ]^{a,c}.

A comparison of the resulting drywell pressure response with these changes is also shown in Figure 1. [ ]^{a,c}

This is still [ ]^{a,c} *less than the vent path pressure drop calculated by the NRC with CONTAIN. We do not understand the reasons for the remaining* [ ]^{a,c} *difference in the calculated vent path pressure drop. The GOTHIC drywell pressure can be made to match the CONTAIN result if the vent path loss coefficient input value is increased by about 50% (from 5.17 to 7).*

The Model 1 and 2 RSLB short-term peak pressure benchmark comparison cases were re-run with the vent path modeling changes described above. The benchmark case vent path loss coefficient input values were not specified. After making the changes listed above, the vent path loss coefficient input value in Model 1 was reduced [ ]^{a,c} *and the vent path loss coefficient input value in Model 2 was reduced* [ ]^{a,c} *to better match the benchmark. Tables A.3-1, A.3-2, and A.3-3 were revised to list these new loss coefficient input values and the revised short-term RSLB benchmark comparison figures for WCAP-16608 (Figures A.3-3 through A.3-11) are attached.*

To summarize, the following vent path input changes were made to the generic GOTHIC BWR Mark I model and should be used for all applications:

1. [
2.]^{a,c}

The sample cases in WCAP-16608 Appendix A were re-run after making the changes listed above; the revised plots are attached and will be incorporated into WCAP-16608-P-A. The text on pages A-16 and A-17 of WCAP-16608-P-A will be modified as shown below to incorporate these input changes:

[ ]^{a,c}

[

]a,c

[

]a,c

The input changes listed below are recommended to model 100% liquid entrainment and homogeneous flow during a large LOCA blowdown event. These changes impact the blowdown vent path pressure drop calculation and should only be used for the short-term peak pressure application:

