10 CFR 50.90

Progress Energy

Serial: RNP-RA/06-0048

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United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23

REQUEST FOR TECHNICAL SPECIFICATIONS
CHANGE RELATED TO CONTAINMENT PEAK PRESSURE

Ladies and Gentlemen:

In accordance with the provisions of the Code of Federal Regulations, Title 10, Part 50.90, Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. (PEC), is submitting a request for an amendment to the Technical Specifications (TS) contained in Appendix A of the Operating License for H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2.

The proposed change is required as a result of a revised Loss of Coolant Accident (LOCA) containment pressure analysis. The revised analysis calculated a peak containment pressure following a LOCA (designated as P_a in the TS) of 41.49 psig, which is greater than the current TS value for P_a of 40.5 psig. Therefore, the value for P_a, as well as other values based on a multiple of P_a in the TS, need to be revised. The proposed change will define P_a as the containment design pressure of 42 psig, which is conservative compared to the revised post-LOCA peak pressure of 41.49 psig.

NRC review and approval is requested for both the proposed TS change and the revised post-LOCA containment analysis. The revised analysis will be incorporated into the Updated Final Safety Analysis Report as the revised licensing basis. Corresponding changes will also be made to the Technical Specifications Bases in accordance with the Bases Control Program.

Attachment I provides an Affirmation as required by 10 CFR 50.30(b).

Attachment II provides a description of the current condition and proposed change, justification for the proposed change, a No Significant Hazards Consideration Determination, and an Environmental Impact Consideration.

Progress Energy Carolinas, Inc.
Robinson Nuclear Plant
3581 West Entrance Road
Hartsville, SC 29550

A017

Attachment III provides a markup of the affected TS pages.

Attachment IV provides a retyped version of the affected TS pages.

Attachment V provides the Westinghouse report of the revised containment analysis.

In accordance with 10 CFR 50.91(b), a copy of this license amendment request is being provided to the State of South Carolina.

Nuclear Regulatory Commission approval of the proposed license amendment by March 9, 2007, is requested, based on the desire to revise the containment leak rate testing procedures prior to the upcoming Refueling Outage 24, which is currently scheduled to start on April 7, 2007.

If you have any questions concerning this matter, please contact Mr. C. T. Baucom at (843) 857-1253.

Sincerely,

J. F. Lucas
Manager – Support Services – Nuclear

Attachments:

I. Affirmation
II. Request for Technical Specifications Change Related to Containment Peak Pressure
III. Markup of Technical Specifications Pages
IV. Retyped Technical Specifications Pages
V. Westinghouse Licensing Report for H. B. Robinson Steam Electric Plant, Unit No. 2, Containment Analysis

RAC/rac

c: Mr. T. P. O'Kelley, Director, Bureau of Radiological Health (SC)
Mr. H. J. Porter, Director, Division of Radioactive Waste Management (SC)
Dr. W. D. Travers, NRC, Region II
Mr. C. P. Patel, NRC, NRR
NRC Resident Inspector, HBRSEP
Attorney General (SC)

AFFIRMATION

The information contained in letter RNP-RA/06-0048 is true and correct to the best of my information, knowledge, and belief; and the sources of my information are officers, employees, contractors, and agents of Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc. I declare under penalty of perjury that the foregoing is true and correct.

Executed On: 7/17/2006

T. D. Walt
Vice President, HBRSEP, Unit No. 2

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

REQUEST FOR TECHNICAL SPECIFICATIONS CHANGE RELATED TO CONTAINMENT PEAK PRESSURE

Description of Current Condition and Proposed Change

The current Technical Specifications (TS) include requirements based on the calculated peak containment internal pressure following a design basis Loss of Coolant Accident (LOCA). This value is designated as P_a and is currently specified as 40.5 psig. Revised containment analyses by Westinghouse for H. B. Robinson Steam Electric Plant, Unit No. 2, have resulted in an increase in the calculated peak containment pressure following a LOCA to 41.49 psig. In lieu of using the specifically calculated pressure of 41.49 psig, the value for P_a is being changed to the containment design pressure of 42 psig, which is slightly greater than the calculated peak containment pressure following a LOCA or a Main Steam Line Break (MSLB).

The TS Sections impacted are:

1. TS Section 3.6.8, "Isolation Valve Seal Water System"

   Surveillance Requirements 3.6.8.1 and 3.6.8.5 contain pressure requirements specified as 44.6 psig. This value is based on 1.1 times the existing P_a of 40.5 psig. Since P_a is being revised to 42 psig, the values in the two surveillance requirements are being increased to 46.2 psig.

2. TS Section 5.5.16, "Containment Leakage Rate Testing Program"

   This section defines P_a as the peak calculated containment internal pressure for the design basis loss of coolant accident and specifies a value of 40.5 psig. It is being revised to specify P_a as the containment design pressure of 42 psig.

Justification for the Proposed Change

The proposed change is necessary based on a revision to the post-LOCA containment analysis. Westinghouse has reanalyzed the containment analysis due to some non-conservatisms discovered in the current analysis. These non-conservatisms only impacted the LOCA analysis and not the MSLB analysis. The revised analysis increases the peak post-LOCA containment pressure from 40.5 psig to 41.49 psig. A copy of the Westinghouse report of the revised analysis is provided as Attachment V.

The TS sections listed above need to be corrected based on the revised analysis. Rather than replace the value of 40.5 psig with the new value of 41.5 psig, P_a is being conservatively defined as equal to the containment design pressure of 42 psig.

The revised analysis does not require changes to the existing surveillance procedure test pressures. Current surveillances of containment leakage (both integrated leakage rate testing and local leakage

rate testing) have been performed at pressures in excess of 42 psig. Current surveillances of the Isolation Valve Seal Water System have been performed at pressures in excess of 46.2 psig. Therefore, the current plant procedures and current plant conditions are consistent with the proposed change. The proposed change will ensure the TS are consistent with a more conservative analysis.

No Significant Hazards Consideration Determination

Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc., is proposing a change to Appendix A, Technical Specifications, of Facility Operating License No. DPR-23, for the H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2. The proposed change revises the definition and specified value for the peak containment pressure (P_a) calculated to occur following a design basis Loss of Coolant Accident (LOCA) as described in Technical Specifications Section 5.5.16, "Containment Leakage Rate Testing Program." Additionally, the specified pressure values for surveillance requirements in Technical Specifications Section 3.6.8, "Isolation Valve Seal Water System," are revised to a value equal to 1.1 times the revised P_a. The proposed change will also revise the licensing basis analysis for the post-LOCA containment pressure and temperature for HBRSEP, Unit No. 2.

An evaluation of the proposed change has been performed in accordance with 10 CFR 50.91(a)(1) regarding no significant hazards considerations using the standards in 10 CFR 50.92(c). A discussion of these standards as they relate to this amendment request follows:

1. Do the Proposed Changes Involve a Significant Increase in the Probability or Consequences of an Accident Previously Evaluated?

   No. The proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated. The revised post-LOCA containment pressure and temperature analysis used more conservative assumptions and the increase in the calculated peak pressure was approximately 1 psig. The revised value of 41.49 psig remains less than the containment design pressure of 42 psig. The increase in the calculated peak temperature was approximately 2°F, which was analyzed to have no impact on structures or equipment. Although there is an increase in the calculated pressure, the allowable containment leakage rate, as measured at the peak pressure, is not being changed. Since there is no increase in the allowable leakage, there is no increase in consequences. The proposed change is related to containment pressure analysis. There are no physical changes being made to the plant, or to the manner in which the plant is operated. Surveillance procedures for containment leakage have been conservatively testing at pressures in excess of 42 psig and surveillance procedures for the Isolation Valve Seal Water System have been conservatively testing at pressures in excess of 46.2 psig. The change can have no impact on the probability of an accident occurring. Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Do the Proposed Changes Create the Possibility of a New or Different Kind of Accident From Any Previously Evaluated?

   No. The proposed change does not create the possibility of a new or different kind of accident from any previously evaluated. There are no physical changes being made to the plant or to the manner in which the plant is operated. Surveillance procedures for containment leakage have been conservatively testing at pressures in excess of 42 psig and surveillance procedures for the Isolation Valve Seal Water System have been conservatively testing at pressures in excess of 46.2 psig. The revised containment analysis results in a calculated peak containment pressure that remains less than the containment design pressure. The increase in the calculated peak temperature was analyzed to have no impact on structures or equipment. Therefore, this change does not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Do the Proposed Changes Involve a Significant Reduction in the Margin of Safety?

   No. The proposed change does not involve a significant reduction in the margin of safety. The proposed change imposes more conservative surveillance test requirements. The calculated increase in post-LOCA peak containment pressure is only 1 psig and the revised value of 41.49 psig remains less than the containment design pressure of 42 psig. The increase in the calculated peak temperature was approximately 2°F, which was analyzed to have no impact on structures or equipment. Although there was an increase in the calculated pressure, the allowable containment leakage rate, as measured at the peak pressure, is not being changed. Therefore, this change does not involve a significant reduction in any margin of safety for HBRSEP, Unit No. 2.

Based on the preceding discussion, it has been determined that the requested change does not involve a significant hazards consideration.

Environmental Impact Consideration

10 CFR 51.22(c)(9) provides criteria for identification of licensing and regulatory actions for categorical exclusion from performing an environmental assessment. A proposed change for an operating license for a facility requires no environmental assessment if operation of the facility in accordance with the proposed change would not (1) involve a significant hazards consideration; (2) result in a significant change in the types or significant increases in the amounts of any effluents that may be released offsite; (3) result in a significant increase in individual or cumulative occupational radiation exposure. Carolina Power and Light Company has reviewed this request and determined that the proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment needs to be prepared in connection with the issuance of the amendment. The basis for this determination follows:

Proposed Change

Carolina Power and Light Company is proposing a change to Appendix A, Technical Specifications, of Facility Operating License No. DPR-23, for the H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2. The proposed change revises the definition and specified value for the peak containment pressure (P_a) calculated to occur following a design basis Loss of Coolant Accident (LOCA) as described in Technical Specifications Section 5.5.16, "Containment Leakage Rate Testing Program." Additionally, the specified pressure values for surveillance requirements in Technical Specifications Section 3.6.8, "Isolation Valve Seal Water System," are revised to a value equal to 1.1 times the revised P_a. The proposed change will also revise the licensing basis analysis for the post-LOCA containment pressure and temperature for HBRSEP, Unit No. 2.

Basis

The proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9) for the following reasons:

1. As demonstrated in the No Significant Hazards Consideration Determination, the proposed change does not involve a significant hazards consideration.

2. The proposed change is related to post-accident calculation results and to surveillance test criteria. Containment leak rate limits remain the same. The proposed change does not affect the generation or control of effluents. Therefore, the proposed change will not result in a significant change in the types or significant increases in the amounts of any effluents that may be released offsite.

3. The proposed change will not cause a significant increase in occupational radiation exposure. There are no proposed physical changes to the facility. There is only a minor change in a surveillance test condition. Current surveillance procedures already test at this modified condition and hence there should be no impact on the occupational dose to perform the surveillance test. Therefore, the proposed change will not result in a significant increase in individual or cumulative occupational radiation exposure.

United States Nuclear Regulatory Commission
Attachment III to Serial: RNP-RA/06-0048
4 Pages (including cover page)

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

REQUEST FOR TECHNICAL SPECIFICATIONS CHANGE RELATED TO CONTAINMENT PEAK PRESSURE

MARKUP OF TECHNICAL SPECIFICATIONS PAGES

3.6 CONTAINMENT SYSTEMS

3.6.8 Isolation Valve Seal Water (IVSW) System

LCO 3.6.8 The IVSW System shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. IVSW system inoperable.	A.1 Restore IVSW system to OPERABLE status.	72 hours
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3. AND B.2 Be in MODE 5.	6 hours 36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.8.1	Verify IVSW tank pressure is ≥ ~~44.6~~ 46.2 psig.	12 hours
SR 3.6.8.2	Verify the IVSW tank volume is ≥ 85 gallons.	31 days

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.6.8.3	Verify the opening time of each air operated header injection valve is within limits.	In accordance with the Inservice Testing Program
SR 3.6.8.4	Verify each automatic valve in the IVSW System actuates to the correct position on an actual or simulated actuation signal.	18 months
SR 3.6.8.5	Verify the IVSW dedicated nitrogen bottles will pressurize the IVSW tank to ≥ ~~44.6~~ 46.2 psig.	18 months
SR 3.6.8.6	Verify IVSW seal header flow rate is: a. ≤ 52.00 cc/minute for Header A, b. ≤ 16.50 cc/minute for Header B, c. ≤ 32.50 cc/minute for Header C, and d. ≤ 23.00 cc/minute for Header D.	18 months

5.5 Programs and Manuals

5.5.16 Containment Leakage Rate Testing Program

This program provides controls for implementation of the leakage rate testing of the containment as required by 10 CFR 50.54(o) and 10 CFR 50, Appendix J, Option B, as modified by approved exemptions for Type A testing. This program shall be in accordance with the guidelines contained in Regulatory Guide 1.163, "Performance-Based Containment Leak-Test Program," dated September 1995, as modified by the following exception:

a. NEI 94-01 - 1995, Section 9.2.3: The first Type A test performed after the April 9, 1992, Type A test shall be performed no later than April 9, 2007.

Type B and C testing shall be implemented in the program in accordance with the requirements of 10 CFR 50, Appendix J, Option A.

The peak containment pressure, P_a, is specified as the containment design pressure of 42 psig, which exceeds Tthe peak calculated containment internal pressure for the design basis loss of coolant accident, P_a, is 40.5 psig.

The maximum allowable containment leakage rate, L_a, at P_a, shall be 0.1% of the containment air weight per day.

Leakage rate acceptance criteria are:

a. Containment leakage rate acceptance criteria is $\leq$ 1.0 L_a. During the first unit startup following testing in accordance with this program, the leakage rate acceptance criteria are $\leq$ 0.60 L_a for the Type B and Type C tests, and $\leq$ 0.75 L_a for Type A tests.

The provisions of SR 3.0.3 are applicable to the Containment Leakage Rate Testing Program.

(continued)

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Attachment IV to Serial: RNP-RA/06-0048
4 Pages (including cover page)

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

REQUEST FOR TECHNICAL SPECIFICATIONS CHANGE RELATED TO CONTAINMENT PEAK PRESSURE

RETYPED TECHNICAL SPECIFICATIONS PAGES

3.6 CONTAINMENT SYSTEMS

3.6.8 Isolation Valve Seal Water (IVSW) System

LCO 3.6.8 The IVSW System shall be OPERABLE.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. IVSW system inoperable.	A.1 Restore IVSW system to OPERABLE status.	72 hours
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3. AND B.2 Be in MODE 5.	6 hours 36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.8.1	Verify IVSW tank pressure is ≥ 46.2 psig.	12 hours
SR 3.6.8.2	Verify the IVSW tank volume is ≥ 85 gallons.	31 days

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.6.8.3	Verify the opening time of each air operated header injection valve is within limits.	In accordance with the Inservice Testing Program
SR 3.6.8.4	Verify each automatic valve in the IVSW System actuates to the correct position on an actual or simulated actuation signal.	18 months
SR 3.6.8.5	Verify the IVSW dedicated nitrogen bottles will pressurize the IVSW tank to ≥ 46.2 psig.	18 months
SR 3.6.8.6	Verify IVSW seal header flow rate is: a. ≤ 52.00 cc/minute for Header A, b. ≤ 16.50 cc/minute for Header B, c. ≤ 32.50 cc/minute for Header C, and d. ≤ 23.00 cc/minute for Header D.	18 months

5.5 Programs and Manuals

5.5.16 Containment Leakage Rate Testing Program

This program provides controls for implementation of the leakage rate testing of the containment as required by 10 CFR 50.54(o) and 10 CFR 50, Appendix J, Option B, as modified by approved exemptions for Type A testing. This program shall be in accordance with the guidelines contained in Regulatory Guide 1.163, "Performance-Based Containment Leak-Test Program," dated September 1995, as modified by the following exception:

a. NEI 94-01 - 1995, Section 9.2.3: The first Type A test performed after the April 9, 1992, Type A test shall be performed no later than April 9, 2007.

Type B and C testing shall be implemented in the program in accordance with the requirements of 10 CFR 50, Appendix J, Option A.

The peak containment pressure, P_a, is specified as the containment design pressure of 42 psig, which exceeds the peak calculated containment internal pressure for the design basis loss of coolant accident.

The maximum allowable containment leakage rate, L_a, at P_a, shall be 0.1% of the containment air weight per day.

Leakage rate acceptance criteria are:

a. Containment leakage rate acceptance criteria is $\leq$ 1.0 L_a. During the first unit startup following testing in accordance with this program, the leakage rate acceptance criteria are $\leq$ 0.60 L_a for the Type B and Type C tests, and $\leq$ 0.75 L_a for Type A tests.

The provisions of SR 3.0.3 are applicable to the Containment Leakage Rate Testing Program.

United States Nuclear Regulatory Commission
Attachment V to Serial: RNP-RA/06-0048
94 Pages (including cover page)

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2

REQUEST FOR TECHNICAL SPECIFICATIONS CHANGE RELATED TO CONTAINMENT PEAK PRESSURE

WESTINGHOUSE LICENSING REPORT FOR H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2, CONTAINMENT ANALYSIS

Attachment 2

LICENSING REPORT

FOR

H.B. ROBINSON NUCLEAR PLANT

INTRODUCTION

The design and licensing of nuclear power plants require that the containment be analyzed for pressure and temperature effects. The analyses include pressure and temperature transients to which the containment might be exposed as a result of postulated reactor coolant system pipe breaks. Containment integrity analyses are performed for dry containment designs to quantify the margin in the containment design pressure and in the peak temperature and pressure for equipment environmental qualification (EQ), and to demonstrate the acceptability of the containment safeguards equipment to mitigate the postulated transient.

This report presents revised mass & energy releases for postulated Loss-of-Coolant (LOCA) accident due to Westinghouse identified issues (Reference 5) with respect to the Reference 4 analysis. In Reference 5, Westinghouse provided a discussion of the following issues that affected the H. B. Robinson Unit No.2 (HBRSEP Unit No.2) Reference 4 analysis.

1) Area of the downcomer in the REFLOOD code

2) Area of the upper plenum in the FROTH code

3) Definitions for other FROTH inputs

4) Commitments made within WCAP-10325 and SER

5) Main feedwater addition following a reactor trip

6) Considerations for AFW system purge and unisolatable volumes

7) Inadequate definition of required AFW flow for the FROTH code

8) Possibility of asymmetric AFW flow

These issues, with the exception of Issue #4, involve input values and methods used in performing the LOCA mass and energy release analyses. As such, application of the models described in References 2 and 10 have not been affected. Reference 3 has provided the NRC review of the Issue #4 issue which has been resolved without a need to change the Reference 2 model. A detailed description of the issues, taken from Reference 5, is provided below.

1) AREA OF THE DOWNCOMER IN THE REFLOOD CODE

Westinghouse designed reactors can be divided into downflow and upflow barrel baffle designs. The guidance for calculating the downcomer area for downflow plants was determined to be incorrect. When the calculation was corrected, a larger downcomer area and thus volume for downflow plants was calculated. This resulted in a longer

time being required for the ECCS to completely fill the downcomer. Sensitivity studies showed that the effect on LOCA mass and energy release, as determined by the resulting effect on the containment pressure, was small. A correction to the HBRSEP Unit No.2 input model was required to address this issue. This correction does not affect the application or the NRC approval of the Reference 2 model.

2) AREA OF THE UPPER PLENUM IN THE FROTH CODE

The FROTH computer program is run in-conjunction with the REFLOOD computer program and calculates the LOCA mass and energy releases for the post-reflood period until the steam generator secondary side pressure(s) is calculated to equilibrate at the containment design pressure. During this time period, the two-phase mixture levels in the core, upper plenum, hot leg and steam generator inlet plenum are the principle parameters of interest. It was determined that in certain instances the cross-sectional area of the upper plenum (AUPP) was being over predicted, which resulted in a reduction in entrainment to the steam generators and thus less steam production. Correction of the upper plenum area results in increased mass and energy releases and a penalty for the calculated containment pressure. A correction to the HBRSEP Unit No.2 input model was required to address this issue. This correction does not affect the application or the NRC approval of the Reference 2 and 10 evaluation models.