1. [
2.]a,c

This information will be added to Section A.3 in WCAP-16608-P-A

a,c

Figure 1

a,c

Figure 2

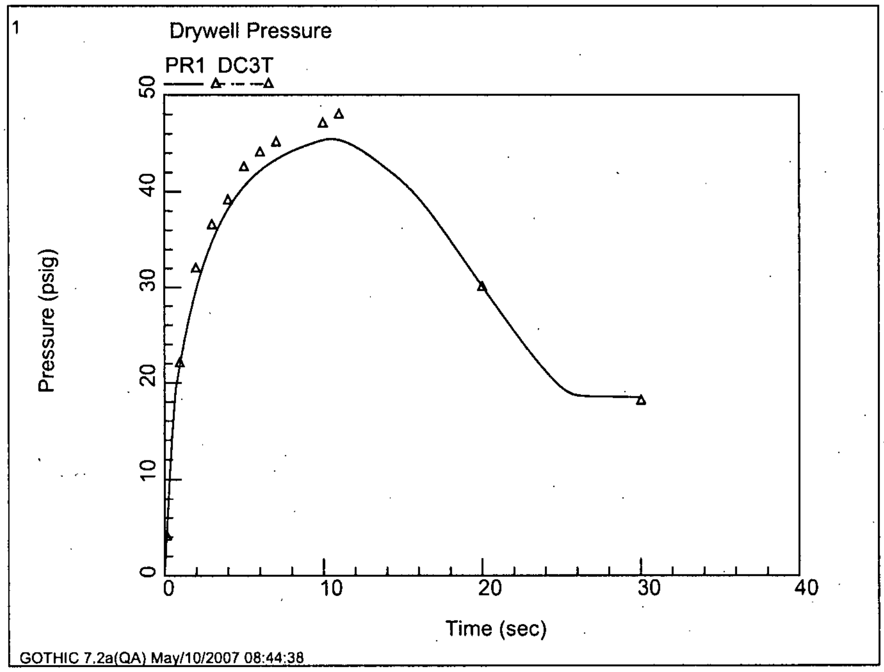

Figure A.3-3 Model 1 Short-Term RSLB Drywell Pressure Comparison

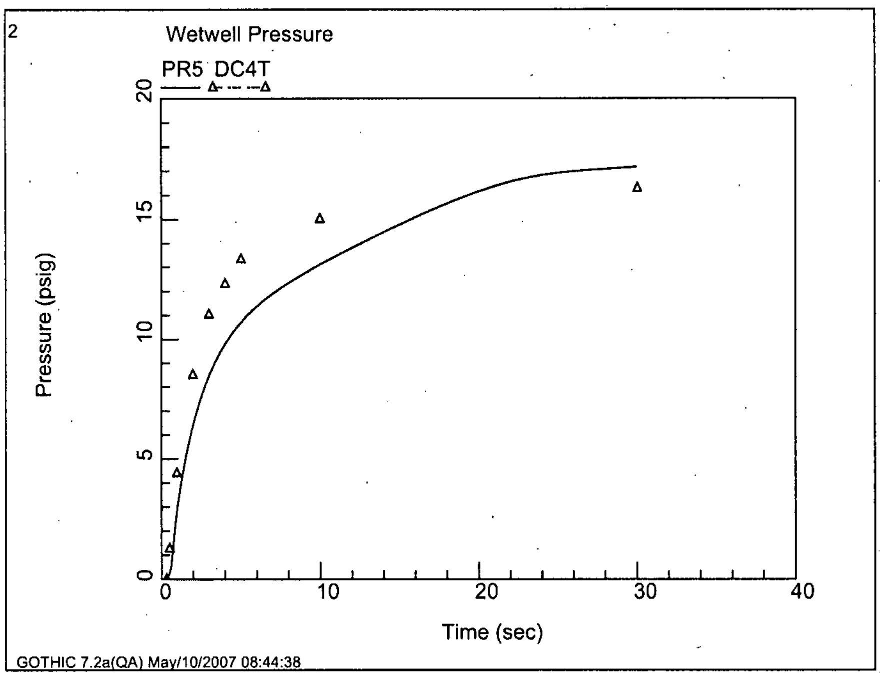

Figure A.3-4 Model 1 Short-Term RSLB Wetwell Pressure Comparison

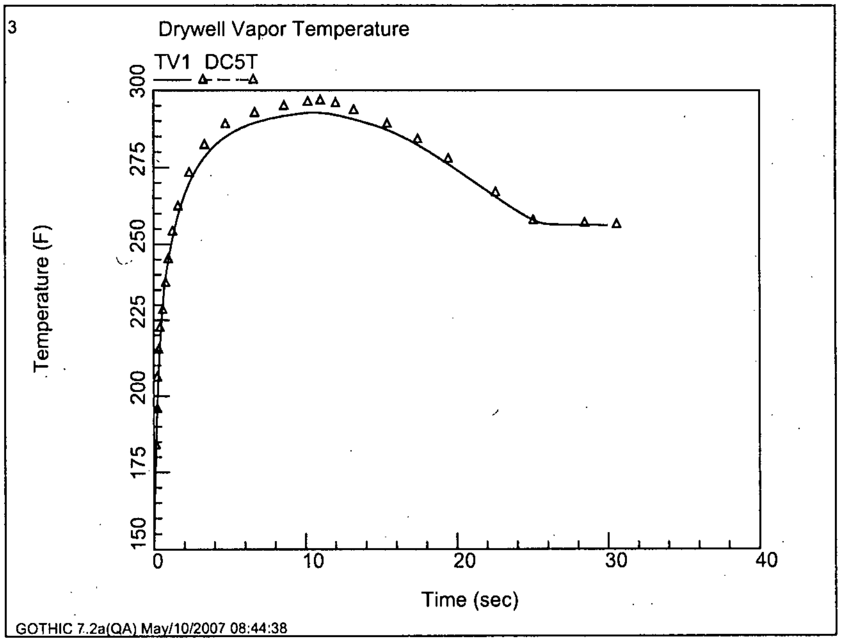

Figure A.3-5 Model 1 Short Term RSLB Drywell Vapor Temperature Comparison

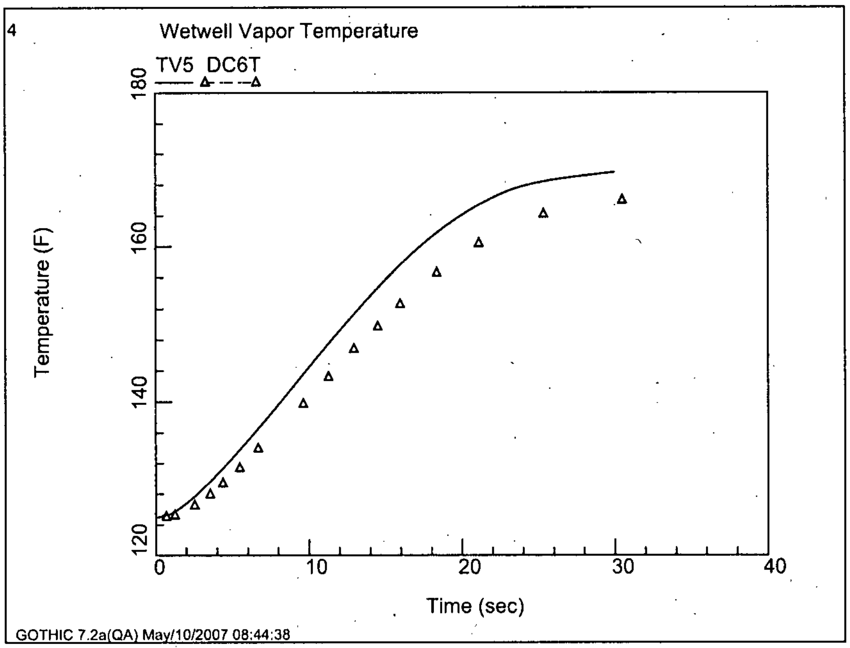

Figure A.3-6 Model 1 Short-Term RSLB Wetwell Vapor Temperature Comparison

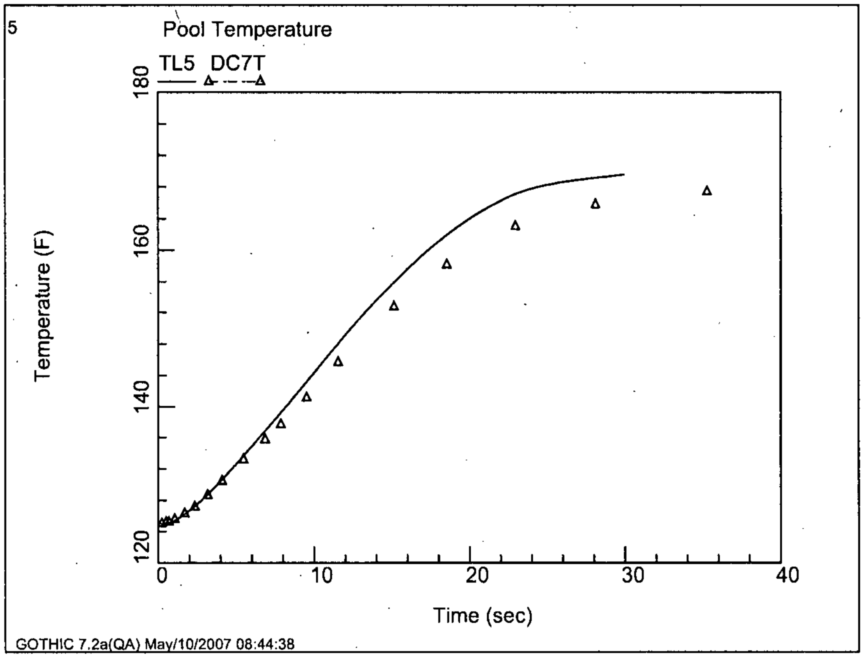

Figure A.3-7 Model 1 Short-Term RSLB Suppression Pool Temperature Comparison

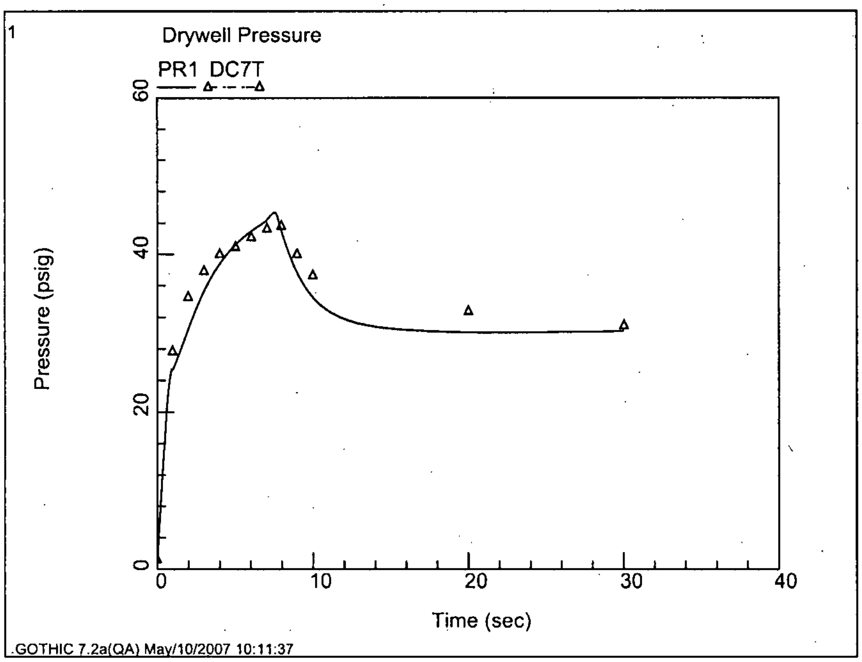

Figure A.3-8 Model 2 Short-Term RSLB Drywell Pressure Comparison

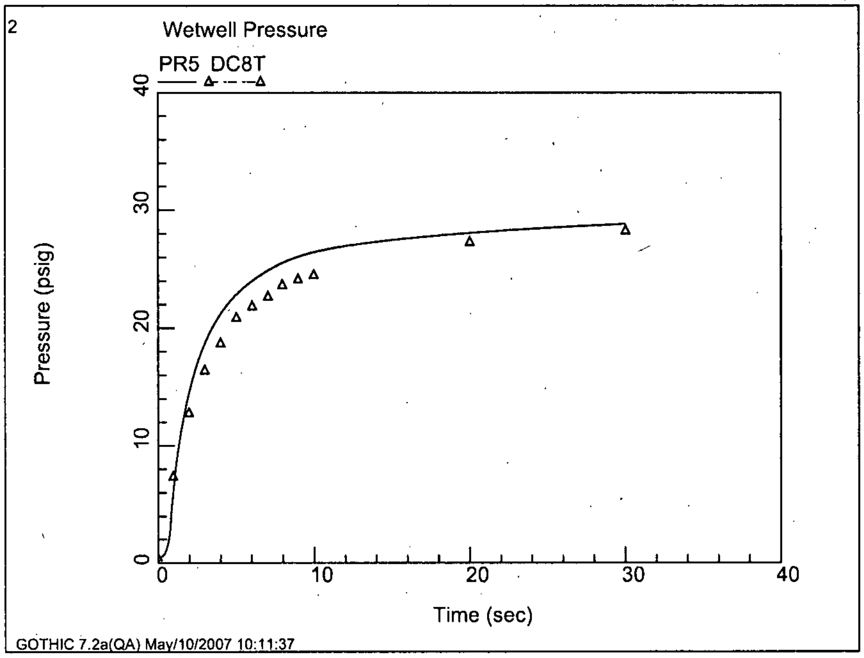

Figure A.3-9 Model 2 Short-Term RSLB Wetwell Pressure Comparison

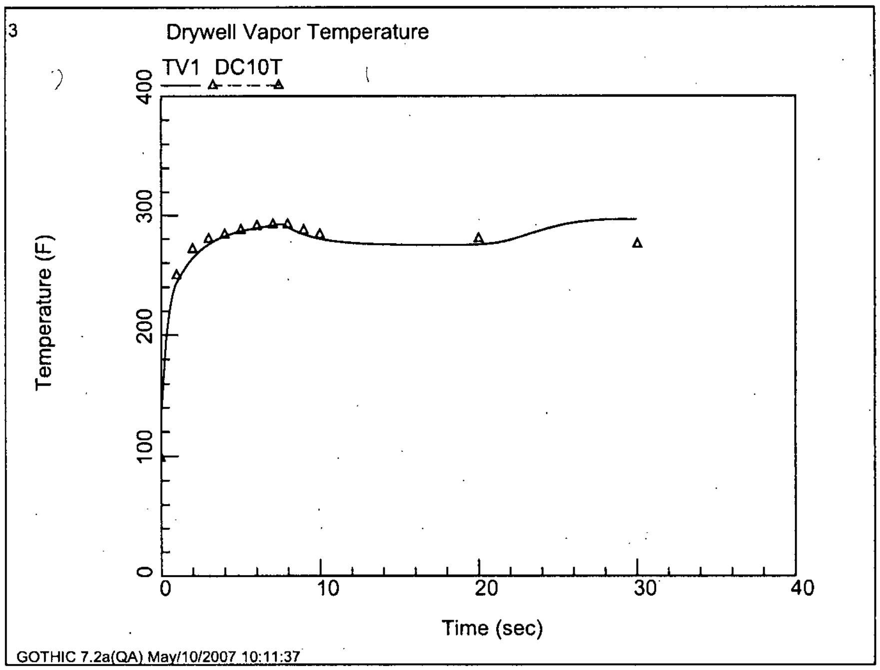

Figure A.3-10 Model 2 Short-Term RSLB Drywell Vapor Temperature Comparison

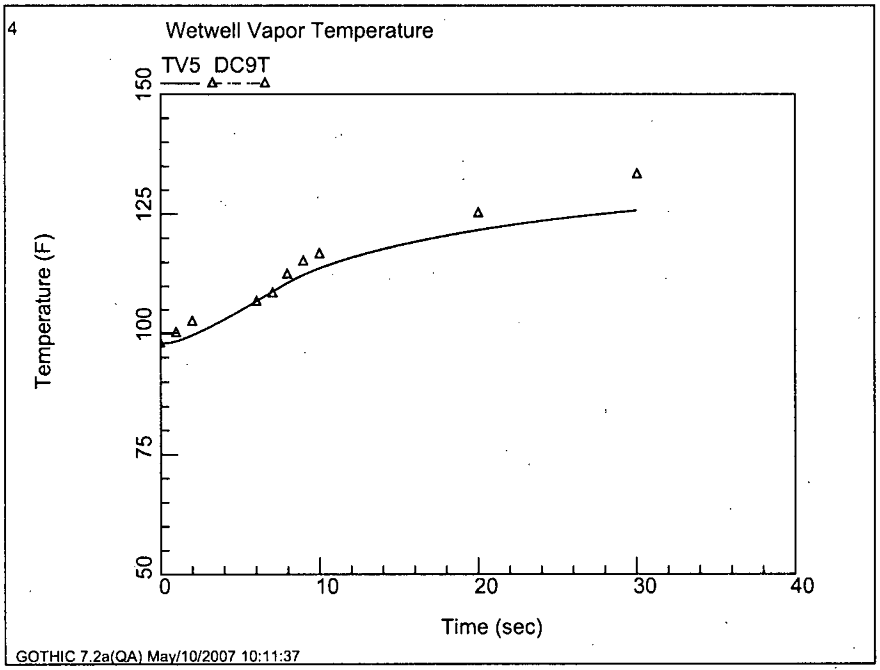

Figure A.3-11 Model 2 Short-Term RSLB Wetwell Vapor Temperature Comparison

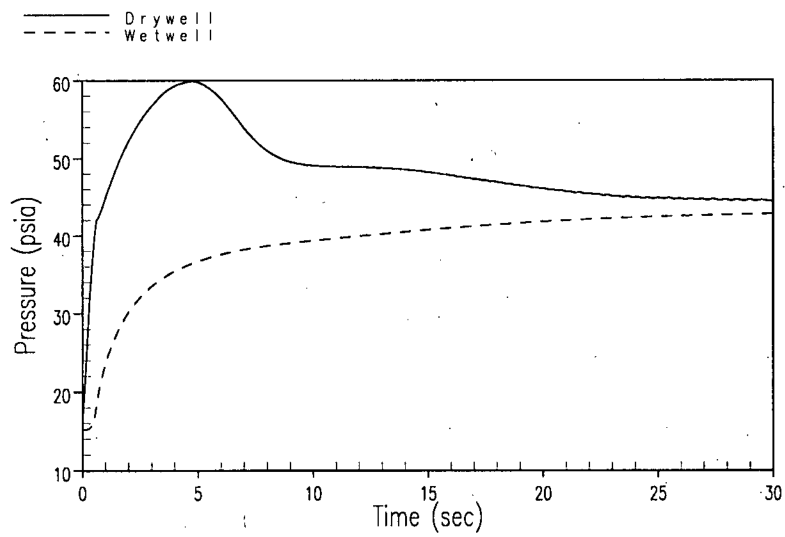

Figure A.4.1-1 RSLB Case 1 Pressure

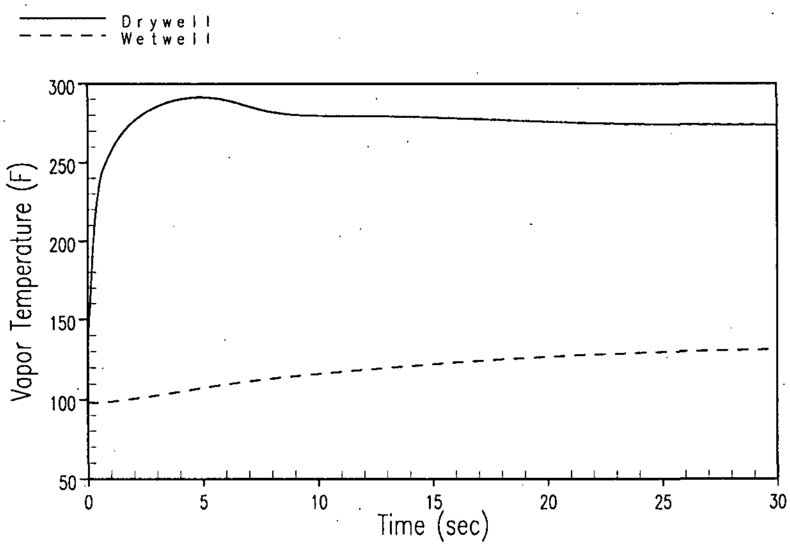

Figure A.4.1-2 RSLB Case 1 Vapor Temperature

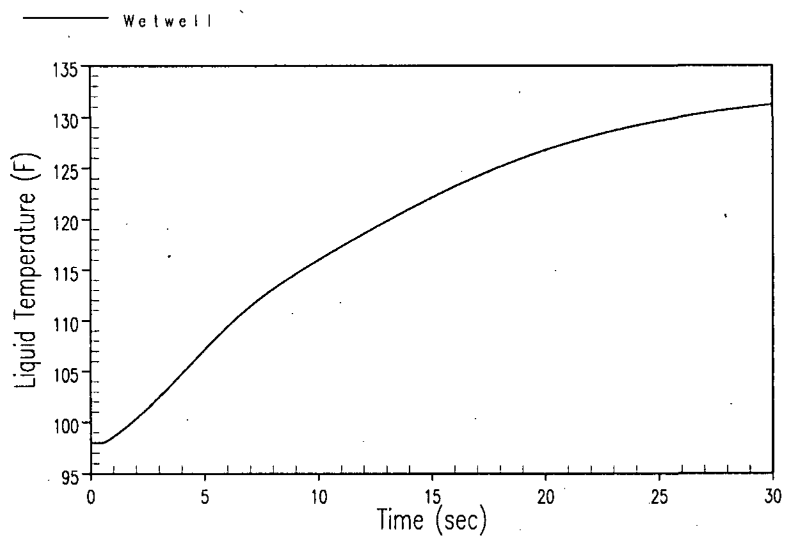