3) DEFINITION FOR OTHER FROTH INPUTS

A review of the FROTH code input variables showed that ASGP, the steam generator (SG) inlet plenum flow area, which is used to calculate the void fraction in the SG inlet plenum, was based on a value that was too small. A review of SG geometry for the inlet plena determined a more appropriate method for calculating ASGP. The result was a larger flow area and a reduction in entrained liquid. The reduction in entrained liquid reduces the mass and energy released post-reflood, and is a benefit for the calculated containment pressure. A correction to the HBRSEP Unit No.2 input model was required to address this issue. This correction does not affect the application or the NRC approval of the Reference 2 and 10 evaluation models.

4) COMMITMENTS MADE WITHIN WCAP-10325 AND SER

The Westinghouse LOCA mass and energy (M&E) release model described in WCAP-10325-P-A (Reference 2) was approved in February 1987 (Reference 21) and has been used to calculate the LOCA mass and energy releases for almost all Westinghouse designed PWRs. As a result of a Westinghouse review of these models, the need to clarify two model features was identified. These are the assumptions placed on the steam generator exit steam enthalpy during the post-reflood period and the assumed power level used in the LOCA M&E analysis. These differences have been determined to be very small relative to the overall conservatism of the analysis. However, since these two model features are applied differently than approved, NRC reporting was deemed to be necessary. These issues were clarified with NRC informally by telephone on May 26, 2005, and followed-up formally with Reference 19. Reference 3 is the NRC's

SER addressing these issues and has determined that no changes to the current model described in Reference 2 are required.

5) MAIN FEEDWATER ADDITION FOLLOWING A REACTOR TRIP

Reference 2 indicates that Westinghouse will account for the addition of main feedwater (MFW) to the steam generator secondaries following a LOCA in the time frame from reactor trip until main feedwater isolation is calculated to occur. The recent methodology review called into question the current modeling of the isolation of the SG secondary side on a reactor trip signal. The continued addition of MFW after reactor trip is adding energy to the secondary side above 212°F and therefore in the long-term this additional energy will be released to the containment. Depending upon the time at which peak containment pressure is calculated, a penalty to peak pressure may occur. Sensitivity studies have shown either a penalty or a benefit when MFW addition after reactor trip is modeled. A correction to the HBRSEP Unit No.2 input model was required to address this issue. This correction does not affect the application or the NRC approval of the Reference 2 and 10 LOCA mass and energy release models.

6) CONSIDERATIONS FOR AFW SYSTEM PURGE & UNISOLATABLE VOLUMES

After isolation of the main feedwater (MFW), a volume of hot MFW will reside in the main feed lines between the auxiliary feedwater (AFW) injection point and the SG secondary side. Once AFW flow is initiated, the hot MFW water will be pushed into the SG secondary side. As the steam generators are calculated to depressurize, there may be additional volume trapped between the AFW injection point and the MFW isolation valve that will flash and be pushed into the SG secondary. These two concerns were not considered in the References 1 & 2 LOCA mass and energy release models. Addition of these effects to the LOCA mass and energy release calculation has been shown to increase the total energy released to containment and results in a penalty to the calculated containment pressure. The HBRSEP Unit No.2 AFW purge and unisolatable volumes were not modeled in this analysis. Instead the more conservative approach of not crediting the cold Auxiliary Feedwater flow was used.

7) INADEQUATE DEFINITION OF REQUIRED AFW FLOW FOR FROTH CODE

In recent data requests to support new LOCA mass and energy release analyses, minimum auxiliary feedwater flow, post-LOCA, is one of the items requested. In some cases, the actual flow used in the analysis assumed that the flow provided was per steam generator, instead of the total flow to all steam generators. This resulted in flow that was high, and therefore a non-conservative low energy release to containment. For plants that currently do not credit any AFW flow during the post-reflood period, there is no impact on the analysis results. For plants that credit too large of an AFW flow, this results in a penalty to the calculated containment pressure. This analysis used the more conservative approach of not crediting the cold Auxiliary Feedwater flow.

8) POSSIBILITY OF ASYMMETRIC AFW FLOW

LOCA analyses are performed assuming that off-site power is lost coincident with the LOCA with the limiting single failure of one diesel generator to start. If the plant design does not start the turbine driven AFW pump on the loss of offsite power or an SI signal, then the typical design will have one motor driven AFW pump in operation which generally will not feed all steam generators. Thus, one or more steam generators may not receive any AFW flow. In some cases, the flow used in the analysis assumed that the flow provided was per steam generator, even though not all steam generators would receive flow. This resulted in flow that was high, and therefore a non-conservative low energy release to containment. The current LOCA mass and energy release models do not contain a provision to model asymmetric AFW flow. Instead, this effect is bounded by the assumption of no AFW delivery. For plants that model AFW flow, and if asymmetric flow is possible, this results in a penalty to the calculated containment pressure. Since it is possible to have asymmetric AFW flow at HBRSEP Unit No.2, the conservative approach of not crediting the cold Auxiliary Feedwater flow was used in this new analysis.

Additional Changes not Reported in Reference 5

Other changes to the HBRSEP Unit No.2 LOCA mass and energy input model were made in performing the new analysis but were not reported in Reference 5 since these changes have little effect on the results and in some instances result in a lower calculated peak pressure. These are:

9) Input Modification Program values for SG Outlet Nozzle Hydraulic Diameter and Flow Area.

10) Reactor Coolant Pump Rated Data used in the Input Modification Program.

The Input Modification Program is a data base of generically applicable data used to develop the plant specific input model. Data collection for the steam generator outlet nozzle and the reactor coolant pump rated conditions of head, flow, torque and moment of inertia were discovered to have in some instances incorrect data. These items were corrected in this new analysis for H. B. Robison.

Additionally, the plant changes previously evaluated in References 17 and 18 have been incorporated into the new analysis. The corresponding containment response is also provided.

Reference 5 has stated that only the Double Ended Pump Suction (DEPS) break with minimum ECCS flow needs to be re-analyzed. The Double Ended Hot Leg (DEHL) break, which calculates a peak pressure to occur during blowdown could only be affected by the post-LOCA addition of main feedwater. However, since main feedwater

addition could cool the steam generator secondary side during blowdown, the transfer of heat from secondary to primary would be reduced and thus less energy would be released out the break. Further, the timing of key events for reactor trip, containment high and high-high signals, which are used to activate safety systems will not be affected since these occur very early in the transient before MFW addition could introduce an appreciable effect. Thus, the DEHL break is considered to be unaffected by the reported issues.

The DEPS break with maximum ECCS flows, while affected, has not been reanalyzed since the results for this break are well below the DEPS case with minimum ECCS flows. In the Reference 4 analysis, the DEPS maximum ECCS case was 2.33 psi below the DEPS minimum ECCS case. This delta is greater than the sum of the effects seen for the DEPS minimum ECCS case (e.g. 0.99 psi). Thus, a reanalysis of the DEPS maximum ECCS case is not expected to exceed the results calculated for the DEPS minimum ECCS case.

Thus, only this single break has been re-analyzed. However, this report will provide again the results previously provided in Reference 4 for the Double Ended Hot Leg (DEHL) break and the DEPS break with maximum ECCS flows. Therefore, included in the body of this report is a discussion of the input parameters and assumptions, methodology, analyses, acceptance criteria, and the results for HBRSEP Unit No.2.

Long-Term LOCA Mass and Energy Releases

Introduction

Discussed in this section are the long-term LOCA mass and energy releases for the hypothetical double-ended pump suction (DEPS) and double-ended hot leg (DEHL) break cases. The mass and energy release rates described in this section form the basis of further computations to evaluate the containment response following the postulated LOCA.

A total of three LOCA mass and energy release cases are presented. However, only the Double Ended Pump Suction break with minimum ECCS flow assumptions has been re-analyzed. These cases addressed two different break locations; the double-ended hot leg break and the double-ended pump suction break (see "Break Size & Location," for a detailed explanation). The above two break locations were analyzed for both minimum and maximum safeguards (i.e. minimum and maximum pumped ECCS flows). The minimum ECCS cases were performed to address maximum available steam release (minimizing steam condensation) and the maximum ECCS cases were performed to address the effects of maximizing mass flow and subsequent effect on containment response. Reference 2 has provided justification that these analyses encompass the most limiting assumptions for break location and safeguards operation.

The limiting long-term LOCA mass and energy releases are extended out in time to approximately 1 million seconds and are utilized as input to the containment response analysis, which demonstrates the acceptability of the containment design, EQ limits, and

containment safeguards systems to mitigate the consequences of a hypothetical large break LOCA. The containment safeguards systems must be capable of limiting the peak containment pressure to less than the design pressure and to limit the temperature and pressure excursion to below the Environmental Qualification (EQ) limits.

Input Parameters and Assumptions

The mass and energy release analysis is sensitive to the assumed characteristics of various plant systems; some of the most-critical items are the RCS initial conditions, core decay heat, accumulators, ECCS flow, and primary and secondary metal mass and steam generator heat release modeling. Specific assumptions concerning each of these items are discussed in this section. Tables 1 through 3 present key data assumed in the analysis. All input parameters are determined based on NRC accepted methodology (References 2 and 3).

Initial Power Level

The initial power level is assumed to be 2346 MWt which is 100.3% of the rated thermal power (2339 MWt) (adjusted for a calorimetric error of 0.3%) for HBRSEP Unit No.2. A maximum initial power is conservative for maximizing the mass and energy releases, with respect to reactor coolant system (RCS) temperature, available decay heat energy and initial core stored energy.

Initial RCS Temperature and Pressure

Initial RCS temperatures are chosen to bound the highest average coolant temperature range of all operating cases. The initial T_{HOT} (vessel outlet temperature) of 610.3°F and initial T_{COLD} (core inlet temperature) of 548.5°F (which includes +4.0°F for instrument error and deadband, Reference 15) were modeled. The use of the higher temperatures is conservative because the initial fluid energy is based on coolant temperatures which are at the maximum levels attained in steady state operation. This position on RCS temperatures was originally established in Reference 10. The RCS pressure is based upon a nominal value of 2250 psia plus an allowance (+30 psi, Reference 15) which accounts for the measurement uncertainty on pressurizer pressure. This assumption only affects the blowdown phase results. The rate at which the RCS blows down is initially more severe at the higher RCS pressure. Additionally the RCS has a higher fluid density at the higher pressure (assuming a constant temperature) and subsequently has a higher RCS mass available for releases. (Note: The RCS initial temperatures were conservatively based upon Steam Generator Tube Plugging (SGTP) level of 0%)

Steam Generator Model

A uniform steam generator tube plugging level of 0% is modeled. This assumption maximizes the reactor coolant volume and fluid release by virtue of consideration of the RCS fluid in all tubes. During the post-blowdown period the steam generators are active heat sources since significant energy remains in the secondary metal and secondary mass that has the potential to be transferred to the primary side. The 0% tube

plugging assumption maximizes heat transfer area and therefore the transfer of secondary heat across the SG tubes. Additionally, this assumption reduces the reactor coolant loop resistance, which reduces the pressure drop upstream of the break for the pump suction breaks and increases break flow. Thus, the analysis conservatively accounts for the level of steam generator plugging by using 0%.

Secondary to primary heat transfer is maximized by assuming conservative coefficients of heat transfer (i.e., steam generator primary/secondary heat transfer and reactor coolant system metal heat transfer). Maximum secondary to primary heat transfer is ensured by maximizing the initial steam generator mass based upon 100% power conditions and then increasing this by 10% to maximize the available energy. The 10% uncertainty addresses uncertainties in SG secondary side volume calculations, and several sources of level measurement errors.

Fuel Design - Core Stored Energy

Core stored energy is the amount of energy in the fuel rods above the local coolant temperature. The selection of the fuel design features for the long-term mass and energy release calculation are based on the need to conservatively maximize the energy stored in the fuel at the beginning of the postulated accident. The following fuel features are considered, 1) Rod Geometry, 2) Rod Power, and 3) Limiting time in life (eg. Burnup). The Core Stored Energy supplied in Reference 16 was used in this analysis. Core stored energy is addressed in the analysis as full power seconds.

Core Decay Heat Model

The American Nuclear Society (ANS) Standard 5.1 was used in the LOCA M&E release model for HBRSEP Unit No.2 for the determination of decay heat energy. This standard was balloted by the Nuclear Power Plant Standards Committee (NUPPSCO) in October 1978 and subsequently approved. The official standard was issued in August 1979.

Significant assumptions in the generation of the decay heat curve for use in design basis containment integrity LOCA analyses include:

1. Decay heat sources considered are fission product decay and heavy element decay of U-239 and Np-239.
2. Decay heat power from fissioning isotopes other than U-235 is assumed to be identical to that of U-235.
3. Fission rate is constant over the operating history of maximum power level.
4. The factor accounting for neutron capture in fission products has been taken from Table 10, of Reference 6.
5. The fuel has been assumed to be at full power for 10^8 seconds.
6. The total recoverable energy associated with one fission has been assumed to be 200 MeV/fission.

7. Two sigma uncertainty (two times the standard deviation) has been applied to the fission product decay.

Based upon NRC staff review, the Safety Evaluation Report (SER) of the March 1979 evaluation model (Reference 2), the use of the ANS Standard-5.1, August 1979 decay heat model was approved for the calculation of mass and energy releases to the containment following a loss-of-coolant accident. Table 19 provides the Decay Heat Curve.

In 1996, the NRC issued an information notice (Reference 7) regarding the use of the ANS 5.1 decay heat standard. The following items address that information notice:

1. The comparisons presented in the information notice are for Peak Cladding Temperature only. Even though decay effects are illustrated, there is no mention of LOCA Mass and Energy Releases and Containment Response calculations. However, there is the implied impact on any analysis that has utilized the ANS standard.

2. For LOCA mass and energy, the current methodology (WCAP-10325-P-A) (Reference 2) utilizes the ANS Standard 5.1 for the determination of the decay heat. The input utilized is called out on page 2-10 of the WCAP. The model, including the decay heat model, has been approved (letter from C. E. Rossi of NRC to W. J. Johnson of Westinghouse, dated 2/17/87, which is included with Reference 2.)

3. For LOCA mass and energy, the ANS 5.1 standard is used in the selection of inputs. Power history, initial fuel enrichment, and neutron flux level, which are called out in the information notice, are also called out in Reference 2.

Reactor Coolant System Fluid Energy

Margin in RCS fluid volume of 3% (which is composed of 1.6% allowance for thermal expansion and 1.4% for uncertainty) is modeled. These uncertainties were originally introduced into the Reference 10 methodology which was accepted by the NRC.

Application of Single-Failure Criterion

An analysis of the effects of the single-failure criterion has been performed on the mass and energy release rates for each break analyzed. An inherent assumption in the generation of the mass and energy release is that offsite power is lost. This results in the actuation of the emergency diesel generators, which are required to power the emergency core cooling system (ECCS). Actuation of the Emergency Diesel Generators results in a delay in the time to start both the ECCS and containment safeguards. A delay in the actuation of these accident mitigating components results in a higher containment pressure and temperature for the postulated LOCA. Since the LOCA Mass and Energy (M&E) codes (Reference 2) are uncoupled from the Containment Pressure code (Reference 11) an assumption on containment pressure is required in the Reference 2 M&E calculations. Maximum containment backpressure equal to the design pressure

is modeled, which reduces the rate of safety injection, condensation of steam by the safety injection, and extends the reflood phase, which maximizes the steam release.

Two single failures have been analyzed: The first postulates the single failure of an emergency diesel generator. This is conservatively assumed to result in the loss of one train of safeguards equipment, which is modeled as: 1 High Head Safety Injection (HHSI) and 1 Low Head Safety Injection (LHSI) pump (Minimum Safeguards). The loss of a diesel generator minimizes ECCS flow and therefore the condensation of steam, increasing the energy release to the containment. The second single failure assumption postulates failure of 1 containment spray pump, resulting in all ECCS equipment operating. This case, referred to as maximum safety injection, maximizes the mass release to containment but also results in more containment heat removal equipment being available. This case considers 2 HHSI and 2 LHSI Pumps (Maximum Safeguards). These two postulated single failures cover the range on possible single failures with regard to the affect on mass and energy releases and containment safeguards availability.

Safety Injection System

Following a Large Break Loss of Coolant Accident (LBLOCA) inside containment, the safety injection system, (SIS) operates to reflood the reactor coolant system. The first phase of the SIS operation is the passive accumulator injection. Three accumulators are assumed available to inject. When the RCS depressurizes to 615 psia (Reference 15) the accumulators begin to inject into the cold legs at the reactor coolant loops. The accumulator injection temperature was modeled at 130°F (References 15). The Sequence of Events tables presented in the containment analysis section provide the actuation times for the accumulators for each case.

The active pumped ECCS operation of the SIS was modeled to address both minimum and maximum safeguards (minimum ECCS and maximum ECCS). The minimum ECCS flow is addressed to calculate the effect on minimizing steam water mixing/steam condensation. The maximum ECCS case addresses the effects of maximizing mass flow out the postulate RCS piping break. The SI signal is assumed to be actuated on the low pressurizer pressure setpoint of 1661.4 psia (References 15). For the maximum ECCS case, the SIS was assumed to deliver to the RCS without delay after the generation of this signal where the intent was to maximize mass flow. For the minimum ECCS case, the SIS was assumed to deliver to the RCS 41.7 seconds (References 15) after the generation of the SI signal. The ECCS flow is delivered as a function of RCS pressure. The pumped ECCS temperature for the injection phase was assumed to be at 100°F (References 15). In the determination of long term containment pressure and temperature transients, credit is taken for cold leg pumped sump recirculation ECCS flow to the core and sump heat removal via the residual heat exchangers (RHR Hx). For the minimum ECCS case during recirculation, failure of one Engineered Safeguards Features (ESF) train one HHSI is available. The ECCS configuration for the recirculation phase maximum ECCS case is 2 HHSI. Tables 2 and 3 provide the pumped ECCS flows as a function of RCS pressure for the minimum and maximum safeguards case,

respectively. The Sequence of Events tables presented in the containment analysis provide the actuation times for the pumped ECCS flow for each case.

Description of Analyses

The evaluation model used for the long-term LOCA mass and energy release calculations is the March 1979 model described in References 2 and 3. This evaluation model has been reviewed and approved generically by the NRC. The approval letter is included with Reference 2. This LOCA mass and energy release methodology has been utilized and approved on the plant-specific dockets for other Westinghouse PWRs such as Catawba Units 1 and 2, Beaver Valley Unit 2, McGuire Units 1 and 2, Millstone Unit 3, Sequoyah Units 1 and 2, Surry Units 1 and 2, Indian Point Unit 2, and Indian Point Unit 3.

A description of the Reference 2 methodology with the changes noted in Reference 3 is provided below.

Mass and Energy Release Phases

The LOCA mass and energy analysis is typically divided into four phases: blowdown, refill, reflood, and post-reflood. Each of these phases is analyzed by the following codes: blowdown - SATAN-VI; refill/reflood - WREFLOOD; and post-reflood - FROTH and EPITOME

The phases and codes are discussed below.

The first phase of a LOCA mass and energy release transient is the blowdown phase, the period of time from accident initiation (when the reactor is at steady state operation) to the time that the RCS and containment reach an equilibrium pressure. The blowdown period is typically <30 seconds. It ends when the RCS active core area is essentially empty, which is within seconds of ECCS injection actuation for the minimum safeguards (Min ECCS) case. For the maximum safeguards case (Max ECCS), ECCS injection is credited after SI signal is reached w/o a delay as noted above in order to maximize the mass flow.

A mass and energy release version of the SATAN-VI code is used for computing the blowdown transient. The code utilizes the control volume (element) approach with the capability for modeling a large variety of thermal fluid system configurations. The fluid properties are considered uniform and thermodynamic equilibrium is assumed in each element. A point kinetics model is used with weighted feedback effects. The major feedback effects include moderator density, moderator temperature, and Doppler broadening. A critical flow calculation for subcooled (modified Zaloudek), two-phase (Moody), or superheated break flow is incorporated into the analysis. The methodology for the use of this model is described in Reference 2.