Figure A.4.1-3 RSLB Case 1 Suppression Pool Temperature

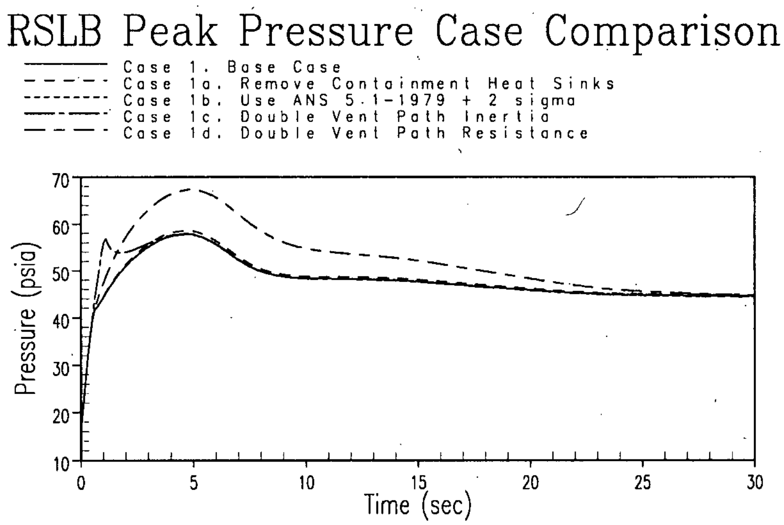

Figure A.4.1-4 RSLB drywell Pressure Sensitivity Case Comparison

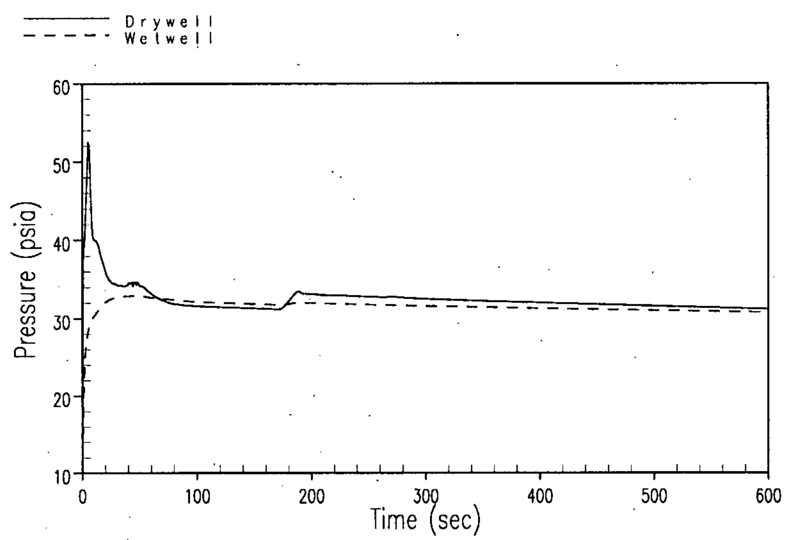

Figure A.4.2-1 RSLB Case 2 Pressure

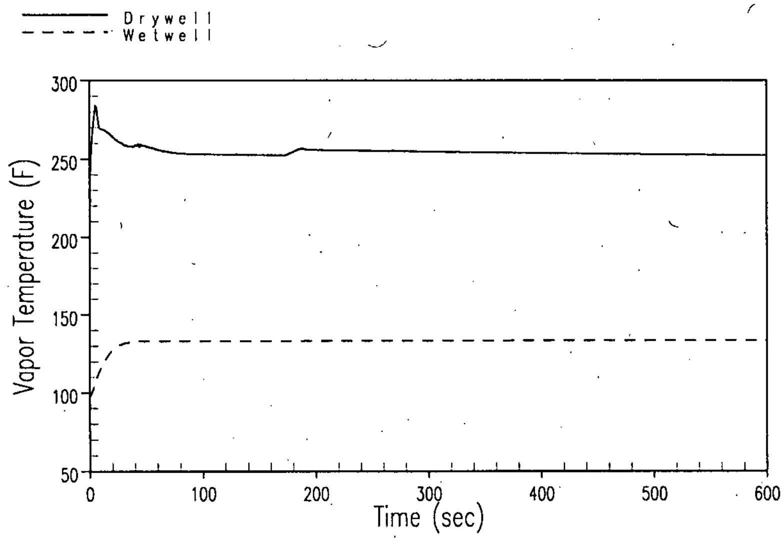

Figure A.4.2-2 RSLB Case 2 Vapor Temperature

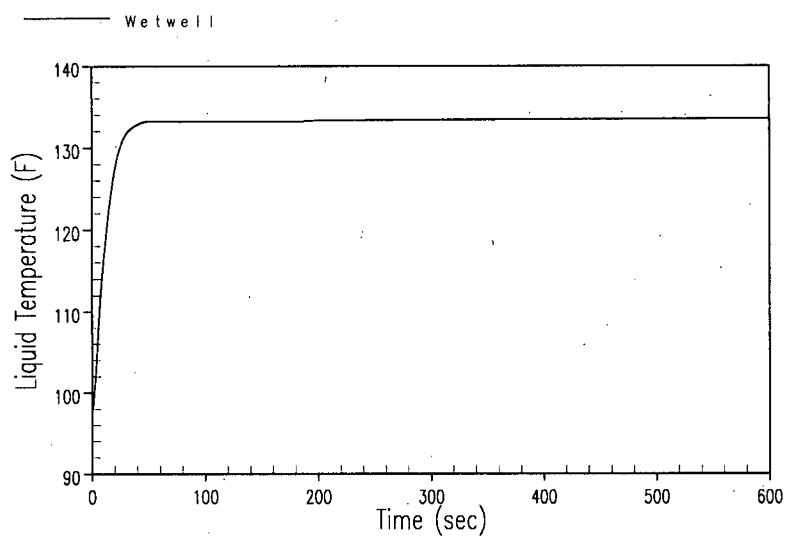

Figure A.4.2-3 RSLB Case 2 Suppression Pool Temperature

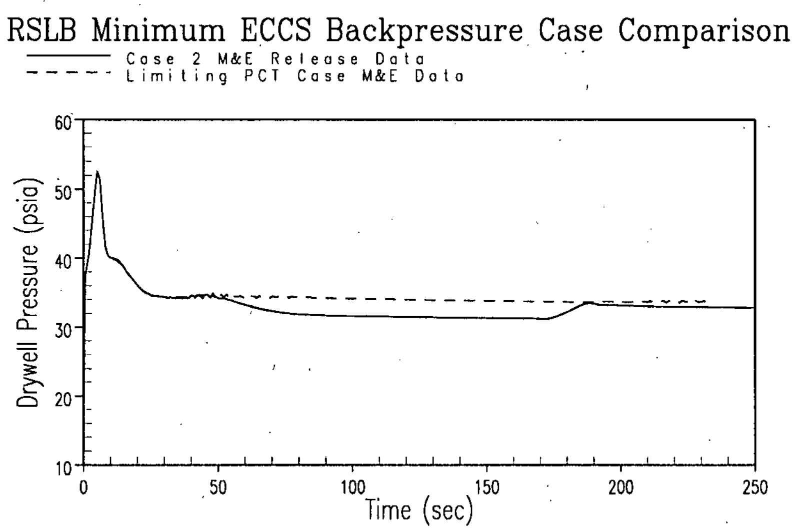

Figure A.4.2-4 RSLB minimum ECCS Backpressure Case Drywell Pressure Comparison

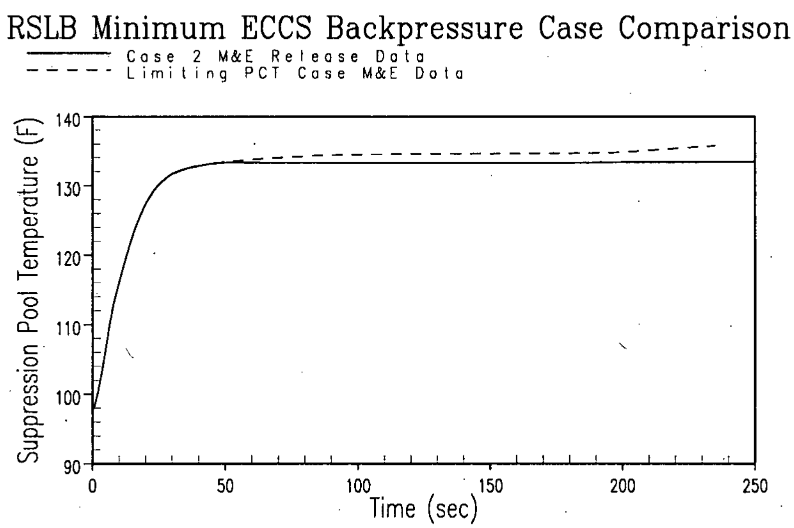

Figure A.4.2-5 RSLB Minimum ECCS Backpressure Case Suppression Pool Temperature Comparison

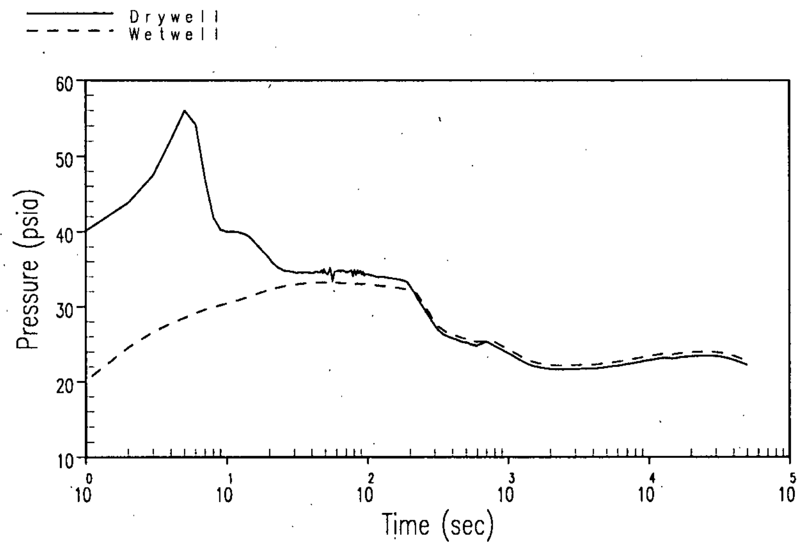

Figure A.4.3-1 RSLB Case 3 Pressure

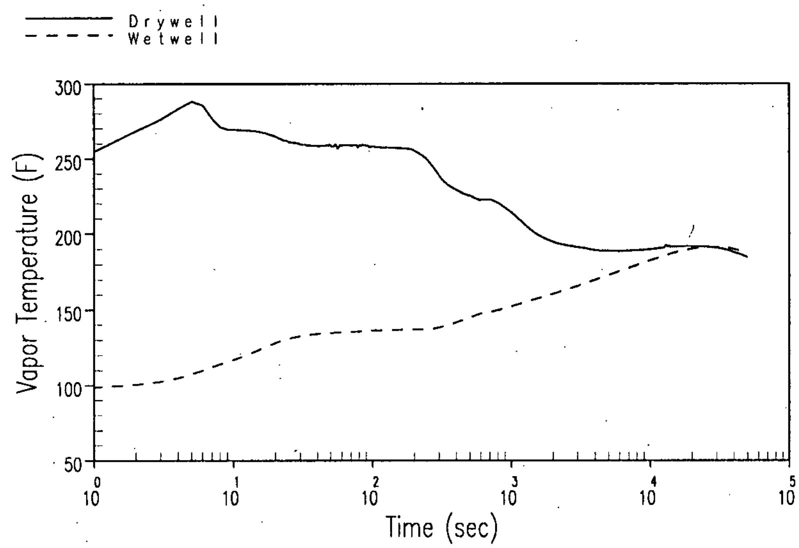

Figure A.4.3-2 RSLB Case 3 Vapor Temperature

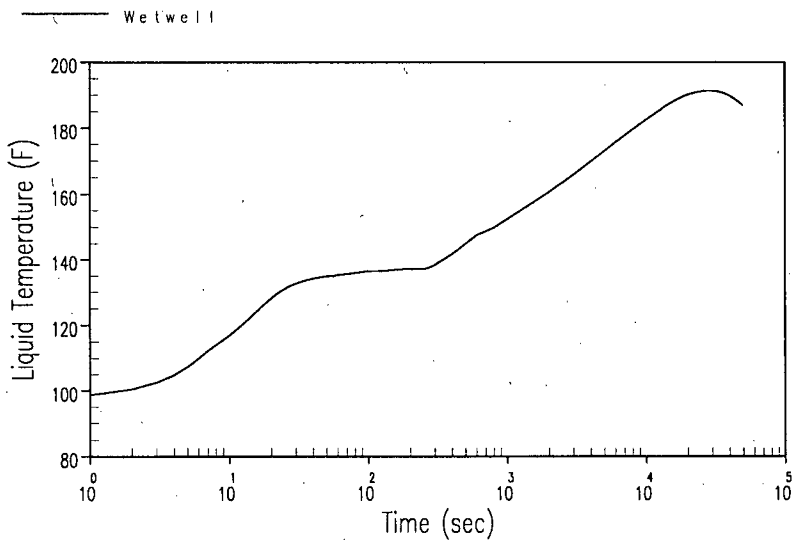

Figure A.4.3-3 RSLB Case 3 Suppression Pool Temperature

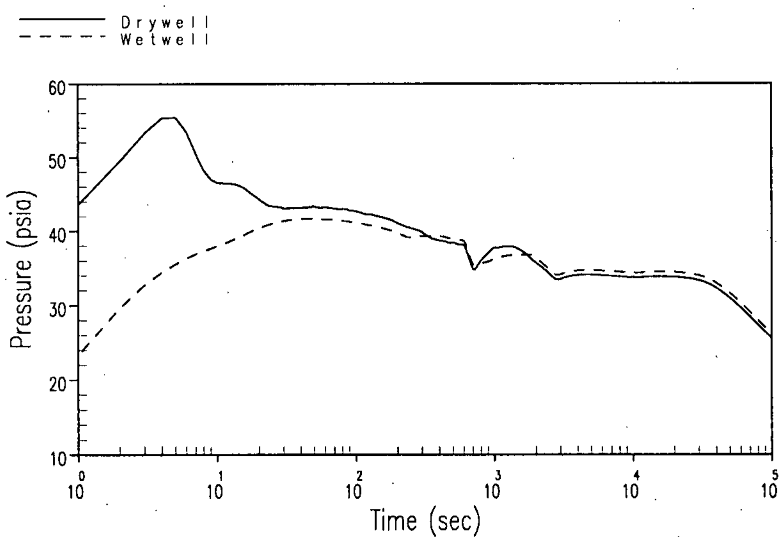

Figure A.4.4-1 RSLB Case 4 Pressure

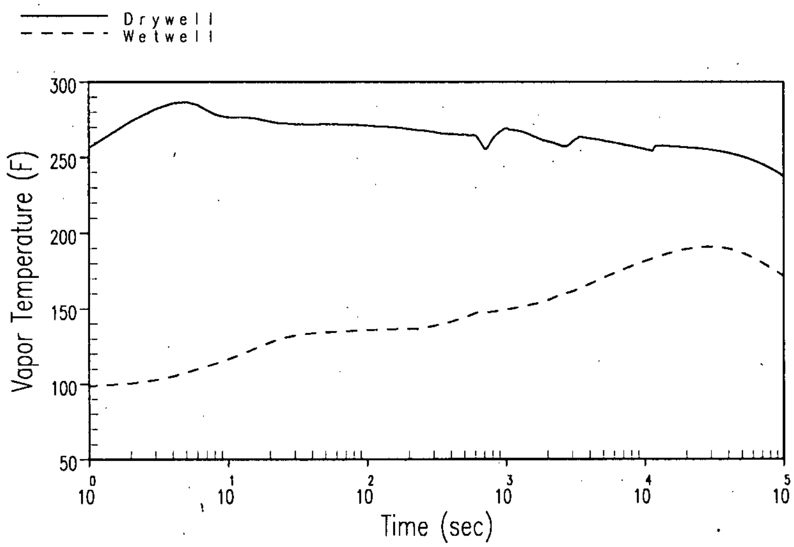

Figure A.4.4-2 RSLB Case 4 Vapor Temperature

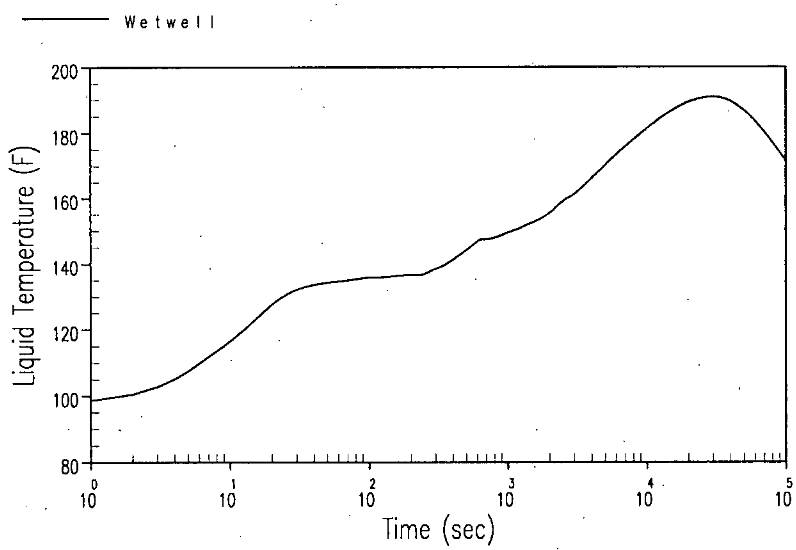

Figure A.4.4-3 RSLB Case 4 Suppression Pool Temperature

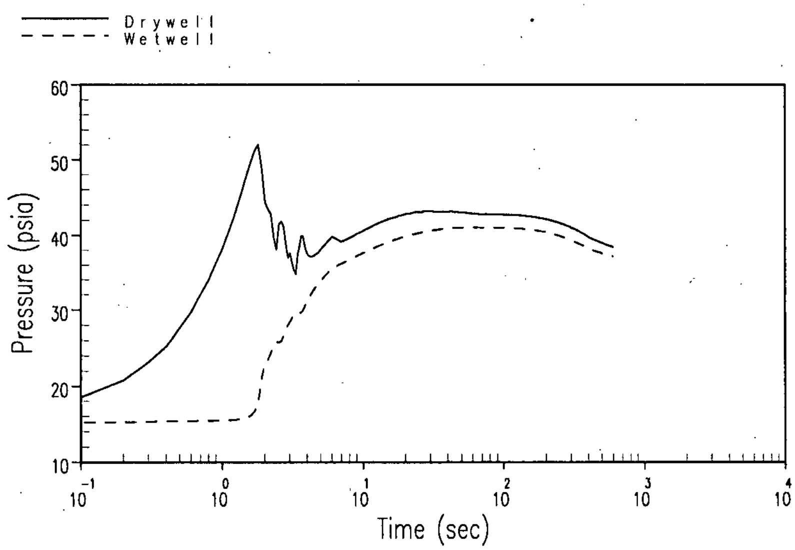

Figure A.4.5-1 MSLB Case 1 Pressure

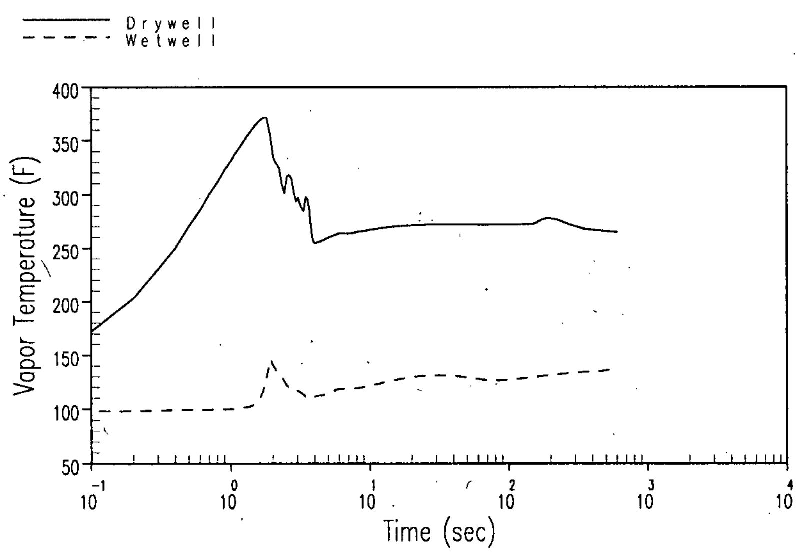

Figure A.4.5-2 MSLB Case 1 Vapor Temperature

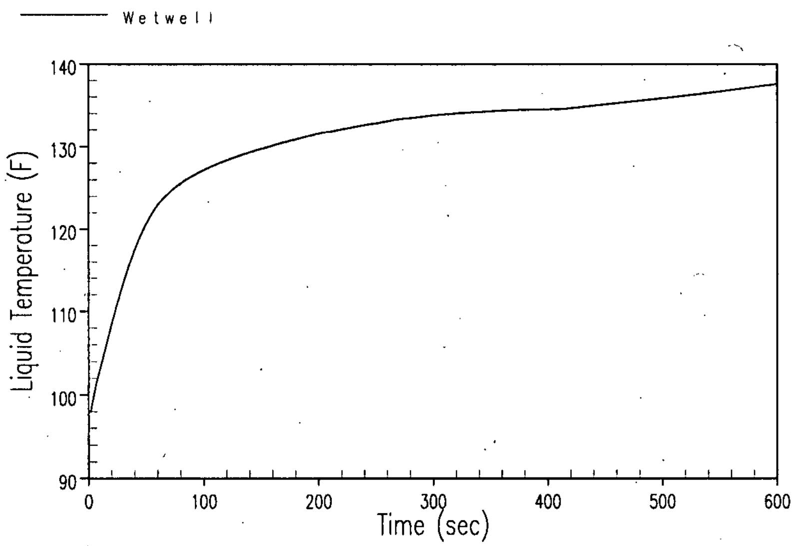

Figure A.4.5-3 MSLB Case 1 Suppression Pool Temperature

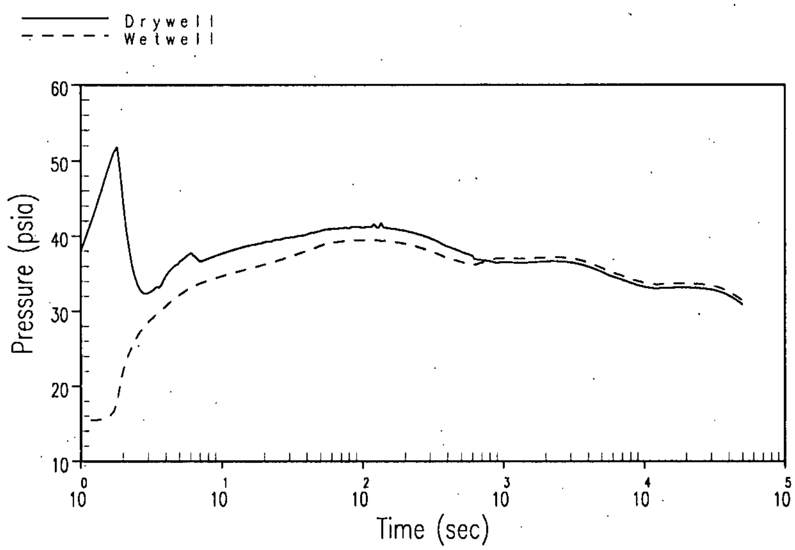

Figure A.4.6-1 MSLB Case 2 Pressure

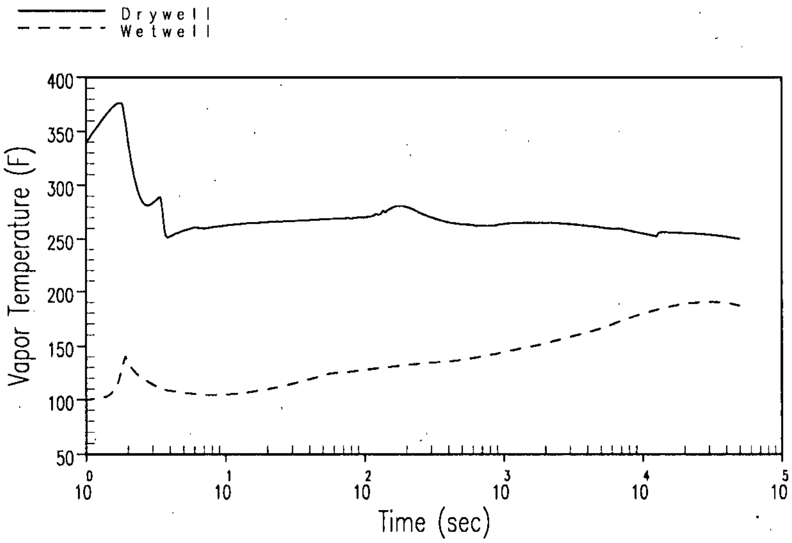

Figure A.4.6-2 MSLB Case 2 Vapor Temperature

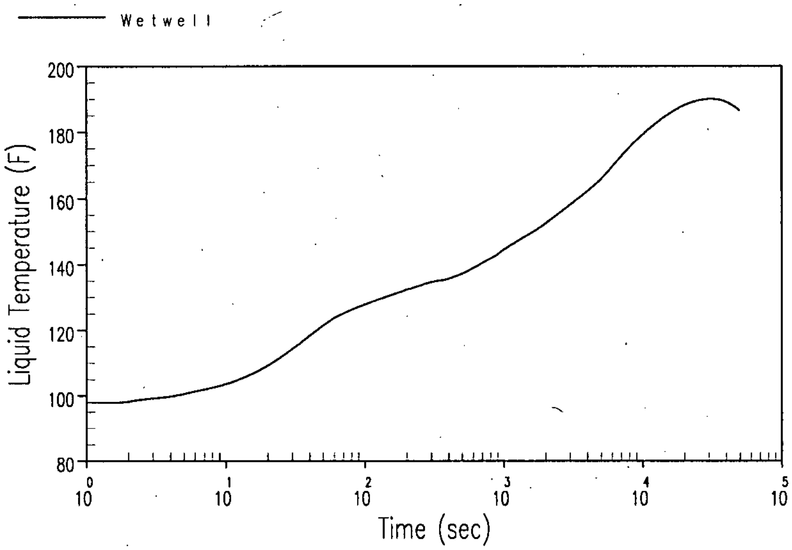

Figure A.4.6-2 MSLB Case 2 Suppression Pool Temperature

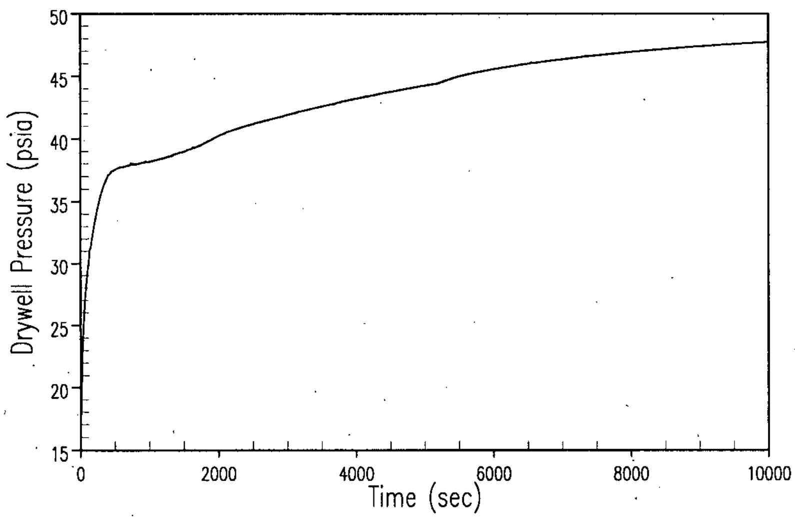

Figure A.4.7-1 SBA Case Drywell Pressure

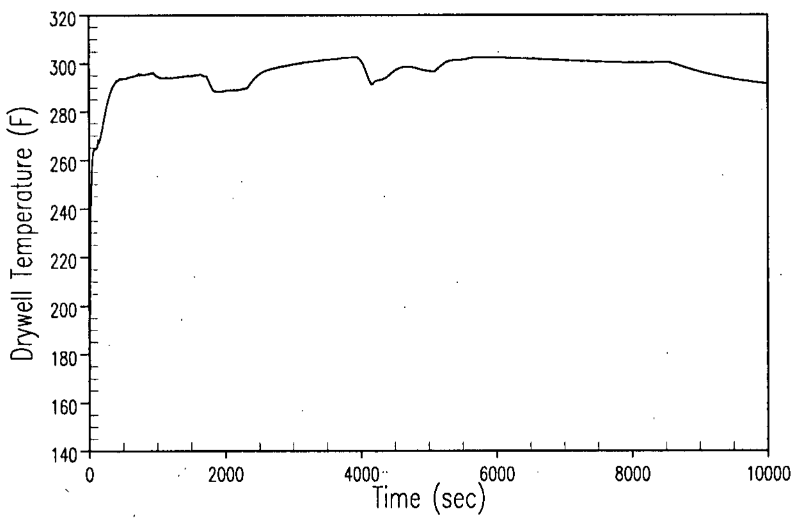

Figure A.4.7-2 SBA Case Drywell Temperature

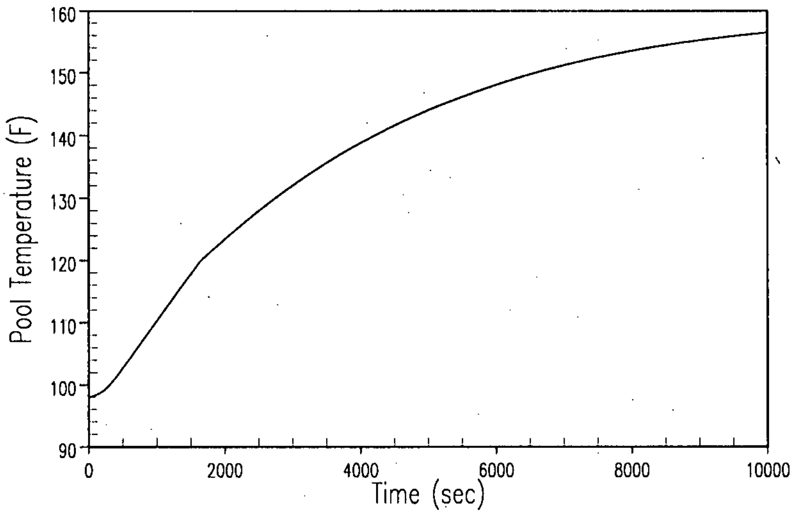

Figure A.4.7-3 SBA Case Suppression Pool Temperature

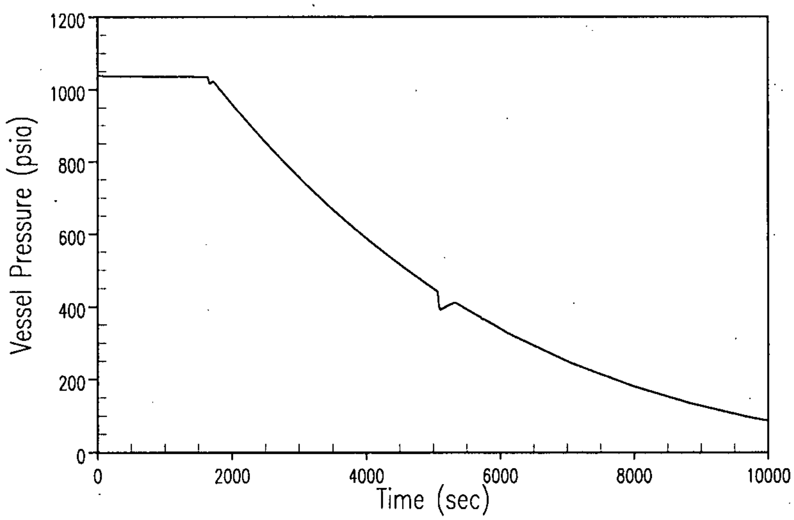

Figure A.4.7-4 SBA Case Vessel Pressure

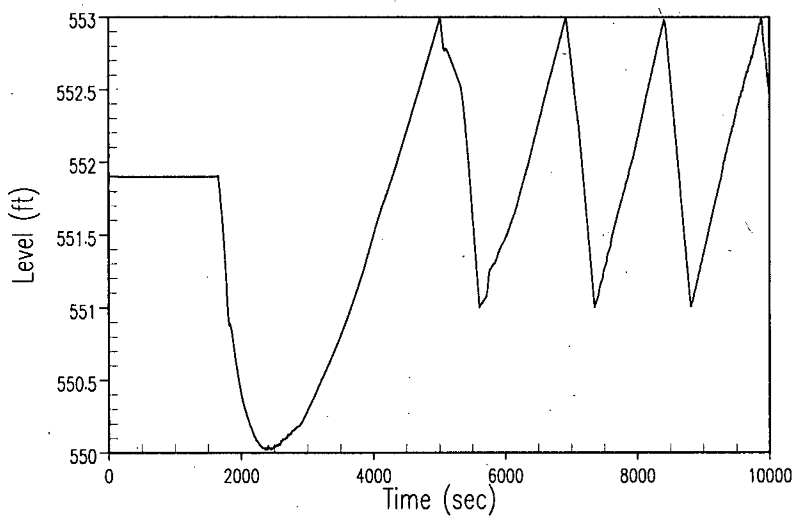

Figure A.4.7-5 SBA Case Vessel Level

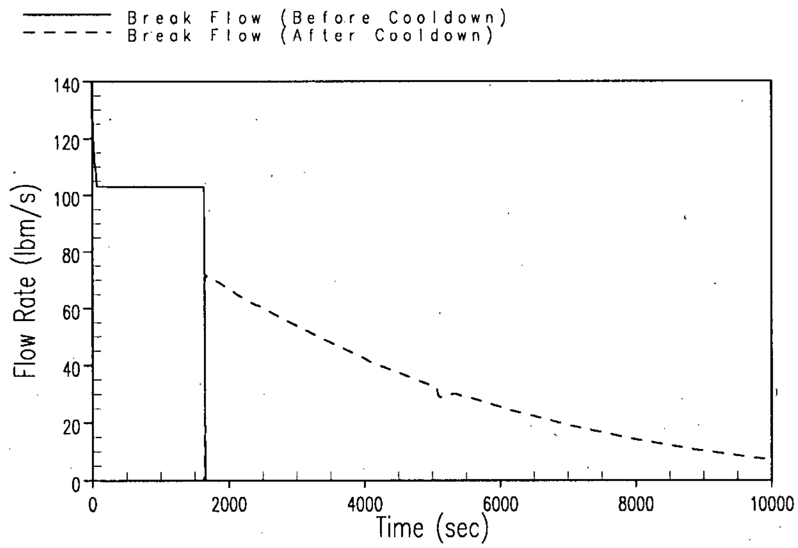

Figure A.4.7-6 SBA Case Break Flow Rate

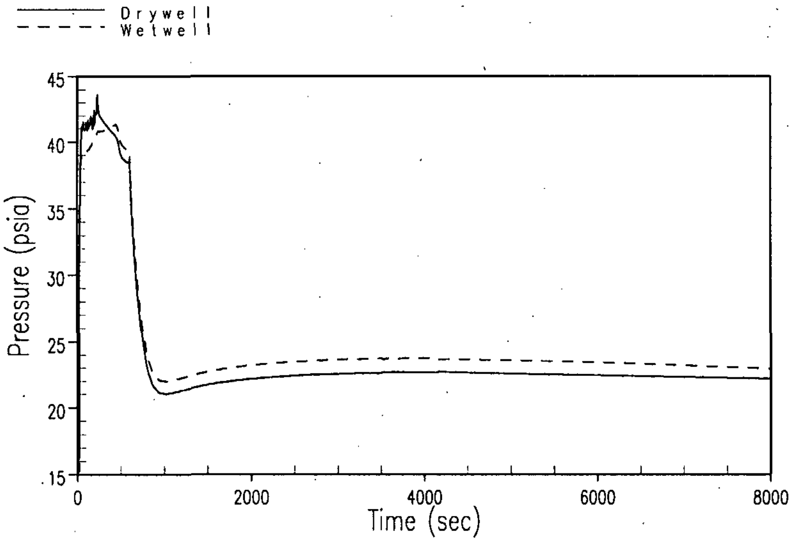

Figure A.4.8-1 ATWS Case Pressure

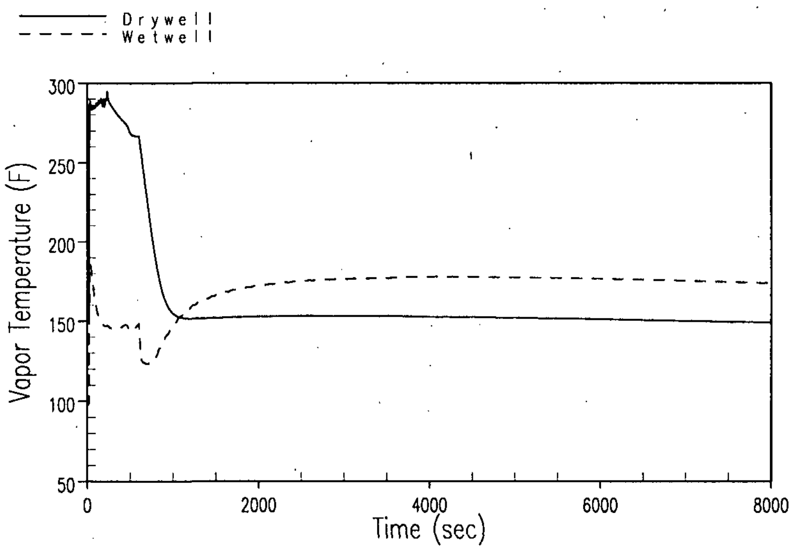

Figure A.4.8-2 ATWS Case Vapor Temperature

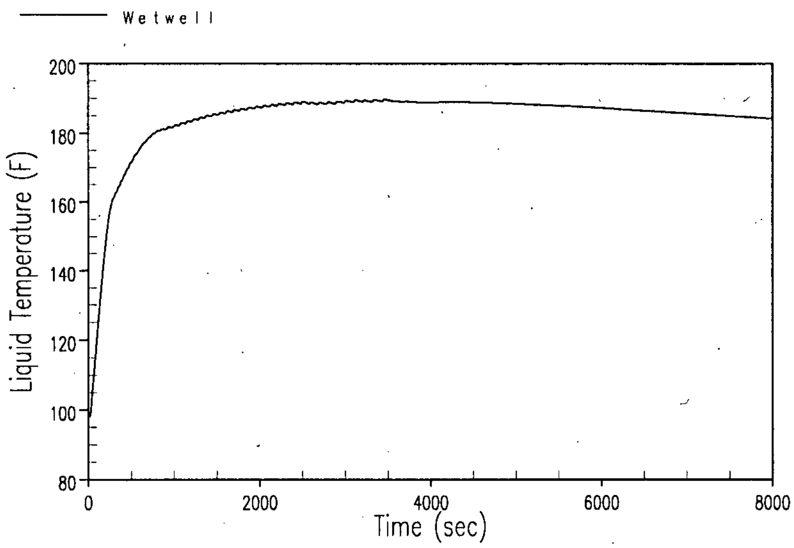

Figure A.4.8-3 ATWS Case Suppression Pool Temperature

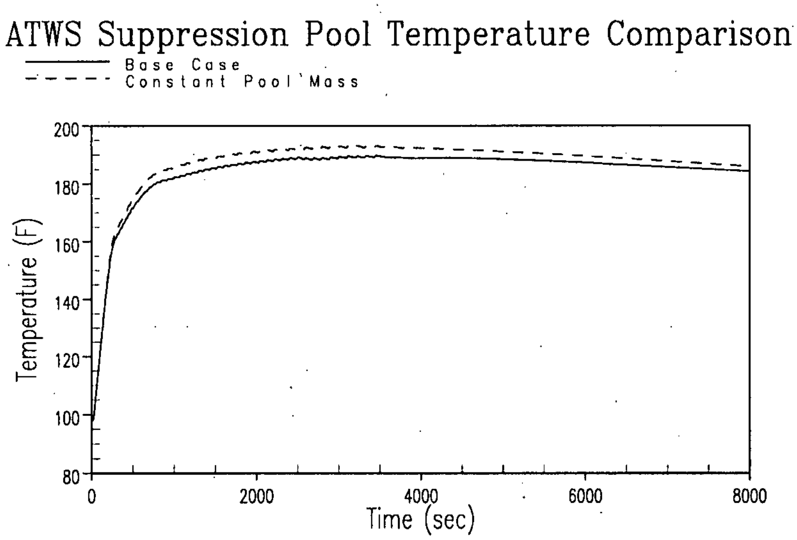

Figure A.4.8-4 ATWS Suppression Pool Temperature Sensitivity

Please also assess the impact of droplet behavior on vent flow for the small and intermediate break accidents.

Response: All of the break flow is released as steam (no liquid drops) in the SBA benchmark and sample cases. Since spray is not initiated in either case, there are no liquid drops in the atmosphere.

All of the break flow is released as liquid drops in the IBA benchmark case. Some of the drops evaporate, some fall to the floor to form a pool, and some pass directly through the vents. Using the standard GOTHIC drop conversion model, the flow through the vent path is approximately
[ ]^{a,c}

The IBA benchmark model was used to perform a drop entrainment sensitivity case by turning off the GOTHIC drop conversion model. With the GOTHIC drop conversion model turned off, the flow through the vent path was approximately **[ ]**^{a,c} *The increase in the vent path drop fraction only had a small impact on the IBA transient response; the peak pressure increased by about* **[ ]**^{a,c} *and the temperature increased by about* **[ ]**^{a,c}

RAI 14. ANS 56.4-1983 guidelines state that flashing should be assumed at the transient atmosphere steam partial pressure. GOTHIC calculates flashing based on the atmosphere total pressure. Since the partial pressure results in a higher steam fraction, shouldn't the recommendations of the ANS standard be used for peak pressure and the GOTHIC approach used for conservative suppression pool temperature?