The refill period is the second phase of the LOCA mass and energy release transient. It is the period of time when the lower plenum is being filled by accumulator and pumped

ECCS water. At the end of blowdown, a large amount of water remains in the cold legs, downcomer, and lower plenum. To conservatively consider the refill period for the purpose of containment mass and energy releases, it is assumed that this water is instantaneously transferred to the lower plenum along with sufficient accumulator water to completely fill the lower plenum. This allows an uninterrupted release of mass and energy to containment. Thus, the refill period is conservatively neglected in the mass and energy release calculation.

The third phase of a LOCA mass and energy release transient is the core reflooding phase, which begins when the primary coolant system has depressurized (following blowdown) due to the loss of water through the break. The water from the lower plenum, supplied by the Emergency Core Cooling System refills the reactor vessel and provides cooling to the core. This phase ends when the core is completely quenched. The model conservatively assumes quenching of the core at the 10-foot elevation on the active fuel for containment functional design calculations. During this phase, decay heat generation will produce boiling in the core resulting in a two-phase mixture of steam and water in the core. This two-phase mixture rises above the core and subsequently enters the steam generators. The most-important feature is the steam/water mixing model (described below), which is used during this phase.

The WREFLOOD code is used for computing the reflood transient. The WREFLOOD code consists of two basic hydraulic models - one for the contents of the reactor vessel, and one for the coolant loops. The two models are coupled through the interchange of the boundary conditions applied at the vessel outlet nozzles and at the top of the downcomer. Additional transient phenomena such as pumped ECCS and accumulators, reactor coolant pump performance, and steam generator release, are included as auxiliary equations which interact with the basic models as required. The WREFLOOD code permits the capability to calculate variations during the core reflooding transient of basic parameters such as core flooding rate, core and downcomer water levels, fluid thermodynamic conditions (pressure, enthalpy, density) throughout the primary system, and mass flow rates through the primary system. The code permits hydraulic modeling of the two flow paths available for discharging steam and entrained water from the core to the break; i.e., the path through the broken loop and the path through the unbroken loop.

A complete thermal equilibrium mixing condition for the steam and emergency core cooling injection water during the reflood phase has been assumed for each loop receiving ECCS water. This is consistent with the usage and application of the Reference 2 mass and energy release evaluation model in recent analyses, e.g., D.C. Cook Docket (Reference 8). Even though the Reference 2 model credits steam/mixing only in the intact loop and not in the broken loop, justification, applicability, and NRC approval for using the mixing model in the broken loop has been documented (Reference 8). This assumption is justified and supported by test data, and is summarized as follows.

The model assumes a complete mixing condition (i.e., thermal equilibrium) for the steam/water interaction. The complete mixing process, however, is made up of two distinct physical processes. The first is a two-phase interaction with condensation of

steam by cold ECCS water. The second is a single-phase mixing of condensate and ECCS water. Since the steam release is the most-important influence to the containment pressure transient, the steam condensation part of the mixing process is the only part that need be considered. (Any spillage directly heats only the sump.)

The most-applicable steam/water mixing test data has been reviewed for validation of the containment integrity reflood steam/water mixing model. This data was generated in 1/3-scale tests (Reference 9), which are the largest scale data available, and thus most-clearly simulates the flow regimes and gravitational effects that would occur in a PWR. These tests were designed specifically to study the steam/water interaction for PWR reflood conditions.

From the entire series of 1/3-scale tests, a group corresponds almost directly to containment integrity reflood conditions. The injection flowrates for this group cover all phases and mixing conditions calculated during the reflood transient. The data from these tests were reviewed and discussed in detail in Reference 2. For all of these tests, the data clearly indicates the occurrence of very effective mixing with rapid steam condensation. The mixing model used in the containment integrity reflood calculation is therefore wholly supported by the 1/3-scale steam/water mixing data.

Additionally, the following justification is also noted. The post-blowdown limiting break for the containment integrity peak pressure analysis is the pump suction double ended break. For this break, there are two flowpaths available in the RCS by which mass and energy may be released to containment. One is through the outlet of the steam generator, and the other is via reverse flow through the reactor coolant pump. Steam which is not condensed by ECCS injection in the intact RCS loop passes around the downcomer and through the broken loop cold leg and pump in venting to containment. This steam also encounters ECCS injection water as it passes through the broken loop cold leg, complete mixing occurs and a portion of it is condensed. It is this portion of steam which is condensed that is taken credit for in this analysis. This assumption is justified based upon the postulated break location, and the actual physical presence of the ECCS injection nozzle. A description of the test and test results is contained in References 2 and 9.

Post-reflood describes the period following the reflood transient. For the pump suction break, a two-phase mixture exits the core, passes through the hot legs, is superheated in the steam generators (Reference 3), and exits the break as superheated steam. After the broken loop steam generator cools, the break flow becomes two phase.

The FROTH code (Reference 10) is used for computing the post-reflood transient. The FROTH code calculates the heat release rates resulting from a two-phase mixture level present in the steam generator tubes. The mass and energy releases that occur during this phase are typically superheated (Reference 3) due to the depressurization and equilibration of the broken loop and intact loop steam generators. During this phase of the transient, the RCS has equilibrated with the containment pressure, but the steam generators contain a secondary inventory at an enthalpy that is much higher than the primary side. Therefore, there is a significant amount of reverse heat transfer that

occurs. Steam is produced in the core due to core decay heat. During the FROTH calculation ECCS injection is addressed for both the injection phase and the recirculation phase.

Steam generator equilibration and depressurization is the process by which secondary side energy is removed from the steam generators in stages. The FROTH computer code calculates the heat removal from the secondary mass until the secondary temperature is at the saturation temperature (T_{sat}) at the containment design pressure. After the FROTH calculations, steam generator secondary energy is removed based on first and second stage rates. The first stage rate is applied during the time interval from the broken loop equilibrium at containment design pressure to the estimated intermediate pressure. While stage 2 is the time interval from the estimated intermediate pressure equilibrium out to an SG pressure of 14.7 psia at 3600 seconds. These rates are applied simultaneously in the transient until the desired depressurization is achieved for each steam generator, which may occur over differing periods of time and rates for each SG. The EPITOME code continues the FROTH calculation for SG cooldown. The first stage rate is applied until the steam generator reaches T_{sat} at the user specified intermediate equilibration pressure, when the secondary pressure is assumed to reach the actual containment pressure. Then the second stage rate is used until the final depressurization, when the secondary reaches the reference temperature of T_{sat} at 14.7 psia, or 212°F. The heat removal of the broken loop and intact loop steam generators are calculated separately.

The Sequence of Events tables located in the containment analysis section provide the case specific broken and intact loop steam generator equilibration times. By reading the output files from SATAN-VI, WREFLOOD, and FROTH, the EPITOME code compiles a summary of data on the entire transient, including formal instantaneous mass and energy release tables and mass and energy balance tables with data at critical times.

During the FROTH calculations, steam generator heat removal rates are calculated using the secondary side temperature, primary side temperature and a secondary side heat transfer coefficient determined using a modified McAdam's correlation. Steam generator energy is removed during the FROTH transient until the secondary side temperature reaches saturation temperature at the containment design pressure. The constant heat removal rate used during the first heat removal stage is based on the final heat removal rate calculated by FROTH. The SG energy available to be released during the first stage interval is determined by calculating the difference in secondary energy available at the containment design pressure and that at the (lower) user specified intermediate equilibration pressure, assuming saturated conditions. This energy is then divided by the first stage energy removal rate, resulting in an intermediate equilibration time. At this time, the rate of energy release drops substantially to the second stage rate. The second stage rate is determined as the fraction of the difference in secondary energy available between the intermediate equilibration and final depressurization at 212°F, and the time difference from the time of the intermediate equilibration to the user specified time of the final depressurization at 212°F. With current methodology, all of the secondary energy remaining after the intermediate equilibration is conservatively assumed to be released by imposing a mandatory (i.e. NRC requirement) cooldown and

subsequent depressurization down to atmospheric pressure at 3600 seconds, i.e., 14.7 psia and 212°F. The required depressurization to 14.7 psia at 3600 seconds was arrived at in licensing of the Reference 2 model with the NRC.

As discussed, the current approved methodology assumes that all energies in the system are taken out to these conditions in the first hour of the event. In actuality, the release of these energies to these conditions would take much longer, on the order of hours. There is the possibility that the remaining energies, for example, down to containment conditions of 130°F could be released, however this is not included in the releases discussed herein. Based upon the current and approved models, this additional energy would tend to slightly increase the water temperature of the spilled fluid coming from the pump side of the break, but would not increase the amount of steam being released from the steam generator side of the break. It is expected that the effects on the long term cooldown would be insignificant.

The methodology for the use of this model is described in Reference 2. The mass and energy release rates are calculated by FROTH and EPITOME until the time of containment depressurization. After containment depressurization (14.7 psia), the mass and energy release available to containment is generated directly from core boiloff/decay heat.

Computer Codes

The Reference 2 and 3 mass and energy release evaluation model is comprised of mass and energy release versions of the following codes: SATAN VI, WREFLOOD, FROTH, and EPITOME. These codes were used to calculate the long-term LOCA mass and energy releases for HBRSEP Unit No.2.

SATAN-VI calculates blowdown, the first portion of the thermal-hydraulic transient for the RCS following break initiation, including pressure, enthalpy, density, mass and energy flowrates, and energy transfer between primary and secondary systems as a function of time.

The WREFLOOD code addresses the portion of the LOCA transient during the core reflood phase.

FROTH models the post-reflood portion of the transient. The FROTH code is used for the steam generator heat addition calculation from the broken and intact loop steam generators.

EPITOME continues the FROTH post-reflood portion of the transient from the time at which the secondary equilibrates to containment design pressure to the end of the transient.

Break Size and Location

Generic studies (Reference 2) have been performed with respect to the effect of postulated break size on the LOCA mass and energy releases. The double ended guillotine break has been found to be limiting due to larger mass flow rates during the blowdown phase of the transient. During the reflood and post-reflood phases, the break size has little effect on the releases.

Three distinct locations in the reactor coolant system loop can be postulated for pipe rupture:

1. Hot leg (between reactor vessel and steam generator)
2. Cold leg (between Reactor Coolant Pump and the reactor vessel)
3. Pump suction (between steam generator and Reactor Coolant Pump)

The DEHL rupture has been shown in previous studies to result in the highest blowdown mass and energy release rates. Although the core flooding rate would be the highest for this break location, the amount of energy released from the steam generator secondary is minimal because the majority of the fluid which exits the core bypasses the steam generators venting directly to containment. As a result, the reflood mass and energy releases are reduced significantly as compared to either the pump suction or cold leg break locations where the core exit mixture must pass through the steam generators before venting through the break. For the hot leg break, generic studies have confirmed that there is no reflood peak (i.e., from the end of the blowdown period the containment pressure continually decreases). Therefore only the mass and energy releases for the hot leg break blowdown phase are calculated and presented in this section of the report.

The cold leg break location has been found in previous studies to be much less limiting in terms of the overall containment energy releases. The cold leg blowdown is faster than that of the pump suction break, and more mass is released into the containment. However, the core heat transfer is greatly reduced (due to the break location the flow will bypass the normal path through the core and go through the path of least resistance to the broken loop) and this results in a considerably lower energy release into containment. Studies have determined that the blowdown transient for the cold leg is less limiting than that for the pump suction and hot leg breaks. During reflood, the flooding rate is greatly reduced because all the core vent paths include the resistance of the reactor coolant pump, in addition to ECCS injection spill, thus the energy release rate into the containment is reduced. Therefore, the cold leg break is not included in the scope of this analysis.

The pump suction break combines the effects of the relatively high core flooding rate, as in the hot leg break, with the addition of the stored energy in the steam generators. As a result, the pump suction break yields the highest energy flow rates during the post-blowdown period by including all of the available energy of the Reactor Coolant System and secondary side in calculating the releases to containment.

The break locations analyzed for this program are the double-ended pump suction (DEPS) rupture (10.48 ft^2), and the double-ended hot leg (DEHL) rupture (9.18 ft^2). Break mass and energy releases have been calculated for the blowdown, reflood, and post-reflood phases of the LOCA for the DEPS cases. For the DEHL case, the releases were calculated only for the blowdown phase.

Sources of Mass and Energy

The sources of mass considered in the LOCA mass and energy release analysis are given in Tables 5, 11, and 17. These sources are the reactor coolant system, accumulators, and pumped safety injection.

The energy inventories considered in the LOCA mass and energy release analysis are given in Tables 6, 12, and 18. The energy sources include:

1. Reactor Coolant System Water
2. Accumulator Water (all inject)
3. Pumped Injection Water (RWST/ECCS)
4. Decay Heat
5. Core Stored Energy
6. Reactor Coolant System Metal - Primary Metal (includes SG tubes)
7. Steam Generator Metal (includes transition cone, lower shell, wrapper, channel head and other internals)
8. Steam Generator Secondary Energy (includes fluid mass and steam mass)
9. Secondary Transfer of Energy (feedwater into and steam out of the steam generator secondary)

The mass and energy inventories are presented at the following times, as appropriate:

1. Time zero (initial conditions)
2. End of blowdown time
3. End of refill time
4. End of reflood time
5. Time of broken loop steam generator equilibration to pressure setpoint
6. Time of intact loop steam generator equilibration to pressure setpoint
7. Time of full depressurization (3600 seconds)

Energy Reference Points

Available Energy: 212°F; 14.7 psia

(The current approved methodology assumes that all energies in the system are taken out to these conditions in the first hour of the event. This is the total available energy.)

Total Energy Content: 32°F; 14.7 psia

(This is the reference point for the system energy.)

In the mass and energy release data presented, no Zirc-water reaction heat was considered because the clad temperature is assumed not to rise high enough for the rate of the Zirc-water reaction heat to be of any significance. This is a feature of the Reference 2 methodology based on Peak Cladding Temperature (PCT) analyses using the models of Appendix K to 10CFR50, to meet the criteria specified in 10CFR50.46. These PCT analyses show that less than 1.0% of the total core Zirconium is reacted during the hypothetical LOCA. Thus, the energy release from the Zirconium water reaction would be small and would not significantly affect the mass and energy releases to containment.

Acceptance Criteria

A large break loss-of-coolant accident is classified as an ANS Condition IV event, an infrequent fault. To satisfy the Nuclear Regulatory Commission acceptance criteria, the relevant requirements are as follows:

A. HBRSEP, Unit No.2 FSAR Chapter 3.1 General Design Criteria; as it relates to General Design Criteria 10, 49, and 52, with respect to containment design integrity and containment heat removal.

B. 10 CFR 50, Appendix K, paragraph I.A: as it relates to sources of energy during the LOCA, provides requirements to assure that all energy sources have been considered.

In order to meet these requirements, the following must be addressed.

1. Sources of Energy
2. Break Size and Location
3. Calculation of Each Phase of the Accident
4. Single Failure Criteria

Each of these items was addressed back in the "Description of Analyses" section.

Results

Using the methodology of Reference 2 and 3, the mass and energy release rates were developed to determine the containment pressure and temperature responses for each of the LOCA cases noted in the section on "Description of Analyses". The LOCA mass and energy releases discussed in this section provide the basis for the containment response analysis provided in the containment analysis section.

Table 4 presents the calculated mass and energy release for the blowdown phase of the DEHL break for the minimum safeguards case. A maximum safeguards case was not run since pumped SI would not start prior to the end of blowdown and containment safeguards actuation times are also after blowdown terminates. Therefore, a minimum and maximum safeguards assumption cases are identical. For the hot leg break mass and energy release tables, break path 1 refers to the mass and energy exiting from the reactor vessel side of the break; break path 2 refers to the mass and energy exiting from the steam generator side of the break. Note that this case was not reanalyzed and therefore the results are identical to the Reference 4 results.

Tables 7 and 13 present the calculated mass and energy releases for the blowdown phase of the DEPS break for the minimum and maximum safeguards cases. For the pump suction breaks, break path 1 in the mass and energy release tables refers to the mass and energy exiting from the steam generator side of the break; break path 2 refers to the mass and energy exiting from the pump side of the break. Note that the maximum safeguards case was not reanalyzed and therefore the maximum safeguard case results are identical to the Reference 4 results.

Tables 8, and 14 present the calculated mass and energy release for the reflood phase of the pump suction double-ended rupture, diesel failure (minimum safeguards), and no failure (maximum safeguards) cases, respectively. Note that the maximum safeguards case was not reanalyzed and therefore the maximum safeguard case results are identical to the Reference 4 results.

The transients of the principal parameters, such as core flooding rate, core and downcomer level, and safety injection and accumulator injection rates during the core reflooding portion of the LOCA are given in Tables 9, and 15 for the DEPS cases. Note that the maximum safeguards case was not reanalyzed and therefore the maximum safeguard case results are identical to the Reference 4 results.

Tables 10 and 16 present the two-phase post-reflood mass and energy release data for the pump suction double-ended cases. Note that the maximum safeguards case was not reanalyzed and therefore the maximum safeguard case results are identical to the Reference 4 results.

The sequences of events for the LOCA transients are included in the composite tables found in the containment analysis section (Table 23 though Table 25).

Conclusions

The consideration of the various energy sources in the long-term mass and energy release analysis provides assurance that all available sources of energy have been included in this analysis. Thus, the review guidelines presented in Standard Review Plan Section 6.2.1.3 have been satisfied. Any other conclusions cannot be drawn from the generation of mass and energy releases directly since the releases are inputs to the containment integrity analyses. The containment response must be performed (as documented in following section on containment analysis).

Table 1 SYSTEM PARAMETERS INITIAL CONDITIONS	
PARAMETERS	**VALUE**
Core Thermal Power (MWt) includes 0.3% calorimetric uncertainty	2346
Reactor Coolant System Total Flowrate (lbm/sec)	27027.78
Vessel Outlet Temperature (°F)	610.3
Core Inlet Temperature (°F)	548.5
Vessel Average Temperature (°F)	579.4
Initial Steam Generator Steam Pressure (psia)	850
Steam Generator Design	Model 44F
Steam Generator Tube Plugging (%)	0
Initial Steam Generator Secondary Side Mass (lbm)	97505.
Assumed Maximum Containment Backpressure (psia)	56.7
Accumulator Water Volume (ft^3) per accumulator N_2 Cover Gas Pressure (psia) Temperature (°F)	 841. 615 130.0
Safety Injection Delay, total (sec) (from beginning of event) Minimum Safeguards Maximum Safeguards	 41.7 16.4
Note: Core Thermal Power, RCS Total Flowrate, RCS Coolant Temperature, and Steam Generator Secondary Side Mass include appropriate uncertainty and/or allowance.	

TABLE 2 TOTAL PUMPED ECCS FLOW RATE ASSUMING A DIESEL FAILURE (MINIMUM SAFEGUARDS)	
INJECTION MODE (REFLOOD PHASE)	
RCS PRESSURE (psia)	**TOTAL FLOW (lbm/sec)**
14.7	568.96
20.0	556.63
40.0	505.35
60.0	451.60
80.0	388.74
100.0	312.04
120.0	205.81
140.0	64.79
160.0	64.17
180.0	63.55
200.0	62.93
220.0	62.35
INJECTION MODE (POST-REFLOOD PHASE)	
RCS Pressure (psia)	**Total Flow (lbm/sec)**
56.7	460.5
RECIRCULATION MODE	
RCS Pressure (psia)	**Total Flow (lbm/sec)**
14.7	57.67

TABLE 3 TOTAL PUMPED ECCS FLOW RATE ASSUMING NO FAILURE (MAXIMUM SAFEGUARDS)	
INJECTION MODE (REFLOOD PHASE)	
RCS PRESSURE (psia)	**TOTAL FLOW (lbm/sec)**
14.7	807.92
40.0	717.59
60.0	641.27
80.0	552.01
100.0	443.10
120.0	292.25
140.0	92.01
180.0	90.24
220.0	88.54
INJECTION MODE (POST-REFLOOD PHASE)	
RCS Pressure (psia)	**Total Flow (lbm/sec)**
56.7	653.86
RECIRCULATION MODE	
RCS Pressure (psia)	**Total Flow (lbm/sec)**
14.7	429.0

TABLE 4 DOUBLE-ENDED HOT LEG BREAK BLOWDOWN MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)

Note that the Double Ended Hot Leg Break case was not reanalyzed and therefore the results are identical to the Reference 4 results.