Response: The liquid break flow is released as small (100 micron) drops during blowdown. The surface area to mass ratio for these drops is very large. As a result, after flashing to the atmospheric total pressure, the drops quickly evaporate to the saturation temperature at the steam partial pressure. This is essentially the same as recommended in the ANS 56.4-1983 guideline.

The description of the Westinghouse Methodology for item 22 in WCAP-16608 Table 2-1 will be revised as shown below to clarify the process:

[

]^{a,c}

The peak suppression pool temperature occurs much later in time than the peak drywell pressure. Therefore, the blowdown drop model does not have any significant impact on the peak suppression pool temperature.

RAI 15. Please provide the information in the table below to reflect the Westinghouse approach to BWR containment analyses. The first row is completed as an example.

a,c

BWR Accident Parameter	Event Interval Analyzed (seconds)	Short-Term Mass and Energy Release Computer Code	Long-Term Mass and Energy Release Computer Code	Decay Heat Model and Uncertainty	Assumed Single Active Failure	Passive heat sinks included	Drywell and Wetwell Spray Credited
Double-ended RSLB Peak Pressure							
Hydrodynamic loads criteria - Double-ended recirculation suction line break (RSLB)							
Hydrodynamic loads criteria - Intermediate (IBA) LOCA							
Hydrodynamic loads criteria - Small (SBA) LOCAs							

BWR Accident Parameter	Event Interval Analyzed (seconds)	Short-Term Mass and Energy Release Computer Code	Long-Term Mass and Energy Release Computer Code	Decay Heat Model and Uncertainty	Assumed Single Active Failure	Passive heat sinks included	Drywell and Wetwell Spray Credited
RSLB Minimum ECCS Back Pressure (All breaks considered to demonstrate compliance with 10 CFR 50.46)							
Minimum NPSHA							
RSB Long Term Pressure and Temperature							
MSLB Peak Pressure							
MSLB Long-Term Pressure and Temper-ature							
ATWS							

a,c

BWR Accident Parameter	Event Interval Analyzed (seconds)	Short-Term Mass and Energy Release Computer Code	Long-Term Mass and Energy Release Computer Code	Decay Heat Model and Uncertainty	Assumed Single Active Failure	Passive heat sinks included	Drywell and Wetwell Spray Credited
Peak Drywell Temperature - Small (SBA) LOCAs							

a,c

RAI 16. WCAP 16608P Section 4.2.1.1 This section states that the DEFAULT option for revaporization will be used. Justify not limiting the revaporization fraction to 8%, according to the guidelines of NUREG 0588. If possible to determine, what revaporization fractions are typical for BWR Mark I calculations?

Response: Revaporization is important in a super-heated steam environment because it can help reduce the vapor temperature to saturation. The revaporization rate should decrease as the steam becomes less superheated. The GOTHIC code interface heat and mass transfer correlations are normally used to calculate the revaporization rate.

The results of a GOTHIC revaporization sensitivity case were provided in a previous RAI response[4]. The GOTHIC interface heat and mass transfer correlations resulted in MSLB peak pressure and temperature values that were very close to those calculated using the 8% revaporization limit specified in NUREG 0588.

RAI 17. WCAP 16608P Section 4.2.1.2 For which calculations discussed in WCAP 16608P is the mist model used? For these cases, provide a sensitivity to show the calculated effect of the mist model on BWR containment peak pressure and peak temperature. What is the basis for the 200 micron drop size? How sensitive are BWR conditions to the default assumption of a 200 micron mist droplet size.

Response: The mist model is turned on by default for all of the calculations to allow the code to produce small water drops in the atmosphere if super-saturated conditions should arise. Neither the peak drywell pressure (calculated for the RSLB LOCA event) nor the peak drywell temperature (calculated for the SBA event) was significantly affected by turning off the mist model. The peak drywell pressure did not change at all and the peak drywell temperature increased by about 2 F when the mist model was turned off.

The 200 micron drop size is based on numerical experiments conducted by NAI, as stated in Section 8.8.9 of the GOTHIC Technical Manual. Mist drop diameter sensitivity cases were made using the RSLB peak pressure case. There was no change in the calculated peak pressure when the mist drop diameter was increased or decreased by an order of magnitude. Therefore, the BWR conditions are not sensitive to the default assumption of a 200 micron mist droplet size.

RAI 18. Section 4.2.2 states that: [

]^{a,c} This contradicts the approach of a BWR licensee who assumes [ ]^{a,c} Please perform a sensitivity calculation to verify that [ ]^{a,c} is the conservative approach for peak containment pressure. Should this be determined on a plant specific basis?

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3 Letter from William D. Crouch, TVA, to USNRC, Browns Ferry Nuclear Plant (BFN) - Units 1, 2 and 3 - Technical Specifications (TS) Changes TS-431 and TS 418 - Extended Power Uprate (EPU) - Response to Round 6 Request for Additional information July 21, 2006 RAI ACVB 38/36 (ADAMS ML0620900710)

4 Letter from Thomas Coutu, Kewaunee to USNRC, Kewaunee Nuclear Power Plant, Docket 50-305, License No. DPR-43, Response to Request for Additional Information Related to NMC Request for the use of GOTHIC 7 for the Kewaunee Nuclear Power Plant Containment Design Basis Accident Analyses July 24, 2003 (ADAMS ML032170646)

Response: [

]a,c

A sensitivity case was run using the GOTHIC BWR Mark I containment. [

]a,c

The direction of conservatism should be determined on a plant specific basis if the plant specific [ ]a,c *varies with component instead of uniformly.* [

]a,c

A sensitivity case was run using the GOTHIC BWR Mark I containment model to determine the impact of [
]a,c *The calculated drywell peak pressure for this case was* [
]a,c

Table A.2.9-1 was revised as shown below [
]a,c

Table A.2.9-1 Containment Model Input and Initial Conditions Biasing

	Peak DW Pressure	ECCS Min Backpressure	Peak SP Temperature	Minimum NPSHa	Peak DW Temperature
DW Free Volume					
WW Free Volume					
Heat Sink Area					
HTX Multiplier					
DW Pressure					
DW Temperature					
DW Humidity					
WW Pressure					
WW Temperature					
SP Temperature					
WW Water Volume					

a,c

RAI 19. <u>Appendix A Section A.4.3</u> (a) Describe how feedwater is modeled in the BWR applications described in WCAP 16608P.