	BREAK PATH NO.1 FLOW*		BREAK PATH NO.2 FLOW**	
TIME	FLOW	ENERGY	FLOW	ENERGY
(SECONDS)	(LBM/SEC)	THOUSANDS (BTU/SEC)	(LBM/SEC)	THOUSANDS (BTU/SEC)
.00000	.0	.0	.0	.0
.00105	42983.9	26867.8	42981.9	26865.5
.00420	43862.4	27418.5	43118.6	26936.5
.101	43200.1	27278.3	25072.8	15637.7
.201	32544.3	20691.5	22369.5	13879.0
.301	32654.6	20703.1	20038.9	12278.3
.502	31160.3	19749.0	18082.7	10750.2
.701	30877.5	19612.7	17113.0	9928.0
1.10	29429.1	19014.9	16223.5	9110.1
1.60	27052.6	18011.8	16457.5	9010.4
2.10	23872.7	16399.2	16966.2	9170.0
2.50	21480.2	15016.9	17119.5	9217.6
3.00	19256.8	13566.6	16991.5	9139.3
3.40	18123.7	12690.9	16712.5	8994.9
3.80	17520.1	12115.9	16276.5	8772.8
4.20	17391.6	11865.7	15718.4	8491.2
4.60	17637.7	11790.2	15011.5	8134.9
5.60	18257.8	11649.8	12765.5	6994.9
6.20	18619.9	11651.2	11426.2	6298.1
6.40	14613.0	9868.6	11023.3	6088.4
7.60	14156.6	9354.8	8909.7	4983.0
8.20	13797.0	9017.5	8066.3	4541.7
8.40	13376.7	8759.0	7805.3	4405.5
9.40	12644.7	8157.9	6612.4	3790.8
10.4	11367.2	7337.9	5562.6	3266.5
11.2	10136.0	6637.7	4834.2	2915.3
12.4	7699.3	5440.0	3745.3	2408.8
13.4	5474.5	4514.5	2674.1	1939.5
14.2	3735.0	3661.1	2162.2	1670.7
15.0	2514.7	2807.8	1882.5	1497.3
15.4	2096.6	2428.9	1731.1	1423.3
17.0	1235.6	1513.2	1160.0	1183.4
17.4	1095.2	1356.7	761.8	933.8
18.0	951.6	1181.7	591.7	729.9
18.4	545.1	690.6	459.8	569.5
19.2	109.7	138.9	104.6	131.7
19.8	.0	.0	.0	.0

*mass and energy exiting from the reactor vessel side of the break
**mass and energy exiting from the SG side of the break

TABLE 5 DOUBLE-ENDED HOT LEG BREAK MASS BALANCE (MINIMUM SAFEGUARDS)

Note that the Double Ended Hot Leg Break case was not reanalyzed and therefore the results are identical to the Reference 4 results.

MASS BALANCE				
TIME (SECONDS)		.00	19.80	19.80+ε
		MASS (THOUSANDS) LBM		
Initial	In RCS, Accumulator and Steam Generator	559.81	559.81	559.81
Added Mass	Pumped Injecton	.00	.00	.00
	Total Added	.00	.00	.00
*** Total Available ***		559.81	559.81	559.81
Distribution	Reactor Coolant	404.21	54.12	80.73
	Accumulator	155.60	117.31	90.69
	Total Contents	559.81	171.42	171.42
Effluent	Bread Flow	.00	388.37	388.37
	ECCS Spill	.00	.00	.00
	Total Effluent	.00	388.37	388.37
*** Total Accountable ***		559.81	559.79	559.79

TABLE 6 DOUBLE-ENDED HOT LEG BREAK ENERGY BALANCE (MINIMUM SAFEGUARDS)

Note that the Double Ended Hot Leg Break case was not reanalyzed and therefore the results are identical to the Reference 4 results.

ENERGY BALANCE				
	Time (Seconds)	.00	19.80	19.80+ε
		ENERGY (MILLION) BTU		
Initial Energy	In RCS, Accumulator and Steam Generator	579.75	579.75	579.75
Added Energy	Pumped Injection	.00	.00	.00
	Decay Heat	.00	4.59	4.59
	Heat From Secondary	.00	-3.70	-3.70
	Total Added	.00	.89	.89
*** Total Available ***		579.75	580.64	580.64
DISTRIBUTION	Reactor Coolant	235.41	14.43	17.08
	Accumulator	15.48	11.67	9.02
	Core Stored	19.95	8.34	8.34
	Primary Metal	131.95	124.88	124.88
	Secondary Metal	29.69	28.96	28.96
	Steam Generator	147.27	142.63	142.63
	Total Contents	579.75	330.90	330.90
Effluent	Break Flow	.00	249.25	249.25
	ECCS Spill	.00	.00	.00
	Total Effluent	.00	249.25	249.25
*** Total Accountable ***		579.75	580.15	580.15

TABLE 7 DOUBLE-ENDED PUMP SUCTION BREAK BLOWDOWN MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)				
	BREAK PATH NO.1 FLOW*		BREAK PATH NO.2 FLOW**	
TIME	FLOW	ENERGY	FLOW	ENERGY
(SECONDS)	(LBM/SEC)	THOUSANDS	(LBM/SEC)	THOUSANDS
		(BTU/SEC)		(BTU/SEC)
.00	.0	.0	.0	.0
.00103	82369.3	44575.4	39613.0	21396.9
.00206	40639.7	21952.1	40313.2	21773.9
.10	40014.4	21683.1	19703.5	10630.5
.20	40418.2	22050.6	22114.5	11943.6
.40	41628.5	23156.5	23112.1	12493.1
.60	42044.6	23917.3	21929.8	11864.3
.90	38891.3	22725.6	21401.9	11593.3
1.40	34692.9	21107.2	20452.5	11085.4
1.90	31103.5	19784.9	19672.2	10660.6
2.20	27779.8	18328.9	19201.6	10403.5
2.30	26231.1	17506.2	18728.9	10145.1
2.50	21041.7	14283.8	17868.5	9676.9
2.70	18854.8	12901.2	17322.6	9381.8
3.10	14590.7	10070.2	16134.0	8740.0
3.30	13147.9	9130.5	15626.9	8468.7
3.80	11143.4	7902.9	14768.6	8013.0
4.60	9292.4	6890.9	13804.1	7504.5
5.00	8768.4	6600.6	14508.3	7898.8
6.00	8108.6	6153.6	14258.0	7782.4
7.20	7762.4	5769.8	13466.2	7340.8
7.60	8204.2	6018.9	13210.9	7196.5
8.00	7055.5	5844.7	12857.2	6997.6
9.20	6343.3	5217.4	11642.6	6333.8
10.4	5880.6	4699.4	10474.0	5693.8
12.6	4536.3	3700.5	8390.0	4566.7
13.6	4023.1	3245.7	7577.3	3881.4
13.8	3930.0	3183.0	7708.0	3882.4
14.0	3835.6	3130.0	6997.4	3468.2
14.4	3633.6	3035.8	7786.4	3768.2
14.6	3547.2	3010.4	6186.0	2962.9
15.0	3333.8	2946.7	7304.1	3420.1
15.2	3246.0	2944.8	5595.3	2609.2
15.4	3125.1	2924.7	7215.7	3297.6
15.6	2935.1	2866.5	10810.9	4993.0
15.8	2810.5	2891.9	5649.8	2615.6
16.0	2572.0	2822.2	4374.9	2017.3

TABLE 7 (Cont'd) DOUBLE-ENDED PUMP SUCTION BREAK BLOWDOWN MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)				
	BREAK PATH NO.1 FLOW*		BREAK PATH NO.2 FLOW**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
16.2	2267.6	2650.3	7592.5	3305.4
16.4	2071.7	2512.1	6159.1	2654.5
16.6	1905.4	2338.6	3673.2	1576.6
17.0	1596.8	1975.2	3608.2	1466.4
17.2	1461.4	1812.4	4016.0	1562.9
17.8	1134.6	1415.4	3057.2	1139.0
18.4	875.9	1097.0	3093.2	1062.9
18.8	691.7	868.4	3631.8	1168.5
19.2	538.3	677.0	3391.0	1053.5
20.0	277.9	350.4	2456.6	732.7
20.8	132.3	167.4	1659.0	479.3
21.4	.0	.0	1281.4	367.6
22.6	.0	.0	.0	.0

* - Mass and Energy exiting the SG side of the break
** - Mass and Energy exiting the pump side of break

TABLE 8 DOUBLE-ENDED PUMP SUCTION BREAK REFLOOD MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)

	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
22.6	.0	.0	.0	.0
23.6	.0	.0	.0	.0
23.7	54.9	64.6	.0	.0
23.8	15.2	17.9	.0	.0
23.9	8.0	9.4	.0	.0
24.1	11.1	13.1	.0	.0
24.7	39.2	46.1	.0	.0
26.7	83.0	97.6	.0	.0
27.7	98.8	116.4	.0	.0
30.7	136.2	160.4	.0	.0
31.7	151.5	178.5	2664.1	398.4
32.7	156.2	184.0	3342.8	504.1
33.7	155.5	183.2	3301.8	501.0
35.7	153.8	181.2	3169.0	486.5
36.7	153.0	180.2	3105.0	479.5
37.6	152.2	179.3	3049.2	473.3
37.7	152.2	179.3	3043.1	472.6
38.7	151.4	178.3	2983.3	465.9
39.7	150.7	177.5	2925.4	459.4
40.7	149.9	176.6	2869.4	453.1
41.7	149.2	175.8	2815.2	447.0
43.7	147.9	174.2	2712.0	435.3
45.7	146.7	172.8	2615.0	424.2
46.3	146.3	172.3	2587.0	420.9
46.7	147.0	173.2	2817.5	432.0
47.7	145.1	170.9	271.1	148.8
55.7	140.6	165.6	265.9	142.7
59.7	138.5	163.1	263.5	139.9
73.7	132.1	155.6	256.2	131.3
81.7	129.1	152.0	252.7	127.1
87.7	127.0	149.6	250.2	124.3
89.7	126.4	148.8	249.5	123.4
97.7	124.0	146.0	246.6	120.0
115.7	119.5	140.7	242.3	113.8
123.7	117.8	138.7	241.5	111.7
131.7	116.4	137.0	242.0	110.0
135.7	115.7	136.2	242.7	109.4
141.7	114.7	135.1	244.6	108.6

TABLE 8 (Cont'd) DOUBLE-ENDED PUMP SUCTION BREAK REFLOOD MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)

	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
TIME	FLOW	ENERGY	FLOW	ENERGY
(SECONDS)	(LBM/SEC)	THOUSANDS (BTU/SEC)	(LBM/SEC)	THOUSANDS (BTU/SEC)
149.7	113.5	133.7	248.5	107.9
157.7	112.3	132.2	253.7	107.6
165.7	111.1	130.8	260.0	107.3
167.7	110.7	130.4	261.7	107.3
171.7	110.0	129.6	265.1	107.2
187.7	107.0	125.9	278.6	106.5
195.7	105.2	123.9	284.8	105.8
197.7	104.8	123.4	286.2	105.6
205.7	102.9	121.2	291.7	104.7
213.7	101.0	118.9	296.7	103.6
229.7	97.0	114.2	305.6	101.1
230.5	96.8	113.9	306.0	100.9

* - Mass and Energy exiting the SG side of the break

** - Mass and Energy exiting the pump side of break

TABLE 9 DOUBLE-ENDED PUMP SUCTION BREAK PRINCIPLE PARAMETERS DURING REFLOOD (MINIMUM SAFEGUARDS)

	FLOODING						INJECTION			
Time (Seconds)	Temp (Deg-F)	Rate (in/Sec)	Carryover Fraction	Core Height (Ft)	Dwncomer Height (Ft)	Flow Frac	Total (Lb_m/Sec)	Accum (Lb_m/Sec)	Spill (Lb_m/Sec)	Enthalpy (Btu/Lb_m)
22.6	185.3	.000	.0	.00	.00	.333	.0	.0	.0	.00
23.4	183.7	21.232	.0	.64	1.02	.000	4769.9	4769.9	.0	99.46
23.5	183.3	22.002	.0	.82	1.03	.000	4754.9	4754.9	.0	99.46
23.6	183.0	21.833	.0	1.01	1.03	.000	4740.0	4740.0	.0	99.46
23.9	182.6	2.032	.085	1.29	1.47	.203	4674.6	4674.6	.0	99.46
24.4	182.7	2.369	.163	1.38	2.49	.340	4601.1	4601.1	.0	99.46
25.3	182.9	2.242	.293	1.50	4.19	.398	4488.1	4488.1	.0	99.46
26.7	183.4	2.181	.435	1.66	6.94	.420	4313.6	4313.6	.0	99.46
30.5	184.7	2.447	.606	2.00	14.04	.435	3914.7	3914.7	.0	99.46
31.7	185.1	2.564	.631	2.10	15.49	.450	3808.1	3808.1	.0	99.46
34.7	186.4	2.444	.666	2.32	15.57	.456	3564.1	3564.1	.0	99.46
37.6	187.6	2.354	.683	2.50	15.57	.454	3360.5	3360.5	.0	99.46
46.3	191.8	2.211	.705	3.00	15.57	.450	2871.1	2871.1	.0	99.46
46.7	192.0	2.213	.706	3.03	15.57	.450	3103.0	2643.6	.0	94.81
47.7	192.6	2.212	.708	3.08	15.56	.445	460.0	.0	.0	68.03
55.8	197.2	2.124	.714	3.50	15.30	.444	460.0	.0	.0	68.03
66.0	204.0	2.039	.719	4.00	15.06	.443	460.1	.0	.0	68.03
76.7	211.9	1.966	.722	4.50	14.89	.443	460.1	.0	.0	68.03
88.0	220.5	1.900	.725	5.00	14.80	.442	460.2	.0	.0	68.03
99.7	228.5	1.841	.728	5.50	14.78	.442	460.2	.0	.0	68.03
111.9	235.8	1.789	.731	6.00	14.82	.441	460.2	.0	.0	68.03
125.7	242.9	1.738	.734	6.54	14.94	.441	460.3	.0	.0	68.03

TABLE 9 (Cont'd) DOUBLE-ENDED PUMP SUCTION BREAK PRINCIPLE PARAMETERS DURING REFLOOD (MINIMUM SAFEGUARDS)

	FLOODING						INJECTION			
Time (Seconds)	Temp (Deg-F)	Rate (in/Sec)	Carryover Fraction	Core Height (Ft)	Dwncomer Height (Ft)	Flow Frac	Total (Lb_m/Sec)	Accum (Lb_m/Sec)	Spill (Lb_m/Sec)	Enthalpy (Btu/Lb_m)
137.8	248.5	1.699	.737	7.00	15.07	.442	460.2	.0	.0	68.03
151.7	254.1	1.657	.741	7.51	15.24	.443	460.2	.0	.0	68.03
165.8	259.1	1.613	.744	8.00	15.38	.444	460.2	.0	.0	68.03
181.7	264.0	1.558	.748	8.53	15.49	.445	460.1	.0	.0	68.03
196.3	267.9	1.503	.751	9.00	15.54	.446	460.1	.0	.0	68.03
213.7	272.0	1.434	.755	9.53	15.57	.447	460.1	.0	.0	68.03
230.5	275.4	1.365	.759	10.00	15.57	.448	460.1	.0	.0	68.03

TABLE 10 DOUBLE ENDED PUMP SUCTION BREAK POST-REFLOOD MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)

	BREAK PATH NO.1*		BREAK PATH NO.2**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
230.6	104.8	132.0	355.6	104.0
235.6	105.5	132.9	354.9	103.6
260.6	104.0	131.0	356.4	103.0
265.6	104.7	131.8	355.8	102.6
290.6	103.1	129.9	357.3	102.0
295.6	103.8	130.7	356.7	101.6
320.6	102.2	128.7	358.2	101.0
325.6	102.8	129.5	357.6	100.6
350.6	101.2	127.5	359.2	100.0
355.6	101.8	128.3	358.6	99.6
380.6	100.2	126.2	360.2	98.9
385.6	100.8	127.0	359.6	98.6
410.6	99.4	125.1	361.1	97.9
415.6	100.0	126.0	360.4	97.5
435.6	99.9	125.9	360.5	98.9
460.6	98.7	124.3	361.8	98.1
465.6	99.3	125.1	361.1	97.7
490.6	98.0	123.5	362.4	96.8
510.6	98.6	124.3	361.8	97.9
530.6	97.6	122.9	362.9	97.2
535.6	98.1	123.6	362.3	96.8
555.6	97.0	122.1	363.5	96.0
580.6	97.1	122.3	363.3	96.8
615.6	95.8	120.7	364.6	95.1
630.6	96.5	121.5	364.0	96.2
665.6	95.0	119.7	365.4	94.4
675.6	95.8	120.7	364.6	95.5
700.6	94.8	119.4	365.7	94.1
715.6	95.1	119.7	365.4	95.0
760.6	93.9	118.3	366.5	93.8
835.6	93.6	117.9	366.8	92.7
935.6	92.1	116.0	368.4	92.3
940.6	51.9	65.4	408.6	102.0
1120.3	51.9	65.4	408.6	102.0
1120.4	58.1	72.3	402.4	98.2
1151.3	57.5	66.2	402.9	31.3

TABLE 10 (Cont'd.)	DOUBLE ENDED PUMP SUCTION BREAK POST-REFLOOD MASS AND ENERGY RELEASES (MINIMUM SAFEGUARDS)			
	BREAK PATH NO.1*		BREAK PATH NO.2**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
2442.0	48.5	55.8	412.0	33.0
2442.1	48.5	55.8	41.3	15.5
3042.0	46.1	53.0	43.7	16.0
3042.1	46.1	53.0	560.2	126.4
3600.0	43.8	50.4	562.4	126.8
3600.1	36.4	41.9	569.8	116.8
4620.0	33.5	38.5	572.7	117.4
4620.1	31.5	36.3	26.1	3.8
6000.1	28.9	33.2	28.8	4.2
10000.0	24.9	28.7	32.7	4.8
39600.0	17.3	19.9	40.4	5.9
100000.0	13.3	15.3	44.4	6.4
500000.1	7.6	8.8	50.0	6.8
1000000.0	5.7	6.5	52.0	7.0

* - Mass and Energy exiting the SG side of the break
** - Mass and Energy exiting the pump side of break

TABLE 11 DOUBLE-ENDED PUMP SUCTION BREAK MASS BALANCE (MINIMUM SAFEGUARDS)

MASS BALANCE

	Time (Seconds)	.00	22.60	22.60	230.53	1120.39	1151.23	3600.00
		MASS (THOUSAND LBM)						
Initial	In RCS and Accumulator	559.81	559.81	559.81	559.81	559.81	559.81	559.81
Added Mass	Pumped Injection	.00	.00	.00	84.67	494.37	508.57	1495.05
	Total Added	.00	.00	.00	84.67	494.37	508.57	1495.05
*** Total Available ***		559.81	559.81	559.81	644.48	1054.18	1068.38	2054.86
Distribution	Reactor Coolant	404.21	37.83	59.43	113.73	113.73	113.73	113.73
	Accumulator	155.60	110.76	89.15	.00	.00	.00	.00
	Total Contents	559.81	148.58	148.58	113.73	113.73	113.73	113.73
Effluent	Break Flow	.00	411.22	411.22	530.74	940.44	954.64	1941.11
	ECCS Spill	.00	.00	.00	.00	.00	.00	.00
	Total Effluent	.00	411.22	411.22	530.74	940.44	954.64	1941.11
*** Total Accountable ***		559.81	559.80	559.80	644.47	1054.17	1068.36	2054.84

TABLE 12 DOUBLE -ENDED PUMP SUCTION BREAK ENERGY BALANCE (MINIMUM SAFEGUARDS)								
		ENERGY BALANCE						
	Time (Seconds)	.00	22.60	22.60	230.53	1120.39	1151.23	3600.0
		ENERGY (MILLION BTU)						
Initial Energy	In RCS, Accumulator and Steam Generator	592.79	592.79	592.79	592.79	592.79	592.79	592.79
Added Energy	Pumped Injection	.00	.00	.00	5.76	33.63	34.60	152.73
	Decay Heat	.00	4.63	4.63	20.91	70.13	71.61	168.33
	Heat From Secondary	.00	8.35	8.35	8.35	8.36	8.36	8.36
	Total Added	.00	12.98	12.98	35.02	112.12	114.57	329.42
*** Total Available ***		592.79	605.77	605.77	627.82	704.92	707.36	922.21
Distribution	Reactor Coolant	235.41	8.23	10.37	29.53	29.53	29.53	29.53
	Accumulator	15.48	11.02	8.87	.00	.00	.00	.00
	Core Stored	19.95	10.99	10.99	3.82	3.74	3.72	2.68
	Primary Metal	131.95	126.14	126.14	101.87	58.92	58.10	41.83
	Secondary Metal	29.69	29.30	29.30	26.69	15.37	15.07	10.85
	Steam Generator	160.31	171.42	171.42	153.05	83.34	81.83	58.24
	Total Contents	592.79	357.09	357.09	314.96	190.89	188.25	143.13
Effluent	Break Flow	.00	248.21	248.21	305.46	506.63	496.24	758.02
	ECCS Spill	.00	.00	.00	.00	.00	.00	.00
	Total Effluent	.00	248.21	248.21	305.46	506.63	496.24	758.02
*** Total Accountable ***		592.79	605.31	605.31	620.42	697.52	684.49	901.15