Response: The GOBLIN M&E model is used to calculate the mass and energy releases for the RSLB, MSLB, and IBA events. The GOBLIN M&E model is based on the GOBLIN ECCS evaluation model. The GOBLIN ECCS evaluation model assumes the feedwater flow rate coasts down over a period of time. The GOBLIN ECCS application models the flow from, **[**

]a,c *the feedwater train. The GOBLIN M&E model includes the feedwater train* **[**

]a,c

In a plant specific analysis, **[**

]a,c

The GOTHIC vessel model is used to calculate the mass and energy releases for the SBA event. Since the plant was assumed to remain at full power in the sample case (see Section A.4.7), the full feedwater flow and enthalpy were modeled until the reactor was manually tripped. A simple vessel level control system was used to adjust makeup flow during the cooldown to maintain the vessel level between 551 and 553 ft for the remainder of the transient.

The BISON code is used to calculate the mass and energy releases for the ATWS event. The BISON feedwater model uses **[**

]a,c

(b) What assurance is there that the feedwater model added to GOBLIN models the feedwater system correctly and conservatively?

Response: The GOBLIN ECCS evaluation model only models **[**
]a,c *The GOBLIN M&E model also models* **[**
]a,c*. This revision to the ECCS model adds the feedwater line mass and energy to the blowdown and post-blowdown vessel mass and energy release to containment. The model was qualified by comparing the calculated suppression pool temperature transient response to the results from another approved methodology.*

RAI 20. <u>Appendix A Section A.4.3</u> In considering NPSHa for the ECCS pumps during BWR Mark I postulated events, it is also important to consider events other than the LOCA, including a stuck open relief valve, and non-design basis events such as Appendix R fire, anticipated transients without scram (ATWS) and station blackout (i.e., ability to cool the suppression pool following restoration of AC power). These events may either be discussed in this topical report review or the staff will request information on the calculation of these events for each plant-specific application which includes consideration of ECCS pump net positive suction head. Such information as that listed below should be discussed and all licensing analyses referencing WCAP 16608P should then be consistent with these descriptions:

+assumed initial power level

+assumed initial pressures, temperatures and relative humidities in the drywell and wetwell
+decay heat model (with or without 2σ uncertainty)
+pump configuration and flow rates assumed
+credit for non-safety systems
+use of drywell and wetwell sprays
+suppression pool level
+initial pressures, temperatures and relative humidity values for drywell and wetwell
+passive heat sinks

Response: Currently, the ECCS pump NPSHa is expected to be calculated outside of GOTHIC using the code calculated transient containment pressure, suppression pool temperature, and suppression pool level, along with the line resistance and variable pump flow rate as inputs. The assumptions made, and biases used, in the containment analysis for the minimum NPSHa application will minimize the calculated wetwell pressure, maximize the calculated suppression pool temperature, and minimize the calculated suppression pool level. The containment response calculations that generate the input for the NPSHa calculations for each event listed above will include the following input biases and/or assumptions:

1. [
2.
3.
4.
5.
6.
7.
8.
9.
10.

]a,c

This Section of the report will be updated to include this information.

RAI 21. The limiting NPSH margin for a Mark I BWR may occur during the short-term period following the initiation of a LOCA (that is, the first ten minutes prior to operator action) or the long-term period (after10 minutes when the operator can reduce the RHR and core spray pump flow rates and activate sprays). WCAP 16608P did not separately address the analysis of available NPSH for the short-term period. Are there any differences between the containment analyses for available NPSH between the short term and long term periods in terms of assumptions and modeling?

Response: There are no differences in the containment analysis model or assumptions between the short-term and long-term periods for calculating the pump NPSHa.

RAI 22. Appendix A Section A.4.3 Although a loss of one train of emergency AC power (following an assumed loss of offsite power) was assumed as the worst single failure for the example, this may not always be the worst single failure. The worst single failure should be assessed for each plant to which this methodology is applied.

Response: Westinghouse agrees; the worst single failure should be assessed on a plant specific basis. The worst single failure for calculating the containment response input for the NPSHa calculation could instead be the loss of an RHR heat exchanger since this would reduce the suppression pool cooling without affecting the number of running ECCS pumps. This Section of the report will be updated to include this information.

RAI 23. Section A.4.3 (Item 6) Explain why **[**

]^{a,c} is conservative for available NPSH calculations.

Response: This assumption is recommended in the guidance for containment modeling given in ANS 56.34-1983 (item 19). Interface heat and mass transfer via steam condensation and cooling of the wetwell atmosphere decreases the wetwell pressure and increases the suppression pool water temperature. This conservatively reduces the available NPSHa.

RAI 24. Section A.4.3 Containment leakage should be included in available NPSH calculations which credit containment accident pressure.

Response: Westinghouse agrees; containment leakage should be included in the plant specific containment response calculation for input to the NPSHa calculation. This wasn't included in the sample case because this information was not available. **[**

]^{a,c}

RAI 25. Section A.4.3 (Item 8) It is the staff's position to request that available NPSH calculations be carried out until credit for containment accident pressure is no longer needed. This time period could be greater than 50,000 seconds.

Response: Westinghouse agrees; the sample case was run for 50000 seconds but the plant specific calculation could be run for a longer period if necessary. The plant specific calculation will be carried out until credit for containment accident pressure is no longer needed.

RAI 26. <u>Section A.4.3 Figure A.4.3-1</u> Explain the initial decrease in drywell pressure during blowdown.

Response: The initial pressure peak was due to inertia just prior to vent clearing, and the second peak was due to the vent path resistance. The inertia peak disappeared after the model input changes described in the response to RAI 13 were made. The revised figures for WCAP-16608 are attached – see RAI 13.

RAI 27. [

$]^{a,c}$ Justify their use for the DLM model.

Response: A conservative upper bound for heat and mass transfer is used in the minimum backpressure and NPSHa calculations. [

$]^{a,c}$ *Comparisons with test data (see Figure 5-41 in the GOTHIC Qualification Report) have shown the DLM correlation to be within approximately 20% of the measured value under both free and forced convection conditions.* [

$]^{a,c}$

RAI 28. Verify that for minimum backpressure and available NPSH calculations, non-safety equipment which cools the containment will be included in the calculations.

Response: This wasn't included in the sample cases because this information was not available; however, if this equipment is expected to be running, it will be included in the minimum backpressure and NPSHa calculations.

RAI 29. <u>Appendix A Figure A.4.4-1</u> At times greater than $2X10^3$ seconds, the wetwell pressure appears to be slightly greater than the drywell pressure. Please explain.

Response: The drywell gas pressure should be about the same as the wetwell gas pressure later in the event. The pressure, as calculated by GOTHIC, includes the head of water above the vertical center of the control volume. This explains why the wetwell pressure appears to be slightly higher than the drywell pressure.

RAI 30. <u>Appendix A Section A.4.1</u> In Table 2.9-1, please provide the bias assumed in each analysis (peak DW pressure, ECCS minimum backpressure, etc.) for wetwell humidity. Why is this conservative? How important is the wetwell humidity for each analysis?

Response: The humidity of the air in the wetwell is assumed to be 100% for each application. This is because it would not be possible to have a very low humidity in the wetwell, which is in constant contact with the suppression pool. [

$]^{a,c}$

RAI 31. Section A.4.2 states that the [
]a,c Is the same method used for the available NPSH calculations?

Response: Yes. Thermal equilibrium between the liquid and vapor phases is also maintained [ ]a,c *for the NPSHa calculations.*

RAI 32. Section A.4.8 How does GOTHIC calculate core power after BISON? Is it just decay heat?

Response: BISON calculates the ATWS mass and energy release input through the time of peak suppression pool temperature. After the end of BISON, the decay heat power is calculated by GOTHIC using the ANS 5.1-1979 decay heat standard (+ 2 sigma uncertainty) assuming the reactor trip occurred at event initiation.

RAI 33. Please provide Reference A-10.

Response: Westinghouse has obtained permission from Exelon for the use of reference A-10, Commonwealth Edison Company Calculation No. 3C2-0978-001, "Containment Temperature Response to 0.05 Sq. Ft. Steam line Break," December 1978. A copy of this reference will be made available to the NRC for review.

RAI 34. For the cases described in Table B-3, please provide the calculated containment parameters of drywell and wetwell pressure and temperature and suppression pool temperature, if available.

Response:

The LOCA M&E from Case 1 was used in Section A.4.1 Case 1
The LOCA M&E from Case 1b was used in Section A.4.1 Case1b
The LOCA M&E from Case 2 was used in Section A.4.2 Case 2
The LOCA M&E from Case 2a was used in Section A.4.2 RSLB Minimum ECCS Backpressure
The LOCA M&E from Case 3 was used in Section A.4.3 Case 3 and Section A.4.3 Case 4
The MSLB M&E from Case 4 was not used in a containment model sample case, so the requested containment output parameters are not available.
The MSLB M&E from Case 5 was used in Section A.4.5 Case 1 and Section A.4.6 Case 2

RAI 35. Section B.3 lists several assumptions made to minimize the mass and energy release for the minimum containment pressure calculations. (a) Please indicate the significance of these assumptions on containment pressure.

Response: The GOTHIC calculated drywell pressure from the minimum ECCS backpressure case serves as an upper bound for the containment backpressure input to the ECCS evaluation model. Biasing the GOBLIN ECCS evaluation model input values to reduce the calculated LOCA M&E releases will yield a slightly lower GOTHIC calculated containment backpressure. A comparison of the containment pressure response with biased M&E input vs. the M&E input from the limiting PCT calculation is shown in Figure A.4.2-4 attached to RAI 13. Biasing the M&E input does not have a significant impact on the containment pressure response.

(b) Why couldn't other assumptions be included such as critical flow correlation less conservative than Moody, assuming 100% power rather than 102% power, a nominal decay heat, etc.

Response: Section B.3 in WCAP-16608 will be updated to include two additional changes to the GOBLIN ECCS evaluation model input to minimize the mass and energy release for the GOTHIC minimum ECCS backpressure calculation:

1. [
2.

]a,c

The minimum ECCS backpressure input bias changes were made to the GOBLIN ECCS model to calculate new M&E release input for the GOTHIC minimum ECCS backpressure calculation. In addition, the GOTHIC minimum ECCS backpressure model was revised to address the vent path input changes described in RAI 13. As a result of these changes, Figures A.4.2-1 through A.4.2-5 from WCAP-16608 will be replaced with the figures shown in RAI 13.

RAI 36. Westinghouse states (Table B-1 of Appendix B) that the licensed core power plus uncertainty is used as input to the BWR mass and energy release model. Please verify that this will be a 2% uncertainty as specified by NRC Regulatory Guide 1.49 unless the licensee has justified a smaller uncertainty based on more accurate feedwater flow measurements.

Response: Table B-1 will be updated to state that a 2% core power uncertainty will be used for the BWR mass and energy release calculations unless a lower uncertainty value has been justified by the licensee.