TABLE 13 DOUBLE-ENDED PUMP SUCTION BREAK BLOWDOWN MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	BREAK PATH NO. 1 FLOW*		BREAK PATH NO. 2 FLOW**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
.0000	.0	.0	.0	.0
.00103	82365.3	44573.2	39618.3	21399.7
.00206	40639.7	21952.1	40313.1	21773.9
.101	40102.2	21732.2	19713.5	10635.9
.202	40673.3	22197.4	22178.2	11978.1
.301	41398.2	22799.7	23342.2	12613.7
.402	42176.3	23481.5	23249.1	12567.5
.602	42826.5	24394.4	22110.8	11962.9
.701	42111.3	24227.3	21855.6	11831.1
.902	39535.1	23132.5	21680.9	11745.5
1.40	35231.4	21460.7	21018.9	11393.6
1.70	33014.7	20601.2	20719.7	11230.1
1.90	31209.1	19889.1	20150.9	10919.0
2.20	27668.3	18276.1	19177.1	10387.9
2.30	25944.3	17333.0	18782.8	10173.0
2.50	20498.7	13919.7	17990.0	9741.9
2.70	18694.1	12804.5	17279.4	9356.8
3.10	14645.1	10142.2	16275.6	8817.1
3.40	12575.4	8813.5	15660.0	8488.9
3.60	11768.7	8310.2	15288.7	8291.1
3.90	10944.0	7812.6	14577.6	7909.6
4.40	9876.7	7210.7	13917.6	7561.1
4.80	9212.2	6860.6	14624.2	7956.6
5.40	8708.8	6604.3	14625.1	7969.0
5.80	8344.7	6416.4	14413.0	7858.8
6.80	7933.9	6059.9	13773.3	7505.8
7.20	7968.6	5947.3	13471.8	7335.3
7.60	8515.3	6345.5	13261.4	7216.6
8.00	7153.8	5957.4	12797.8	6958.1
8.80	6686.5	5571.5	11953.3	6499.7
10.6	5928.9	4735.8	10193.7	5540.5
12.4	4762.6	3790.2	8439.2	4594.3
13.6	4138.0	3299.6	7605.2	3833.9
14.0	3921.7	3200.1	7430.1	3638.1
14.4	3704.0	3127.1	6690.8	3193.9
14.6	3591.1	3098.9	6971.9	3291.3
14.8	3478.8	3079.6	6376.1	2984.0
15.2	3211.6	3044.7	6593.4	3015.4

TABLE 13 (Cont'd) DOUBLE-ENDED PUMP SUCTION BREAK BLOWDOWN MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	BREAK PATH NO. 1 FLOW*		BREAK PATH NO. 2 FLOW**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
15.4	3063.9	3038.3	5849.1	2651.6
15.8	2546.0	2853.0	5382.8	2363.7
16.2	2126.3	2581.4	4430.1	1882.9
17.0	1496.5	1857.4	3590.1	1414.1
17.6	1148.4	1433.4	3769.2	1366.7
18.0	956.8	1197.7	4261.2	1463.9
18.2	779.6	977.4	4243.9	1428.8
18.6	481.9	605.8	3429.2	1130.4
19.6	152.8	193.1	565.8	188.3
20.2	79.9	101.3	858.0	287.2
20.4	58.9	74.9	785.6	261.5
21.0	.0	.0	.0	.0

* - Mass and Energy exiting the SG side of the break
** - Mass and Energy exiting the pump side of break

TABLE 14 DOUBLE-ENDED PUMP SUCTION BREAK REFLOOD MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	BREAK PATH NO. 1*		BREAK PATH NO. 2*	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
21.0	.0	.0	.0	.0
21.5	.0	.0	217.9	14.8
21.9	.0	.0	217.9	14.8
22.0	44.0	51.7	217.9	14.8
22.1	23.6	27.8	217.9	14.8
22.6	49.9	58.7	217.9	14.8
23.3	79.4	93.4	217.9	14.8
25.0	126.8	149.4	217.9	14.8
26.0	161.5	190.2	4103.2	545.9
27.0	165.9	195.5	4559.5	612.9
28.0	164.6	193.9	4472.9	604.0
30.0	162.1	191.0	4297.7	585.5
31.0	160.9	189.6	4213.6	576.5
32.0	159.8	188.3	4132.6	567.8
33.0	158.8	187.1	4054.8	559.4
34.0	157.8	185.9	3980.1	551.3
34.8	157.0	185.0	3922.5	545.0
35.0	156.9	184.8	3908.4	543.5
36.0	155.9	183.7	3839.5	535.9
37.0	155.1	182.7	3773.3	528.7
39.0	153.4	180.7	3648.4	514.9
41.0	151.9	178.9	3532.4	502.1
43.0	150.5	177.2	3424.3	490.1
45.0	149.1	175.7	3323.2	478.8
47.0	147.9	174.2	3228.2	468.1
48.0	142.9	168.3	405.6	141.7
49.0	145.4	171.3	401.0	143.8
53.0	144.3	169.9	404.9	143.4
61.0	142.1	167.4	411.4	142.5
65.0	141.1	166.2	414.4	142.0
81.0	137.3	161.7	424.8	140.0
86.0	136.1	160.3	427.8	139.4
102.0	132.4	155.9	436.8	137.2
104.0	131.9	155.4	437.9	136.9
112.0	130.1	153.2	442.2	135.8
114.0	129.6	152.6	443.3	135.5
122.0	127.7	150.3	447.6	134.4

Table 14 (Cont'd) DOUBLE-ENDED PUMP SUCTION BREAK REFLOOD MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	Break Flow Path No.1*		Break Flow Path No.2**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
138.0	123.8	145.7	456.2	132.0
142.0	122.8	144.6	458.3	131.4
150.0	120.8	142.2	462.6	130.3
152.0	120.3	141.6	463.7	130.0
168.0	116.2	136.8	472.4	127.6
170.0	115.6	136.2	473.4	127.3
186.0	111.6	131.3	482.1	125.0
188.0	111.0	130.7	483.1	124.7
204.0	107.0	126.0	491.8	122.6
206.0	106.5	125.4	492.9	122.3
238.0	98.7	116.2	510.7	118.6
246.0	96.9	114.1	515.4	117.9
246.6	96.8	113.9	515.8	117.9

* - Mass and Energy exiting the SG side of the break
** - Mass and Energy exiting the pump side of break

TABLE 15 DOUBLE-ENDED PUMP SUCTION BREAK PRINCIPLE PARAMETERS DURING REFLOOD (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	FLOODING						INJECTION			
Time (Seconds)	Temp (Deg-F)	Rate (in/Sec)	Carryover Fraction	Core Height (Ft)	Dwncomer Height (Ft)	Flow Frac	Total (Lb_m/Sec)	Accum (Lb_m/Sec)	Spill (Lb_m/Sec)	Enthalpy (Btu/Lb_m)
21.0	220.3	.000	.000	.00	.00	.333	.0	.0	.0	.00
21.7	217.4	25.116	.000	.65	1.65	.000	5770.3	5116.4	.0	95.90
21.9	215.6	28.495	.000	1.10	1.60	.000	5716.6	5062.7	.0	95.87
22.3	214.8	2.912	.137	1.35	2.94	.365	5641.1	4987.2	.0	95.82
22.4	214.8	2.929	.163	1.37	3.31	.383	5615.8	4961.9	.0	95.80
23.1	214.6	2.758	.303	1.50	6.01	.418	5498.6	4844.7	.0	95.72
23.9	214.6	2.681	.410	1.61	8.87	.429	5380.9	4727.0	.0	95.64
26.0	214.4	2.936	.569	1.86	15.53	.464	5077.9	4426.7	.0	95.43
27.0	214.4	2.795	.604	1.95	15.57	.469	4965.6	4315.3	.0	95.34
27.6	214.4	2.716	.620	2.01	15.57	.469	4896.6	4246.2	.0	95.29
34.8	215.6	2.347	.694	2.50	15.57	.462	4235.0	3583.7	.0	94.63
43.8	218.5	2.198	.716	3.00	15.57	.457	3667.3	3015.3	.0	93.87
48.0	220.2	2.150	.720	3.21	15.57	.448	654.2	.0	.0	68.04
49.0	220.6	2.156	.722	3.26	15.57	.448	652.9	.0	.0	68.04
53.8	223.1	2.124	.726	3.50	15.57	.448	652.9	.0	.0	68.03
64.4	230.0	2.064	.732	4.00	15.57	.449	652.9	.0	.0	68.04
76.0	238.1	2.006	.738	4.52	15.57	.449	652.9	.0	.0	68.04
87.2	244.8	1.955	.742	5.00	15.57	.449	652.8	.0	.0	68.03
100.0	251.5	1.899	.746	5.53	15.57	.450	652.8	.0	.0	68.04
112.1	256.9	1.848	.750	6.00	15.57	.450	652.9	.0	.0	68.04
126.0	262.3	1.789	.754	6.53	15.57	.450	652.9	.0	.0	68.04
139.3	266.8	1.733	.758	7.00	15.57	.451	652.9	.0	.0	68.03

TABLE 15 DOUBLE-ENDED PUMP SUCTION BREAK PRINCIPLE PARAMETERS DURING REFLOOD
(Cont'd) (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	FLOODING							INJECTION		
Time (Seconds)	Temp (Deg-F)	Rate (in/Sec)	Carryover Fraction	Core Height (Ft)	Dwncomer Height (Ft)	Flow Frac	Total (Lb_m/Sec)	Accum (Lb_m/Sec)	Spill (Lb_m/Sec)	Enthalpy (Btu/Lb_m)
156.0	271.6	1.662	.764	7.57	15.57	.451	652.9	.0	.0	68.04
169.7	274.9	1.603	.768	8.00	15.57	.451	652.9	.0	.0	68.04
188.0	278.8	1.526	.774	8.55	15.57	.451	653.0	.0	.0	68.04
204.4	281.8	1.457	.781	9.00	15.57	.450	653.1	.0	.0	68.04
226.0	285.1	1.367	.792	9.54	15.57	.450	653.1	.0	.0	68.04
246.6	287.7	1.281	.807	10.00	15.57	.449	653.2	.0	.0	68.04

TABLE 16 DOUBLE-ENDED PUMP SUCTION BREAK POST-REFLOOD MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	BREAK PATH NO. 1*		BREAK PATH NO. 2**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
246.7	104.2	130.6	549.6	111.2
271.7	103.5	129.7	550.3	110.4
276.7	104.1	130.4	549.7	110.1
291.7	103.1	129.2	550.7	109.7
296.7	103.6	129.9	550.2	109.3
306.7	103.0	129.1	550.8	109.1
311.7	103.5	129.7	550.3	108.8
326.7	102.5	128.5	551.3	108.4
331.7	103.0	129.1	550.8	108.1
341.7	102.3	128.3	551.5	107.8
346.7	102.8	128.9	551.0	107.5
356.7	102.1	128.0	551.7	107.2
361.7	102.6	128.6	551.2	109.2
376.7	102.4	128.3	551.4	108.6
401.7	101.4	127.1	552.4	107.7
406.7	101.9	127.7	551.9	107.3
416.7	101.4	127.1	552.4	107.0
436.7	101.8	127.6	552.0	106.0
451.7	100.9	126.5	552.9	105.5
481.7	101.4	127.1	552.4	106.2
506.7	100.5	125.9	553.3	105.1
531.7	100.9	126.5	552.9	103.7
581.7	99.8	125.1	554.0	103.3
591.7	100.3	125.7	553.5	102.6
606.7	99.6	124.9	554.2	103.9
616.7	100.1	125.4	553.8	103.2
636.7	99.4	124.6	554.4	102.1
656.7	99.8	125.1	554.0	102.7
786.7	98.4	123.4	555.4	100.1
791.7	54.0	67.7	599.8	112.8
1029.3	54.0	67.7	599.8	112.8
1029.4	57.5	71.4	596.3	108.7
1144.7	57.5	71.4	596.3	108.7
1144.8	56.1	64.6	597.7	41.0
1824.0	50.1	57.6	603.7	42.1
1824.1	50.1	57.6	41.4	11.7
2424.0	47.1	54.2	44.4	12.3

TABLE 16 DOUBLE-ENDED PUMP SUCTION BREAK POST-REFLOOD MASS AND ENERGY RELEASES (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

	BREAK PATH NO. 1*		BREAK PATH NO. 2**	
TIME (SECONDS)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)	FLOW (LBM/SEC)	ENERGY THOUSANDS (BTU/SEC)
2424.1	47.1	54.2	571.8	125.0
3600.0	42.3	48.7	576.6	125.9
3600.1	36.4	41.9	582.5	119.4
4002.0	34.8	40.0	584.1	119.8
4002.1	32.7	37.6	475.3	69.4
4560.0	31.6	36.4	476.4	69.5
4560.1	31.6	36.4	111.8	16.3
10000.0	24.9	28.7	118.5	17.2
39600.0	17.3	19.9	126.2	18.4
39600.1	17.3	19.9	412.2	59.8
100000.0	13.3	15.3	416.2	60.3
500000.1	7.6	8.8	421.9	57.0
1000000.0	5.7	6.5	423.9	57.2

* - Mass and Energy exiting the SG side of the break
** - Mass and Energy exiting the pump side of break

TABLE 17 DOUBLE-ENDED PUMP SUCTION BREAK MASS BALANCE (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

MASS BALANCE								
	Time (Seconds)	.00	21.00	21.00+ε	246.641	1029.37	1144.72	3600.00
		MASS (THOUSAND LBM)						
Initial	In RCS and ACC	559.81	559.81	559.81	559.81	559.81	559.81	559.81
Added Mass	Pumped Injection	.00	.00	.00	147.24	658.96	734.37	1961.21
	Total Added	.00	.00	.00	147.24	658.96	734.37	1961.21
*** Total Available ***		559.81	559.81	559.81	707.05	1218.77	1294.18	2521.02
Distribution	Reactor Coolant	404.21	34.89	54.16	96.52	96.52	96.52	96.52
	Accumulator	155.60	118.50	99.23	.00	.00	.00	.00
	Total Contents	559.81	153.39	153.39	96.52	96.52	96.52	96.52
Effluent	Break Flow	.00	406.41	406.41	610.521	1122.24	1197.65	2424.49
	ECCS Spill	.00	.00	.00	.00	.00	.00	.00
	Total Effluent	.00	406.41	406.41	610.521	1122.24	1197.65	2424.49
*** Total Accountable ***		559.81	559.80	559.80	707.041	1218.76	1294.17	2521.01

TABLE 18 DOUBLE -ENDED PUMP SUCTION BREAK ENERGY BALANCE (MAXIMUM SAFEGUARDS)

Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 results.

		ENERGY BALANCE						
	Time (Seconds)	.00	21.00	21.00+ε	246.64	1029.37	1144.72	3600.00
		ENERGY (MILLION BTU)						
Initial Energy	In RCS, Accumulator and Steam Generator	579.75	579.75	579.75	579.75	579.75	579.75	579.75
Added Energy	Pumped Injection	.00	.00	.00	10.02	44.83	49.96	237.89
	Decay Heat	.00	4.42	4.42	21.95	65.66	71.25	168.04
	Heat From Secondary	.00	-3.52	-3.52	-3.52	-1.47	-1.47	-1.47
	Total Added	.00	.90	.90	28.45	109.02	119.74	404.46
*** Total Available ***		579.75	580.65	580.65	608.2	688.77	699.49	984.21
Distribution	Reactor Coolant	235.41	9.70	11.62	26.38	26.38	26.38	26.38
	Accumulator	15.48	11.79	9.87	.00	.00	.00	.00
	Core Stored	19.95	11.08	11.08	3.82	3.64	3.60	2.68
	Primary Metal	131.95	125.79	125.79	101.18	59.26	56.21	43.04
	Secondary Metal	29.69	29.45	29.45	26.21	15.74	14.59	11.35
	Steam Generator	147.27	145.70	145.70	125.97	73.13	67.88	52.78
	Total Contents	579.75	333.50	333.50	283.56	178.16	168.66	136.23
Effluent	Break Flow	.00	246.68	246.68	317.22	503.20	507.02	825.43
	ECCS Sill	.00	.00	.00	.00	.00	.00	.00
	Total Effluent	.00	246.68	246.68	317.22	503.20	507.02	825.43
*** Total Accountable ***		579.75	580.18	580.18	600.79	681.36	675.68	961.66

TABLE 19 DECAY HEAT CURVE 1979 ANS PLUS 2 SIGMA UNCERTAINTY

Time (sec)	Decay Heat Generation Rate (P/P_0)
1.00E+01	0.053876
1.50E+01	0.050401
2.00E+01	0.048018
4.00E+01	0.042401
6.00E+01	0.039244
8.00E+01	0.037065
1.00E+02	0.035466
1.50E+02	0.032724
2.00E+02	0.030936
4.00E+02	0.027078
6.00E+02	0.024931
8.00E+02	0.023389
1.00E+03	0.022156
1.50E+03	0.019921
2.00E+03	0.018315
4.00E+03	0.014781
6.00E+03	0.013040
8.00E+03	0.012000
1.00E+04	0.011262
1.50E+04	0.010097
2.00E+04	0.009350
4.00E+04	0.007778
6.00E+04	0.006958
8.00E+04	0.006424
1.00E+05	0.006021
1.50E+05	0.005323
4.00E+05	0.003770
6.00E+05	0.003201
8.00E+05	0.002834
1.00E+06	0.002580

Long Term LOCA Containment Response (COCO) Analysis

Accident Description

The HBRSEP Unit No.2 Steam Electric Plant, Unit No.2 containment system is designed such that for all loss-of-coolant accident (LOCA) break sizes, up to and including the double-ended severance of a reactor coolant pipe, the containment peak pressure remains below the design pressure. This section details the containment response subsequent to a hypothetical LOCA. The containment response analysis uses the long term mass and energy release data discussed in previous sections.

The containment response analysis demonstrates the acceptability of the containment safeguards systems to mitigate the consequences of a LOCA inside containment. The impact of LOCA mass and energy releases on the containment pressure is addressed to assure that the containment pressure remains below its design pressure at the licensed core power conditions. In support of equipment design and licensing criteria (e.g. qualified operating life), with respect to post accident environmental conditions, long term containment pressure and temperature transients are generated to conservatively bound the potential post-LOCA containment conditions.

Input Parameters and Assumptions

An analysis of containment response to the rupture of the RCS must start with knowledge of the initial conditions in the containment. The pressure, temperature, and humidity of the containment atmosphere prior to the postulated accident are specified in the analysis as shown in Table 20.

Also, values for the initial temperature of the service water (SW) and refueling water storage tank (RWST) are assumed, along with containment spray (CS) pump flowrate and Reactor Containment Fan Cooler (RCFC) heat removal performance. All of these values are chosen conservatively, as shown in Table 20. Long term sump recirculation is addressed via Residual Heat Removal System (RHR) heat exchanger performance. The primary function of the RHR system is to remove heat from the core by way of Emergency Core Cooling System (ECCS). Table 20 provides the RHR system parameters assumed in the analysis.

A series of cases was performed for the LOCA containment response. Previous sections have documented the M&E releases for the minimum and maximum safeguards cases for a DEPS break and the releases from the blowdown of a DEHL break.

For the maximum safeguards DEPS case a failure of a containment spray pump was assumed as the single failure, which leaves available as active heat removal systems, one containment spray pump and four RCFCs. Table 22 provides the performance data for one spray pump in operation. (Note: For the Maximum safeguards case a limiting assumption was made concerning the modeling of the recirculation system, i.e., heat exchangers. Minimum safeguards data was conservatively used to model the RHR heat

exchangers, i.e., one RHR Hx was credited for residual heat removal. Emergency safeguards equipment data is given in Table 20.)

The minimum safeguards case was based upon a diesel train failure (which leaves available as active heat removal systems one containment spray pump and 2 RCFCs). Due to the duration of the DEHL transient (i.e. blowdown only), no containment safeguards equipment is modeled.

The calculations for the new DEPS case with minimum ECCS flows were performed out to 100,000 seconds (approximately 1.6 days). The DEHL cases were terminated soon after the end of the blowdown. The sequence of events for each of these cases is shown in Tables 23 through 25.

The following are the major assumptions made in the analysis.

(a) The mass and energy released to the containment are described in the previous sections for LOCA.

(b) Homogeneous mixing is assumed. The steam-air mixture and the water phases each have uniform properties. More specifically, thermal equilibrium between the air and the steam is assumed. However, this does not imply thermal equilibrium between the steam-air mixture and the water phase.

(c) Air is taken as an ideal gas, while compressed water and steam tables are employed for water and steam thermodynamic properties.

(d) For the blowdown portion of the LOCA analysis, the discharge flow separates into steam and water phases at the breakpoint. The saturated water phase is at the total containment pressure, while the steam phase is at the partial pressure of the steam in the containment. For the post-blowdown portion of the LOCA analysis, steam and water releases are input separately.

(e) The saturation temperature at the partial pressure of the steam is used for heat transfer to the heat sinks and the fan coolers.

<u>Description of COCO Model</u>

Calculation of containment pressure and temperature is accomplished by use of the digital computer code COCO (Reference 11). COCO is a mathematical model of a generalized containment; the proper selection of various options in the code allows the creation of a specific model for particular containment design. The values used in the specific model for different aspects of the containment are derived from plant-specific input data. The COCO code has been used and found acceptable to calculate containment pressure transients for many dry containment plants, most recently including Vogtle Units 1 and 2, Turkey Point Unit 3, Salem Units 1 and 2, Diablo Canyon Units 1 and 2, Indian Point Unit 2, and Indian Point 3. Transient phenomena within the

reactor coolant system affect containment conditions by means of convective mass and energy transport through the pipe break.

For analytical rigor and convenience, the containment air-steam-water mixture is separated into a water (pool) phase and a steam-air phase. Sufficient relationships to describe the transient are provided by the equations of conservation of mass and energy as applied to each system, together with appropriate boundary conditions. As thermodynamic equations of state and conditions may vary during the transient, the equations have been derived for all possible cases of superheated or saturated steam and subcooled or saturated water. Switching between states is handled automatically by the code.

Passive Heat Removal

The significant heat removal source during the early portion of the transient is the containment structural heat sinks. Provision is made in the containment pressure response analysis for heat transfer through, and heat storage in, both interior and exterior walls. Every wall is divided into a large number of nodes. For each node, a conservation of energy equation expressed in finite-difference form accounts for heat conduction into and out of the node and temperature rise of the node. Table 26 is the summary of the containment structural heat sinks used in the analysis. The thermal properties of each heat sink material are shown in Table 27.

The heat transfer coefficient to the containment structure for the early part of the event is calculated based primarily on the work of Tagami (Reference 12). From this work, it was determined that the value of the heat transfer coefficient can be assumed to increase parabolically to a peak value. In COCO, the value then decreases exponentially to a stagnant heat transfer coefficient which is a function of steam-to-air-weight ratio.

The h for stagnant conditions is based upon Tagami's steady state results.

Tagami presents a plot of the maximum value of the heat transfer coefficient, h, as function of "coolant energy transfer speed", defined as follows:

$$h = \frac{\text{Total Coolant Energy Transferred into Containment}}{\text{(Containment Volume)(Time Interval to Peak Pressure)}}$$

From this, the maximum heat transfer coefficient of steel is calculated:

$$h_{max} = 75\left(\frac{E}{t_p\ V}\right)^{0.60} \qquad \text{(Equation 1)}$$

where:

h_{max} = maximum value of h (Btu/hr ft^2 °F).

t_p = time from start of accident to end of blowdown for LOCA and steam line isolation for secondary breaks (sec).

V = containment net free volume (ft^3).

E = total coolant energy discharge from time zero to t_p(Btu).

75 = material coefficient for steel.

(Note: Paint is accounted for by the thermal conductivity of the material (paint) on the heat sink structure, not by an adjustment on the heat transfer coefficient.)

The basis for the equations is a Westinghouse curve fit to the Tagami data.

The parabolic increase to the peak value is calculated by COCO according to the following equation:

$$h_s = h_{max} \left(\frac{t}{t_p}\right)^{0.5}, \ 0 \leq t \leq t_p \qquad \text{(Equation 2)}$$

where:

h_s = heat transfer coefficient between steel and air/steam mixture (Btu/hr ft^2 °F).

t = time from start of event (sec).

For concrete, the heat transfer coefficient is taken as 40 percent of the value calculated for steel during the blowdown phase.

The exponential decrease of the heat transfer coefficient to the stagnant heat transfer coefficient is given by:

$$h_s = h_{stag} + (h_{max} - h_{stag})e^{-0.05(t-t_p)} \qquad t > t_p \qquad \text{(Equation 3)}$$

where:

h_{stag} = $2 + 50X, 0 \leq X \leq 1.4$.

h_{stag} = h for stagnant conditions (Btu/hr ft^2 °F).

X = steam-to-air weight ratio in containment.

Active Heat Removal

For a large break, the engineered safety features are quickly brought into operation. Because of the brief period of time required to depressurize the reactor coolant system or the main steam system, the containment safeguards are not a major influence on the blowdown peak pressure; however, they reduce the containment pressure after the blowdown and maintain a low long-term pressure and a low long-term temperature.

RWST, Injection

During the injection phase of post-accident operation, the emergency core cooling system pumps water from the refueling water storage tank into the reactor vessel. Since this water enters the vessel at refueling water storage tank temperature, which is less than the temperature of the water in the vessel, it is modeled as absorbing heat from the core until the saturation temperature is reached. Safety injection and containment spray can be operated for a limited time, depending on the refueling water storage tank (RWST) capacity.

RHR, Sump Recirculation

After the supply of refueling water is exhausted, the recirculation system is operated to provide long term cooling of the core. In this operation, water is drawn from the sump, cooled in a residual heat removal (RHR) exchanger, then pumped back into the reactor vessel to remove core residual heat and energy stored in the vessel metal. The heat is removed from the RHR heat exchanger by the component cooling water (CCW). The RHR Hxs and CCW Hxs are coupled in a closed loop system, where the ultimate heat sink is the service water cooling to the CCW Hx.

Containment Spray

Containment spray (CS) is an active removal mechanism which is used for rapid pressure reduction and for containment iodine removal. During the injection phase of operation, the containment spray pumps draw water from the RWST and spray it into the containment through nozzles mounted high above the operating deck. As the spray droplets fall, they absorb heat from the containment atmosphere. Since the water comes from the RWST, the entire heat capacity of the spray from the RWST temperature to the temperature of the containment atmosphere is available for energy absorption. During the recirculation phase there is a short period of no spray during the switchover of the spray pump from the RWST to RHR piggy back mode. Later spray is terminated upon the entry into ECCS hot leg recirculation (11 hours).

When a spray droplet enters the hot, saturated, steam-air containment environment, the vapor pressure of the water at its surface is much less than the partial pressure of the steam in the atmosphere. Hence, there will be diffusion of steam to the drop surface and condensation on the droplet. This mass flow will carry energy to the droplet. Simultaneously, the temperature difference between the atmosphere and the droplet will cause the droplet temperature and vapor pressure to rise. The vapor pressure of the

droplet will eventually become equal to the partial pressure of the steam, and the condensation will cease. The temperature of the droplet will essentially equal the temperature of the steam-air mixture.

The equations describing the temperature rise of a falling droplet are as follows.

$$\frac{d}{dt}(Mu) = mh_g + q \qquad \text{(Equation 4)}$$

where,

M = droplet mass

u = internal energy

m = diffusion rate

h_g = steam enthalpy

q = heat flow rate

t = time

$$\frac{d}{dt}(M) = m \qquad \text{(Equation 5)}$$

where,

$q = h_c A * (T_s - T)$

$m = k_g A * (P_s - P_v)$

A = area

h_c = coefficient of heat transfer

k_g = coefficient of mass transfer

T = droplet temperature

T_s = steam temperature

P_s = steam partial pressure

P_v = droplet vapor pressure

The coefficients of heat transfer (h_c) and mass transfer (k_g) are calculated from the Nusselt number for heat transfer, Nu, and the Nusselt number for mass transfer, Nu'.

Both Nu and Nu' may be calculated from the equations of Ranz and Marshall (Reference 13).

$$Nu = 2 + 0.6(Re)^{1/2}(Pr)^{1/3} \qquad \text{(Equation 6)}$$

where,

Nu = Nusselt number for heat transfer

Pr = Prandtl number

Re = Reynolds number

$$Nu' = 2 + 0.6(Re)^{1/2}(Sc)^{1/3} \qquad \text{(Equation 7)}$$

where,

Nu' = Nusselt number for mass transfer

Sc = Schmidt number

Thus, Equations 4 and 5 can be integrated numerically to find the internal energy and mass of the droplet as a function of time as it falls through the atmosphere. Analysis shows that the temperature of the (mass) mean droplet produced by the spray nozzles rises to a value within 99 percent of the bulk containment temperature in less than 2 seconds. Detailed calculations of the heatup of spray droplets in post-accident containment atmospheres by Parsly (Reference 14) show that droplets of all sizes encountered in the containment spray reach equilibrium in a fraction of their residence time in typical pressurized water reactor containment. These results confirm the assumption that the containment spray will be 100 percent effective in removing heat from the atmosphere.

RCFC

The reactor containment fan coolers (RCFCs) are another means of heat removal. Each RCFC has a fan which draws in the containment atmosphere from the upper volume of the containment via a return air riser. Since the RCFCs do not use water from the RWST, the mode of operation remains the same both before and after the ECCS change to the recirculation mode. The steam/air mixture is routed through the enclosed RCFC unit, past essential service water cooling coils. The fan then discharges the air through ducting containing a check damper. The discharged air is directed at the lower containment volume. See Table 21 for RCFCs heat removal capability assumed for the containment response analyses.

Acceptance Criteria

The containment response for design-basis containment integrity is an ANS Condition IV event, an infrequent fault. The relevant requirements to satisfy Nuclear Regulatory Commission acceptance criteria are as follows.

A. GDC 10 and GDC 49 from the HBRSEP Unit No.2 FSAR Chapter 3.1. In order to satisfy the requirements of GDC 10 and 49, the peak calculated containment pressure should be less than the containment design pressure of 42 psig;

B. HBRSEP Unit No.2 FSAR Chapter 3.1, GDC 52: In order to satisfy the requirements of GDC 52, the calculated pressure at 24 hours should be less than 50% of the peak calculated value. (This is related to the criteria for doses at 24 hours.)

C. HBRSEP Unit No.2 UFSAR Chapter 15.6.5 requirement the calculated pressure at 24 hours should be less than 50% of the peak calculated value.

Analysis Results

The containment pressure, steam temperature and water (sump) temperature profiles from each of the LOCA cases are shown in Figures 1 through 4 for the DEPS break cases. The results of the DEHL break are shown in Figures 5 and 6. Note that the DEPS case with maximum ECCS flows and the DEHL case were not reanalyzed and therefore the results are identical to the Reference 4 results.

Double Ended Pump Suction Break with Minimum Safeguards

This analysis assumes a loss of offsite power coincidence with a double ended rupture of the RCS piping between the steam generator outlet and the RCS pump inlet (suction). The associated single failure assumption is the failure of a diesel to start, resulting in one train of ECCS and containment safeguards equipment being available. This combination results in a minimum set of safeguards being available. Further, loss of offsite power delays the actuation times of the safeguards equipment due to the required diesel startup time after receipt of the Safety Injection signal.

The postulated RCS break results in a rapid release of mass and energy to the containment with a resulting rapid rise in both the containment pressure and temperature. This rapid rise in containment pressure results in the generation of a containment Hi signal at 0.76 seconds and a containment Hi-Hi signal at 1.92 seconds. The containment pressure continues to rise rapidly in response to the release of mass and energy during the blowdown period which ends at 22.6 seconds. The peak pressure during the blowdown period was 38.17 psig. The end of blowdown marks a time when the initial inventory in the RCS has been exhausted and a slow process of filling the RCS downcomer in preparation for reflood has begun. Since the mass and energy release during this period is low, pressure decreases slightly to 37.8 psig and then continues to decrease due to the initiation of the containment spray at 40.12 seconds and fan coolers 46.76 seconds. Reflood continues at a reduced flooding rate due to the buildup of mass in the RCS core which offsets the downcomer head. This reduction in flooding rate and the continued action of the RCFCs and Spray leads to a slowly decreasing pressure out to the end of reflood, which occurs at 230.525 seconds. At this juncture, by design of the Reference 2 model, energy removal from the SG secondary begins at a very much increased rate, resulting in a rise in containment pressure from 230.525 seconds out to 938.62 seconds when peak pressure occurs. By 940.6 seconds, enough energy has been

removed from the faulted SG to bring the faulted SG secondary pressure down to the containment design pressure of 42 psig. The result of this SG secondary energy release is the ultimate peak pressure for this transient of 41.49 psig at 938.626 seconds. After this event, the mass and energy released is reduced given that most of the energy removal from the SGs has been accomplished. Containment pressure slowly falls out to the cold leg recirculation time of 2442 seconds. At this time, the ECCS is realigned for cold leg recirculation resulting in an increase in the SI temperature due to delivery from the hot sump. At 11 hours, (39600 seconds) containment spray is terminated as a result of aligning the ECCS for hot leg recirculation. The loss containment spray results in a rapid rise in containment pressure until the steam temperature increases to the level that the fan coolers can remove the decay heat energy at about 60,000 seconds. These changes result in a slower containment pressure reduction rate but containment pressure continues to decrease due to lower decay heat, SG energy release and continued RCFC cooling. This trend continues to the end of the transient at 1.0E+05 seconds. Table 29 provides a detailed time history for the containment pressure, containment steam temperature and the sump temperature.

Double Ended Pump Suction Break with Maximum safeguards

The DEPS break with maximum safeguards has a transient history very similar to the minimum safeguards case discussed above. Table 24 provides the key sequence of events and Table 28 shows that a peak pressure of 38.17 psig @ 18.66 seconds was calculated. Note that the DEPS case with maximum ECCS flows was not reanalyzed and therefore the results are identical to the Reference 4 results.

Double Ended Hot Leg Break with Minimum Safeguards

This analysis assumes a loss of offsite power coincident with a double ended rupture of the RCS piping between the reactor vessel outlet nozzle and the steam generator inlet (i.e. a break in the RCS hot leg). The associated single failure assumption is the failure of a diesel to start, resulting in one train of ECCS and containment safeguards equipment being available. This combination results in a minimum set of safeguards being available. Further, loss of offsite power delays the actuation times of the safeguards equipment due to the required diesel startup time after receipt of the Safety Injection signal.

The postulated RCS break results in a rapid release of mass and energy to the containment with a resulting rapid rise in both the containment pressure and temperature. This rapid rise in containment pressure results in the generation of a containment Hi signal at 0.72 seconds and a containment Hi-Hi signal at 2.09 seconds. The containment pressure continues to rise rapidly in response to the release of mass and energy until the end of blowdown at 19.8 seconds, with the pressure reaching a value of 39.83 psig at 18.66 seconds. The end of blowdown marks a time when the initial inventory in the RCS has been exhausted and a process of filling the RCS downcomer in preparation for reflood has begun. Since the reflood for a hot leg break is very fast due to the low resistance to steam venting posed by the broken hot leg, Westinghouse

terminates hot leg break mass and energy release transients at end of blowdown. The basis for this is further developed in References 2 and 10.
Note that the DEHL case was not reanalyzed and therefore the results are identical to the Reference 4 results.

Double Ended Hot Leg Break with Maximum Safeguards

The DEHL break with maximum safeguards was not analyzed since neither the ECCS pumps nor containment safeguards start prior to the end of blowdown. Thus, the maximum ECCS case would be identical to the minimum ECCS case as discussed above in the DEHL minimum ECCS.

Environmental Qualification Analyses

The most limiting LOCA case for EQ considerations is the Double Ended Pump Suction break with the single failure of a loss of a diesel generator as was verified in Reference 20. The single failure of loss of a diesel generator results in one train of pumped safety injection and one train of containment pressure reducing equipment. Thus, in the long-term, energy removal is more limited resulting in higher long-term containment pressures and temperatures. Thus, the Double Ended Pump Suction (DEPS) break with minimum safeguards was reanalyzed to support the qualification of equipment important to LOCA. The mass energy releases calculated in the previous section were used again and the containment initial condition for pressure was changed to be 13.7 psia. While this results in a lower peak pressure, the partial pressure for steam is higher and therefore, equipment inside containment would also reach a higher temperature. The result for peak component temperature was 263.73°F for this break. Table 30 provides a detailed time history of the containment pressure, containment steam temperature, component temperature and the sump temperature. Table 30 shows that the analysis for EQ was terminated at 100,000 seconds. Reference 20 has previously supplied EQ data out to 1,000,000 Seconds. However, since the major effect of the Reference 5 changes occur prior to 3600 seconds, analysis past 100,000 seconds were deemed unnecessary and the EQ data from 100,000 to 1,000,000 seconds provided in Reference 20 are still applicable to HBRSEP Unit No.2.

The Double Ended Hot Leg (DEHL) break with minimum safeguards was not reanalyzed based on the Reference 5 position that hot leg break are unaffected by the reported issues. The DEHL case has previously calculated a peak component temperature of 259.01°F, which is well below the 263°F EQ limit. Detailed results for both containment pressure and component temperature can be found in Table 31.

The DEPS case with minimum ECCS flow result of 263.73°F exceeds the previous result for HBRSEP Unit No.2 of 261.76°F (Reference 4). Progress Energy/ HBRSEP Unit No.2 should review this increase with regard to their EQ program.

The EQ pressure limit of 42 psig limit has been satisfied by all the LOCA containment analyses.

Conclusion

The Double Ended Pump Suction (DEPS) LOCA with minimum ECCS flows has been reanalyzed to address the issues reported by Westinghouse in Reference 5. The Double Ended Pump Suction break with maximum ECCS flows and the Double Ended Hot Leg break were not reanalyzed based on the information provided in Reference 5. The peak pressure for the new DEPS break with minimum ECCS flow was calculated to be 41.49 psig which is less than 42 psig design pressure for HBRSEP Unit No.2. The long-term pressures are well below 50% of the peak value within 24 hours. The EQ case for the DEPS break with minimum ECCS flow result of 263.73°F exceeds the previous result for HBRSEP Unit No.2 of 261.76°F. Progress Energy/ HBRSEP Unit No.2 should review this increase with regard to their EQ program.

TABLE 20 LOCA CONTAINMENT RESPONSE ANALYSIS PARAMETERS	
Service water temperature (°F)	100
RWST water temperature (°F)	100
Initial containment temperature (°F)	130
Initial containment pressure (psia)	15.7
Initial relative humidity (%)	30
Net free volume (ft^3)	2.013×10^6
Reactor Containment Fan Coolers	
Total	4
Analysis maximum	4
Analysis minimum	2
Containment High setpoint (psig)	5.5
Delay time (sec)	
With Offsite Power	35.4
Without Offsite Power	46.0
Containment Spray Pumps	
Total	2
Analysis maximum	1
Analysis minimum	1
Flowrate (gpm)	
Injection phase (per pump)- See Table 22	932
Recirculation phase (total)	932
Containment High High setpoint (psig)	12
Delay time (sec)	
With Offsite Power (delay after High High setpoint)	23.5
Without Offsite Power (total time from t=0)	38.2
ECCS Recirculation Switchover, sec	
Minimum Safeguards	2442.
Maximum Safeguards	1824.
Containment Spray Termination time, (sec)	
Minimum Safeguards	39600.
Maximum Safeguards	39600.

TABLE 20 LOCA CONTAINMENT RESPONSE ANALYSIS PARAMETERS (Cont'd)	
Emergency Core Cooling System (ECCS) Flows	
Minimum ECCS - (gpm)	
Injection alignment	4119.
Recirculation alignment	3877.
Piggyback alignment	425.
Maximum ECCS - (gpm)	
Injection alignment	5838.
Recirculation alignment	3877.
Piggyback alignment	1052.
Residual Heat Removal System	
RHR Heat Exchangers	
Modeled in analysis *	1
Recirculation switchover time, sec	
Minimum SG Maximum SG	2442. 1824.
UA, 10^6 * BTU/hr-°F	29.4
Flows - Tube Side and Shell Side - gpm	
Minimum SG Maximum SG	3877.0 3877.0
Qsump Shellside *	8970.

TABLE 20 LOCA CONTAINMENT RESPONSE ANALYSIS PARAMETERS (Cont'd)	
Component Cooling Water Heat Exchangers	
Modeled in analysis	1
UA, 10^6 * BTU/hr-°F	2.2
Flows - Shell Side and Tube Side - gpm	
Shellside *	8970.
Tubeside * (service water)	5000.
Additional heat loads, (BTU/hr)	7.1×10^6

* Minimum safeguards data representing one Emergency Diesel Generator (EDG) in operation

TABLE 21 REACTOR CONTAINMENT FAN COOLER PERFORMANCE	
Containment Temperature (°F)	Heat Removal Rate [Btu/sec] Per Reactor Containment Fan Cooler
130	1820.44
152	3448.69
200	7459.49
263	13112.10
300	16538.24

Table 22 CONTAINMENT SPRAY PERFORMANCE	
Containment Pressure (psig)	with 1 Pump (gpm)
0	932.
10	932.
20	932.
30	932.
42	932.

TABLE 23	DOUBLE-ENDED PUMP SUCTION BREAK SEQUENCE OF EVENTS (MINIMUM SAFEGUARDS)
Time (sec)	Event Description
0.0	Break Occurs, Reactor Trip and Loss of Offsite Power are assumed
0.76	Containment HI-1 Pressure Setpoint Reached
1.92	Containment HI-2 Pressure Setpoint Reached
4.8	Low Pressurizer Pressure SI Setpoint = 1661.4 psia Reached (Safety Injection Begins coincident with Low Pressurizer Pressure SI Setpoint)
12.4	Broken Loop Accumulator Begins Injecting Water
12.6	Intact Loop Accumulator Begins Injecting Water
21.6	Main Feedwater Fully Isolated
22.6	End of Blowdown Phase
40.12	Containment Spray Pump(s) (RWST) start
46.5	Safety Injection Begins
46.725	Broken Loop Accumulator Water Injection Ends
47.725	Intact Loop Accumulator Water Injection Ends
46.76	Reactor Containment Fan Coolers Actuate
230.53	End of Reflood for MIN SI Case
938.63	Peak Pressure and Temperature Occur
940.6	Mass and Energy Release Assumption: Broken Loop SG Equilibration to 56.7 psia
1121.93	Mass and Energy Release Assumption: Intact Loop SG Equilibration to 56.7 psia
2442.	RHR stopped for alignment to cold leg recirculation
3042.	RHR restarts in cold leg recirculation alignment
4620.	High Pressure SI and Spray flow stopped in preparation for piggyback operation
6000.	High Pressure SI and Spray restart in piggyback alignment
39600.	Containment Spray is Terminated and ECCS is aligned for Hot Leg Recirculation
10^5	Transient Modeling Terminated

TABLE 24 DOUBLE-ENDED PUMP SUCTION BREAK SEQUENCE OF EVENTS (MAXIMUM SAFEGUARDS) **Note that the Maximum Safeguards case was not reanalyzed and therefore the Maximum Safeguard case results are identical to the Reference 4 result**	
Time (sec)	Event Description
0.0	Break Occurs, Reactor Trip and Loss of Offsite Power are assumed
0.75	Containment HI-1 Pressure Setpoint Reached
1.89	Containment HI-2 Pressure Setpoint Reached
4.7	Low Pressurizer Pressure SI Setpoint = 1661.4 psia Reached (Safety Injection Begins coincident with Low Pressurizer Pressure SI Setpoint)
12.2	Broken Loop Accumulator Begins Injecting Water
12.3	Intact Loop Accumulator Begins Injecting Water
18.667	Peak Pressure and Temperature Occur
21.0	End of Blowdown Phase
21.1	Safety Injection Begins
25.39	Containment Spray Pump(s) (RWST) start
36.15	Reactor Containment Air Recirculaton Fan Coolers Actuate
47.038	Broken Loop Accumulator Water Injection Ends
47.838	Intact Loop Accumulator Water Injection Ends
246.6	End of Reflood for Max SI Case
791.7	Mass and Energy Release Assumption: Broken Loop SG Equilibration to 56.7 psia
1030.4	Mass and Energy Release Assumption: Intact Loop SG Equilibration to 56.7 psia
1824.	RHR stopped for alignment to cold leg recirculation
2424.	RHR restarts in cold leg recirculation alignment
4002.	High Pressure SI and Spray stopped in preparation for piggyback operation
4560.	High Pressure SI restarts in piggyback alignment
6000.	Spray restarts in piggyback alignment
39600.	Containment Spray is Terminated and ECCS is aligned for Hot Leg Recirculation
10^6	Transient Modeling Terminated

TABLE 25 DOUBLE-ENDED HOT LEG BREAK SEQUENCE OF EVENTS (MINIMUM SAFEGUARDS) **Note that the Double Ended Hot Leg (DEHL) Break case was not reanalyzed and therefore the DEHL case results are identical to the Reference 4 results.**	
Time (sec)	**Event Description**
0.0	Break Occurs, Reactor Trip and Loss of Offsite Power are assumed
0.72	Containment HI-1 Pressure Setpoint Reached
2.09	Containment HI-2 Pressure Setpoint Reached
4.0	Low Pressurizer Pressure SI Setpoint = 1661.4 psia reached
11.0	Broken Loop Accumulator Begins Injecting Water
11.1	Intact Loop Accumulator Begins Injecting Water
18.66	Peak Pressure and Temperature Occur
19.80	End of Blowdown Phase
19.80	Transient Modeling Terminated

TABLE 26 CONTAINMENT HEAT SINKS

No.	Material	Heat Transfer Area ft^2	Thickness ft
1	Containment Cylinder	46,926	
	Stainless Steel		0.00158
	Insulation & Epoxy		0.1045
	Carbon Steel		0.03285
	Concrete		3.5
2	Uninsulated Portion of the Containment Cylinder	3,462	
	Epoxy		0.0005
	Carbon Steel		0.090026
	Concrete		3.5
3	Containment Dome	6,456	
	Stainless Steel		0.00158
	Insulation & Epoxy		0.1045
	Carbon Steel		0.0417
	Concrete		2.5
4	Containment Dome	20,094	
	Epoxy		0.0005
	Carbon Steel		0.0417
	Concrete		2.5
5	Interior Unlined Concrete	59846	
	Epoxy		0.001297
	Concrete		1.97
6	Interior Unlined Concrete (W/internal steel) Flooded	3659	
	Epoxy		0.00292
	Concrete		1.74
	Carbon Steel		0.0221
	Concrete		8.46
7	Interior Unlined Concrete (W/internal Steel) Dry	7318	
	Epoxy		0.00292
	Concrete		1.74
	Carbon Steel		0.0221
	Concrete		8.46
8	Interior lined Concrete	8847	
	Stainless Steel		0.00198
	Concrete		3.388

TABLE 26 (Cont'd) CONTAINMENT HEAT SINKS			
No.	Material	Heat Transfer Area ft^2	Thickness ft
9	Structural and Misc Exposed Steel - Epoxy coated carbon steel	101757	
	Epoxy		0.000583
	Carbon Steel		0.035065
10	Structural and Misc Exposed Steel - Bare Stainless Steel	2708	0.01425
11	Galvanized Steel	54865	
	Zinc		0.0000833
	Carbon Steel		0.01102
12	Insulted Copper Cable (Used for EQ Calc only)	0.059	
	Hyplon		0.00125
	EPR		0.0025
	Copper		0.005667
13	Carbon Steel Plate (Used for EQ)	0.0872	
	Carbon Steel		0.005208

TABLE 27 THERMOPHYSICAL PROPERTIES OF CONTAINMENT HEAT SINKS

Material	THERMAL CONDUCTIVITY (Btu/hr-ft - °F)	VOLUMETRIC HEAT CAPACITY (Btu/ft³ - °F)
Stainless Steel	9.4	60.1
Carbon Steel	29.53	56.9
Zinc	65.3	40.7
Concrete	1.05	22.5
Insulation & Epoxy	0.01088	0.58
Epoxy	0.23	18.3
Hyplon	0.125	32.537
EPR	0.1445	20.5
Copper	219.0	50.778
Carbon Steel (EQ component)	27.0	48.02

TABLE 28 LOCA CONTAINMENT RESPONSE RESULTS
(LOSS OF OFFSITE POWER ASSUMED)

CASE	PEAK PRESS. (psig)	PEAK STEAM TEMP. (°F)	PRESSURE (psig) @ 24 hours	STEAM TEMPERATURE (°F) @ 24 hours
DEPS MINSI	41.49 @ 938.626 sec	263.293 @ 938.626 sec	12.19@ 86,400 sec	192.1@ 86,400 sec
DEPS MAXSI	38.17 @ 18.66 sec	258.43 @ 18.66 sec	5.621@ 87,120 sec	154.4@ 87,120 sec
DEHL MINSI (30% Relative Humidity Case)	39.83 @ 18.66 sec	259.8 @ 18.66 sec	NA	NA
DEHL MAXSI	NA	NA	NA	NA

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
.00100000	1.000	130.00	130.00
.25000000	2.458	142.71	169.40
.50000000	3.952	155.59	185.55
.75000000	5.476	167.88	194.99
1.0000000	6.959	178.89	201.35
1.5000000	9.782	197.28	209.91
2.0000000	12.43	211.76	215.78
2.5000000	14.79	222.52	220.02
3.0000000	16.59	228.93	223.01
3.5000000	18.02	232.71	225.33
4.0000000	19.25	235.18	227.26
4.5000000	20.37	236.92	228.95
5.0000000	21.43	238.22	230.48
5.5000000	22.47	239.37	231.94
6.0000000	23.49	240.31	233.32
6.5000000	24.46	241.06	234.62
7.0000000	25.40	241.64	235.87
7.5000000	26.31	242.07	237.06
8.0000000	27.22	242.52	238.18
8.5000000	28.10	242.89	239.17
9.0000000	28.93	243.06	240.10
9.5000000	29.75	243.79	241.04
10.000000	30.55	244.85	241.88
10.500000	31.33	246.36	242.67
11.000000	32.06	247.76	243.42
11.500000	32.76	249.06	244.12
12.000000	33.42	250.27	244.78
12.500000	34.03	251.38	245.39
13.000000	34.61	252.40	245.97
13.500000	35.13	253.32	246.52
14.000000	35.60	254.13	247.05
14.500000	36.02	254.86	247.56
15.000000	36.41	255.52	248.02
15.500000	36.80	256.17	248.47
16.000000	37.20	256.84	248.92
16.500000	37.54	257.40	249.28
17.000000	37.77	257.78	249.49
17.500000	37.94	258.06	249.73
18.000000	38.05	258.25	249.92
18.500000	38.13	258.37	250.12
19.000000	38.16	258.43	250.34
19.500000	38.17	258.44	250.55
20.000000	38.15	258.41	250.73
20.500000	38.11	258.34	250.88

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
21.000000	38.05	258.24	251.00
21.500000	37.98	258.12	251.09
22.000000	37.90	257.99	251.16
22.500000	37.81	257.85	251.19
23.000000	37.73	257.71	251.20
23.500000	37.64	257.57	251.20
24.000000	37.57	257.45	251.21
24.500000	37.49	257.32	251.21
25.000000	37.42	257.20	251.21
25.500000	37.35	257.09	251.21
26.000000	37.29	256.98	251.22
26.500000	37.23	256.88	251.22
27.000000	37.17	256.79	251.22
27.500000	37.11	256.69	251.22
28.000000	37.06	256.60	251.22
28.500000	37.01	256.52	251.22
29.000000	36.96	256.44	251.22
29.500000	36.92	256.36	251.22
34.500000	36.55	255.74	249.39
39.500000	36.31	255.32	245.94
44.500000	36.13	255.01	243.41
49.500000	35.97	254.74	241.25
54.500000	35.96	254.66	241.46
59.500000	35.98	254.61	241.67
64.500000	35.99	254.56	241.82
69.500000	36.00	254.54	241.97
74.500000	36.00	254.53	242.11
79.500000	36.00	254.53	242.27
84.500000	36.00	254.54	242.41
89.500000	36.01	254.55	242.54
94.500000	36.03	254.57	242.68
99.500000	36.04	254.60	242.81
104.50000	36.06	254.63	242.94
109.50000	36.08	254.66	243.08
114.50000	36.10	254.69	243.19
119.50000	36.12	254.73	243.32
124.50000	36.14	254.77	243.44
129.50000	36.16	254.81	243.57
134.50000	36.19	254.85	243.69
139.50000	36.21	254.89	243.82
144.50000	36.24	254.93	243.94
149.50000	36.26	254.98	244.06
154.50000	36.29	255.02	244.18
159.50000	36.32	255.07	244.31
164.50000	36.35	255.11	244.43

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
169.50000	36.37	255.16	244.56
174.50000	36.40	255.20	244.68
179.50000	36.43	255.25	244.81
184.50000	36.45	255.29	244.94
189.50000	36.48	255.34	245.07
194.50000	36.50	255.38	245.21
199.50000	36.53	255.41	245.35
204.50000	36.55	255.45	245.47
209.50000	36.57	255.48	245.61
214.50000	36.59	255.51	245.75
219.50000	36.60	255.54	245.89
224.50000	36.62	255.57	246.02
229.50000	36.63	255.59	246.16
234.50000	36.65	255.62	246.31
239.50000	36.67	255.65	246.47
244.50000	36.69	255.69	246.63
249.50000	36.72	255.73	246.78
254.50000	36.74	255.77	246.94
259.50000	36.77	255.81	247.09
264.50000	36.79	255.86	247.24
269.50000	36.82	255.90	247.40
274.50000	36.85	255.95	247.54
279.50000	36.88	256.00	247.69
284.50000	36.91	256.04	247.83
289.50000	36.94	256.09	247.98
294.50000	36.97	256.14	248.12
299.50000	37.00	256.20	248.26
304.50000	37.03	256.25	248.40
309.50000	37.06	256.30	248.54
314.50000	37.09	256.35	248.68
319.50000	37.12	256.41	248.81
324.50000	37.16	256.46	248.95
329.50000	37.19	256.51	249.08
334.50000	37.22	256.57	249.21
339.50000	37.26	256.63	249.34
344.50000	37.29	256.68	249.47
349.50000	37.32	256.74	249.60
354.50000	37.36	256.79	249.73
359.50000	37.39	256.85	249.86
364.50000	37.43	256.91	249.98
369.50000	37.46	256.96	250.11
374.50000	37.50	257.02	250.23
379.50000	37.53	257.08	250.36
384.50000	37.57	257.13	250.48
389.50000	37.60	257.19	250.60

TABLE 29	DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS		
TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
394.50000	37.64	257.25	250.72
399.50000	37.67	257.30	250.84
404.50000	37.71	257.36	250.96
409.50000	37.74	257.42	251.07
414.50000	37.77	257.47	251.19
419.50000	37.81	257.53	251.31
424.50000	37.85	257.59	251.42
429.50000	37.88	257.65	251.53
434.50000	37.92	257.71	251.65
439.50000	37.96	257.77	251.76
444.50000	38.00	257.84	251.87
449.50000	38.04	257.90	251.98
454.50000	38.07	257.96	252.09
459.50000	38.11	258.02	252.20
464.50000	38.15	258.08	252.31
469.50000	38.19	258.14	252.41
474.50000	38.22	258.20	252.52
479.50000	38.26	258.26	252.62
484.50000	38.30	258.32	252.73
489.50000	38.33	258.38	252.83
494.50000	38.37	258.44	252.94
499.50000	38.41	258.50	253.04
504.50000	38.45	258.56	253.14
509.50000	38.48	258.62	253.24
514.50000	38.52	258.69	253.34
519.50000	38.56	258.75	253.44
524.50000	38.60	258.81	253.54
529.50000	38.64	258.87	253.64
534.50000	38.68	258.93	253.74
539.50000	38.72	258.99	253.84
544.50000	38.75	259.05	253.94
549.50000	38.79	259.11	254.03
554.50000	38.83	259.17	254.13
559.50000	38.86	259.23	254.22
564.50000	38.90	259.29	254.32
569.50000	38.94	259.35	254.41
574.50000	38.98	259.41	254.51
579.50000	39.01	259.47	254.60
584.50000	39.05	259.53	254.69
589.50000	39.09	259.59	254.78
594.50000	39.13	259.65	254.87
599.50000	39.16	259.71	254.96
604.50000	39.20	259.76	255.06
609.50000	39.24	259.82	255.14
614.50000	39.27	259.88	255.23

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS			
TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
619.50000	39.31	259.93	255.32
624.50000	39.34	259.99	255.41
629.50000	39.38	260.05	255.50
634.50000	39.42	260.11	255.59
639.50000	39.45	260.17	255.67
644.50000	39.49	260.22	255.76
649.50000	39.53	260.28	255.84
654.50000	39.56	260.34	255.93
659.50000	39.60	260.39	256.01
664.50000	39.63	260.44	256.10
669.50000	39.67	260.50	256.18
674.50000	39.70	260.55	256.27
679.50000	39.74	260.61	256.35
684.50000	39.77	260.67	256.43
689.50000	39.81	260.72	256.51
694.50000	39.84	260.78	256.60
699.50000	39.88	260.83	256.68
704.50000	39.91	260.88	256.76
709.50000	39.95	260.94	256.84
714.50000	39.98	260.99	256.92
719.50000	40.02	261.05	257.00
724.50000	40.05	261.10	257.08
729.50000	40.09	261.16	257.15
734.50000	40.12	261.21	257.23
739.50000	40.16	261.26	257.31
744.50000	40.19	261.32	257.39
749.50000	40.22	261.37	257.47
754.50000	40.26	261.42	257.54
759.50000	40.29	261.47	257.62
764.50000	40.32	261.52	257.69
769.50000	40.36	261.57	257.77
774.50000	40.39	261.62	257.84
779.50000	40.42	261.68	257.91
784.50000	40.46	261.73	257.98
789.50000	40.49	261.78	258.05
794.50000	40.52	261.83	258.12
799.50000	40.56	261.88	258.19
804.50000	40.59	261.93	258.25
809.50000	40.62	261.98	258.32
814.50000	40.66	262.04	258.38
819.50000	40.69	262.09	258.45
824.50000	40.73	262.14	258.51
829.50000	40.76	262.19	258.57
834.50000	40.79	262.24	258.63
839.50000	40.83	262.29	258.69

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
844.50000	40.86	262.35	258.75
849.50000	40.89	262.40	258.81
854.50000	40.93	262.45	258.87
859.50000	40.96	262.50	258.93
864.50000	40.99	262.55	258.99
869.50000	41.03	262.60	259.04
874.50000	41.06	262.65	259.10
879.50000	41.09	262.70	259.15
884.50000	41.13	262.75	259.21
889.50000	41.16	262.80	259.26
894.50000	41.19	262.85	259.32
899.50000	41.23	262.91	259.37
904.50000	41.26	262.96	259.42
909.50000	41.29	263.01	259.48
914.50000	41.33	263.06	259.53
919.50000	41.36	263.11	259.58
924.50000	41.39	263.15	259.63
929.50000	41.43	263.20	259.68
934.50000	41.46	263.25	259.73
938.626	**41.49**	**263.29**	259.77
939.50000	41.48	263.29	259.78
944.50000	41.46	263.26	259.83
949.50000	41.44	263.22	259.88
954.50000	41.42	263.19	259.94
959.50000	41.40	263.16	259.99
964.50000	41.38	263.13	260.04
969.50000	41.36	263.10	260.09
974.50000	41.34	263.07	260.14
979.50000	41.33	263.04	260.18
984.50000	41.31	263.02	260.23
989.50000	41.29	262.99	260.28
994.50000	41.27	262.96	260.33
999.50000	41.26	262.93	260.38
1099.0000	40.95	262.45	261.26
1199.0000	40.75	262.11	258.69
1299.0000	40.51	261.73	252.85
1399.0000	40.28	261.36	247.74
1499.0000	40.06	261.00	243.16
1599.0000	39.84	260.64	239.01
1699.0000	39.62	260.27	235.25
1799.0000	39.40	259.91	231.82
1899.0000	39.17	259.53	228.68
1999.0000	38.95	259.15	225.79
2099.0000	38.72	258.77	223.13
2199.0000	38.49	258.38	220.65

TABLE 29 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	SUMP TEMP (DEG-F)
2299.0000	38.25	257.97	218.37
2399.0000	38.01	257.56	216.23
2499.0000	37.76	257.14	214.24
2599.0000	37.63	256.91	214.86
2699.0000	37.48	256.66	215.45
2799.0000	37.34	256.41	216.01
2899.0000	37.18	256.16	216.57
2999.0000	37.03	255.89	217.11
3099.0000	36.87	255.62	217.64
3199.0000	36.59	255.13	219.19
3299.0000	36.31	254.66	220.67
3399.0000	36.04	254.18	222.06
3499.0000	35.77	253.71	223.39
3599.0000	35.49	253.23	224.64
3699.0000	35.12	252.56	225.48
3799.0000	34.69	251.81	226.04
3899.0000	34.28	251.05	226.57
3999.0000	33.87	250.31	227.07
4999.0000	31.19	245.24	229.68
5999.0000	30.92	244.70	229.03
6999.0000	28.87	240.57	229.03
7999.0000	26.18	234.74	228.89
8999.0000	23.91	229.42	228.34
9999.0000	21.97	224.50	227.45
19999.000	13.87	199.02	212.52
29999.000	11.30	188.29	199.31
39999.000	9.775	180.87	189.46
49999.000	13.01	195.59	187.52
59999.000	13.31	196.79	186.24
69999.000	13.07	195.82	185.02
79999.000	12.57	193.73	184.32
89999.000	11.97	191.18	183.43
99999.000	11.35	188.42	182.57
100000.00	11.35	188.42	182.57

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
.00100000	-1.0000	130.000	130.000	130.000
.25000000	.47447	144.554	131.639	166.293
.50000000	1.9805	158.949	137.873	181.499
.75000000	3.5135	172.421	147.817	190.567
1.0000000	5.0025	184.267	159.394	196.776
1.5000000	7.8320	203.620	182.099	205.278
2.0000000	10.482	218.474	201.092	211.198
2.5000000	12.841	229.258	215.601	215.517
3.0000000	14.637	235.458	223.478	218.575
3.5000000	16.052	238.926	228.185	220.953
4.0000000	17.276	241.058	231.220	222.944
4.5000000	18.393	242.461	233.285	224.682
5.0000000	19.444	243.442	234.743	226.251
5.5000000	20.482	244.296	235.923	227.754
6.0000000	21.487	244.966	236.854	229.175
6.5000000	22.459	245.469	237.578	230.524
7.0000000	23.394	245.807	238.116	231.808
7.5000000	24.297	246.028	238.512	233.035
8.0000000	25.200	246.278	238.891	234.193
8.5000000	26.079	246.456	239.208	235.211
9.0000000	26.908	246.452	239.368	236.171
9.5000000	27.685	246.284	239.377	237.076
10.000000	28.416	245.977	239.251	237.935
10.500000	29.162	246.815	239.923	238.751
11.000000	29.900	248.218	241.251	239.526
11.500000	30.598	249.520	242.571	240.254
12.000000	31.255	250.725	243.841	240.936
12.500000	31.873	251.840	245.047	241.573
13.000000	32.448	252.863	246.178	242.170
13.500000	32.965	253.771	247.215	242.744
14.000000	33.434	254.584	248.161	243.295
14.500000	33.863	255.321	249.030	243.824
15.000000	34.251	255.981	249.827	244.298
15.500000	34.638	256.634	250.600	244.777
16.000000	35.043	257.310	251.391	245.243
16.500000	35.380	257.869	252.079	245.618
17.000000	35.609	258.246	252.617	245.850
17.500000	35.781	258.528	253.052	246.090
18.000000	35.898	258.720	253.397	246.297
18.500000	35.974	258.842	253.669	246.505
19.000000	36.013	258.906	253.879	246.740
19.500000	36.019	258.916	254.031	246.963
20.000000	36.003	258.889	254.138	247.151

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK
MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
20.500000	35.962	258.822	254.205	247.308
21.000000	35.906	258.730	254.241	247.437
21.500000	35.834	258.612	254.248	247.539
22.000000	35.753	258.479	254.235	247.616
22.500000	35.669	258.342	254.212	247.657
23.000000	35.585	258.203	254.183	247.670
23.500000	35.503	258.068	254.152	247.679
24.000000	35.427	257.943	254.126	247.688
24.500000	35.351	257.817	254.099	247.695
25.000000	35.280	257.699	254.074	247.703
25.500000	35.213	257.587	254.052	247.709
26.000000	35.148	257.480	254.033	247.717
26.500000	35.087	257.378	254.016	247.722
27.000000	35.029	257.281	254.001	247.729
27.500000	34.973	257.188	253.988	247.734
28.000000	34.920	257.099	253.977	247.739
28.500000	34.869	257.014	253.967	247.744
29.000000	34.820	256.933	253.959	247.749
29.500000	34.773	256.854	253.953	247.752
34.500000	34.399	256.222	253.931	246.012
39.500000	34.143	255.784	253.959	242.729
44.500000	33.955	255.461	253.999	240.356
49.500000	33.788	255.172	253.998	238.600
54.500000	33.768	255.065	254.060	238.825
59.500000	33.769	254.995	254.134	239.044
64.500000	33.775	254.934	254.197	239.235
69.500000	33.770	254.888	254.257	239.392
74.500000	33.752	254.855	254.312	239.539
79.500000	33.743	254.840	254.373	239.691
84.500000	33.741	254.836	254.433	239.848
89.500000	33.745	254.842	254.495	240.024
94.500000	33.748	254.846	254.548	240.179
99.500000	33.753	254.856	254.599	240.323
104.50000	33.762	254.870	254.649	240.465
109.50000	33.773	254.889	254.699	240.606
114.50000	33.787	254.911	254.747	240.743
119.50000	33.802	254.937	254.795	240.882
124.50000	33.818	254.964	254.841	241.003
129.50000	33.837	254.996	254.888	241.136
134.50000	33.857	255.029	254.935	241.273
139.50000	33.877	255.064	254.982	241.400
144.50000	33.900	255.102	255.030	241.536
149.50000	33.923	255.140	255.077	241.663
154.50000	33.947	255.181	255.125	241.798

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK
MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
159.50000	33.971	255.223	255.173	241.926
164.50000	33.997	255.266	255.221	242.058
169.50000	34.023	255.310	255.270	242.192
174.50000	34.048	255.353	255.317	242.327
179.50000	34.074	255.397	255.364	242.463
184.50000	34.099	255.439	255.409	242.600
189.50000	34.124	255.480	255.453	242.732
194.50000	34.148	255.521	255.496	242.869
199.50000	34.172	255.560	255.537	243.018
204.50000	34.193	255.596	255.575	243.152
209.50000	34.214	255.631	255.611	243.294
214.50000	34.232	255.662	255.645	243.438
219.50000	34.250	255.692	255.675	243.577
224.50000	34.266	255.718	255.703	243.720
229.50000	34.280	255.742	255.728	243.860
234.50000	34.299	255.773	255.759	244.020
239.50000	34.323	255.812	255.799	244.181
244.50000	34.347	255.854	255.841	244.342
249.50000	34.373	255.897	255.884	244.502
254.50000	34.400	255.941	255.929	244.660
259.50000	34.427	255.987	255.974	244.815
264.50000	34.455	256.034	256.021	244.972
269.50000	34.485	256.083	256.071	245.125
274.50000	34.515	256.134	256.121	245.274
279.50000	34.546	256.186	256.172	245.424
284.50000	34.577	256.238	256.224	245.572
289.50000	34.609	256.291	256.277	245.719
294.50000	34.641	256.344	256.331	245.865
299.50000	34.675	256.400	256.386	246.009
304.50000	34.708	256.457	256.442	246.152
309.50000	34.743	256.513	256.499	246.292
314.50000	34.777	256.570	256.556	246.433
319.50000	34.811	256.628	256.613	246.571
324.50000	34.846	256.685	256.670	246.710
329.50000	34.882	256.745	256.730	246.846
334.50000	34.918	256.804	256.789	246.982
339.50000	34.954	256.864	256.849	247.115
344.50000	34.990	256.924	256.908	247.249
349.50000	35.026	256.983	256.968	247.380
354.50000	35.062	257.043	257.027	247.511
359.50000	35.099	257.104	257.088	247.641
364.50000	35.136	257.165	257.149	247.770
369.50000	35.172	257.226	257.209	247.896
374.50000	35.209	257.286	257.270	248.024

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
379.50000	35.246	257.346	257.330	248.149
384.50000	35.282	257.406	257.390	248.274
389.50000	35.319	257.467	257.451	248.397
394.50000	35.356	257.528	257.512	248.521
399.50000	35.393	257.589	257.573	248.642
404.50000	35.430	257.650	257.633	248.764
409.50000	35.467	257.710	257.693	248.883
414.50000	35.503	257.769	257.753	249.003
419.50000	35.541	257.830	257.814	249.120
424.50000	35.579	257.893	257.876	249.238
429.50000	35.618	257.957	257.940	249.353
434.50000	35.658	258.022	258.005	249.469
439.50000	35.698	258.088	258.071	249.582
444.50000	35.738	258.153	258.136	249.696
449.50000	35.778	258.219	258.201	249.808
454.50000	35.818	258.283	258.266	249.921
459.50000	35.857	258.347	258.330	250.031
464.50000	35.896	258.411	258.393	250.142
469.50000	35.936	258.475	258.458	250.251
474.50000	35.976	258.539	258.522	250.361
479.50000	36.015	258.602	258.585	250.468
484.50000	36.053	258.665	258.648	250.576
489.50000	36.092	258.727	258.710	250.682
494.50000	36.129	258.788	258.771	250.789
499.50000	36.168	258.851	258.834	250.894
504.50000	36.208	258.915	258.898	250.999
509.50000	36.248	258.980	258.963	251.102
514.50000	36.289	259.046	259.029	251.206
519.50000	36.330	259.112	259.095	251.307
524.50000	36.370	259.177	259.159	251.410
529.50000	36.410	259.241	259.223	251.510
534.50000	36.450	259.304	259.286	251.611
539.50000	36.489	259.367	259.350	251.710
544.50000	36.528	259.430	259.413	251.810
549.50000	36.567	259.492	259.475	251.909
554.50000	36.605	259.553	259.536	252.008
559.50000	36.643	259.614	259.597	252.105
564.50000	36.681	259.674	259.657	252.202
569.50000	36.720	259.736	259.719	252.298
574.50000	36.758	259.798	259.781	252.395
579.50000	36.798	259.860	259.843	252.489
584.50000	36.837	259.923	259.906	252.584
589.50000	36.876	259.986	259.969	252.677
594.50000	36.915	260.047	260.030	252.771

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
599.50000	36.953	260.108	260.091	252.864
604.50000	36.991	260.167	260.150	252.957
609.50000	37.028	260.226	260.210	253.048
614.50000	37.064	260.284	260.268	253.141
619.50000	37.101	260.342	260.325	253.231
624.50000	37.138	260.401	260.384	253.322
629.50000	37.176	260.461	260.444	253.411
634.50000	37.215	260.522	260.506	253.501
639.50000	37.253	260.583	260.566	253.589
644.50000	37.291	260.642	260.626	253.678
649.50000	37.328	260.701	260.685	253.765
654.50000	37.365	260.759	260.742	253.853
659.50000	37.401	260.815	260.799	253.940
664.50000	37.437	260.871	260.855	254.027
669.50000	37.472	260.927	260.911	254.113
674.50000	37.508	260.984	260.968	254.199
679.50000	37.546	261.043	261.027	254.284
684.50000	37.583	261.101	261.085	254.368
689.50000	37.620	261.159	261.143	254.452
694.50000	37.656	261.215	261.199	254.536
699.50000	37.691	261.270	261.255	254.619
704.50000	37.726	261.325	261.309	254.702
709.50000	37.762	261.380	261.364	254.784
714.50000	37.797	261.436	261.420	254.867
719.50000	37.834	261.493	261.477	254.947
724.50000	37.870	261.549	261.534	255.029
729.50000	37.906	261.605	261.590	255.109
734.50000	37.942	261.660	261.645	255.190
739.50000	37.977	261.715	261.700	255.269
744.50000	38.012	261.769	261.754	255.349
749.50000	38.047	261.823	261.808	255.427
754.50000	38.081	261.876	261.861	255.507
759.50000	38.115	261.929	261.914	255.585
764.50000	38.149	261.981	261.966	255.663
769.50000	38.182	262.033	262.018	255.740
774.50000	38.216	262.085	262.070	255.818
779.50000	38.249	262.137	262.122	255.894
784.50000	38.283	262.188	262.173	255.971
789.50000	38.316	262.239	262.225	256.047
794.50000	38.349	262.291	262.276	256.123
799.50000	38.382	262.342	262.327	256.198
804.50000	38.416	262.393	262.378	256.273
809.50000	38.449	262.444	262.429	256.346
814.50000	38.482	262.495	262.480	256.420

TABLE 30	DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS - EQ RESULT			
TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
819.50000	38.515	262.546	262.532	256.491
824.50000	38.548	262.597	262.583	256.562
829.50000	38.582	262.648	262.634	256.632
834.50000	38.615	262.699	262.685	256.701
839.50000	38.648	262.750	262.736	256.769
844.50000	38.682	262.801	262.787	256.837
849.50000	38.715	262.852	262.838	256.903
854.50000	38.748	262.902	262.888	256.970
859.50000	38.781	262.953	262.939	257.035
864.50000	38.815	263.004	262.990	257.100
869.50000	38.848	263.054	263.040	257.164
874.50000	38.881	263.104	263.091	257.228
879.50000	38.914	263.155	263.141	257.291
884.50000	38.947	263.205	263.191	257.353
889.50000	38.980	263.255	263.241	257.415
894.50000	39.012	263.305	263.291	257.476
899.50000	39.045	263.355	263.341	257.537
904.50000	39.078	263.404	263.390	257.597
909.50000	39.111	263.454	263.440	257.656
914.50000	39.143	263.503	263.490	257.716
919.50000	39.176	263.553	263.539	257.774
924.50000	39.208	263.602	263.588	257.832
929.50000	39.241	263.651	263.637	257.889
934.50000	39.273	263.700	263.686	257.946
939.50000	39.294	263.731	**263.720**	258.005
944.50000	39.275	263.702	263.693	258.063
949.50000	39.254	263.669	263.663	258.121
954.50000	39.234	263.638	263.634	258.180
959.50000	39.215	263.607	263.605	258.237
964.50000	39.195	263.577	263.576	258.294
969.50000	39.177	263.548	263.548	258.351
974.50000	39.158	263.518	263.520	258.407
979.50000	39.140	263.490	263.492	258.463
984.50000	39.122	263.462	263.465	258.519
989.50000	39.104	263.434	263.438	258.574
994.50000	39.087	263.407	263.411	258.628
999.50000	39.070	263.380	263.385	258.683
1099.5000	38.769	262.904	262.910	259.679
1199.5000	38.579	262.596	262.601	258.284
1299.5000	38.334	262.203	262.208	252.503
1399.5000	38.100	261.825	261.830	247.348
1499.5000	37.876	261.459	261.464	242.777
1599.5000	37.649	261.089	261.094	238.663
1699.5000	37.426	260.722	260.727	234.914

TABLE 30 DOUBLE ENDED PUMP SUCTION BREAK MINIMUM ECCS FLOWS - EQ RESULT

TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
1799.5000	37.199	260.347	260.352	231.514
1899.5000	36.972	259.971	259.976	228.380
1999.5000	36.741	259.585	259.591	225.519
2099.5000	36.509	259.197	259.202	222.857
2199.5000	36.270	258.796	258.801	220.414
2299.5000	36.031	258.391	258.396	218.123
2399.5000	35.784	257.972	257.978	216.011
2499.5000	35.580	257.624	257.628	214.967
2599.5000	35.436	257.382	257.385	215.595
2699.5000	35.288	257.132	257.136	216.161
2799.5000	35.136	256.876	256.879	216.735
2899.5000	34.983	256.615	256.619	217.273
2999.5000	34.826	256.348	256.352	217.818
3099.5000	34.618	255.993	255.998	218.724
3199.5000	34.335	255.507	255.514	220.264
3299.5000	34.059	255.031	255.038	221.703
3399.5000	33.783	254.552	254.559	223.081
3499.5000	33.509	254.074	254.080	224.372
3599.5000	33.234	253.591	253.597	225.610
3699.5000	32.896	252.992	253.001	226.551
3799.5000	32.464	252.223	252.233	227.088
3899.5000	32.048	251.472	251.483	227.584
3999.5000	31.636	250.723	250.733	228.054
4999.5000	29.145	246.016	246.016	230.258
5999.5000	28.812	245.366	245.367	229.595
6999.5000	26.649	240.994	241.003	229.623
7999.5000	23.951	235.135	235.143	229.463
8999.5000	21.673	229.779	229.786	228.878
9999.5000	19.721	224.828	224.834	227.956
19999.500	11.615	199.120	199.122	212.693
29999.500	9.0652	188.321	188.322	199.310
39999.500	7.6254	181.271	181.264	189.444
49999.500	10.751	195.630	195.629	187.497
59999.500	11.041	196.803	196.803	186.215
69999.500	10.804	195.834	195.834	184.988
79999.500	10.311	193.773	193.773	184.299
89999.500	9.7098	191.164	191.164	183.399
99999.500	9.1081	188.441	188.442	182.546
100000.00	9.1081	188.441	188.442	182.546

TABLE 31 DOUBLE ENDED HOT LEG - EQ RESULTS				
TIME (SEC)	PRESSURE (PSIG)	STEAM TEMP (DEG-F)	COMPONENT TEMP (DEG-F)	SUMP WATER TEMP (DEG-F)
0.0010	-1.000	130.00	130.00	130.00
.50000	2.361	159.51	138.23	176.97
1.0000	4.983	180.49	157.73	191.87
1.5000	7.428	196.79	177.56	200.88
2.0000	9.728	209.52	194.11	207.30
2.5000	11.85	219.28	207.03	212.24
3.0000	13.80	226.64	215.44	216.26
3.5000	15.59	232.18	221.74	219.67
4.0000	17.24	236.43	226.67	222.68
4.5000	18.80	239.79	230.63	225.39
5.0000	20.29	242.49	233.89	227.88
5.5000	21.69	244.62	236.57	230.16
6.0000	23.03	246.30	238.76	232.26
6.5000	24.25	247.43	240.46	234.09
7.0000	25.34	247.94	241.55	235.57
7.5000	26.36	248.20	242.33	236.93
8.0000	27.32	248.26	242.88	238.19
8.5000	28.22	248.12	243.21	239.36
9.0000	29.05	247.79	243.33	240.43
9.5000	29.83	247.34	243.30	241.43
10.000	30.62	248.09	244.02	242.34
10.500	31.40	249.55	245.52	243.19
11.000	32.14	250.89	246.99	243.96
11.500	32.82	252.11	248.38	244.65
12.000	33.45	253.23	249.68	245.25
12.500	34.04	254.26	250.89	245.77
13.000	34.58	255.19	252.01	246.19
13.500	35.09	256.05	253.05	246.50
14.000	35.55	256.82	254.00	246.73
14.500	35.96	257.51	254.86	246.88
15.000	36.32	258.10	255.63	246.99
15.500	36.62	258.60	256.29	247.07
16.000	36.89	259.03	256.88	247.13
16.500	37.12	259.41	257.41	247.18
17.000	37.32	259.73	257.88	247.23
17.500	37.48	259.98	258.27	247.26
18.000	37.60	260.18	258.60	247.27
18.500	37.66	260.27	258.84	247.30
19.000	37.65	260.26	258.97	247.31
19.500	37.59	260.16	259.01	247.33
20.000	37.50	260.02	258.99	247.35

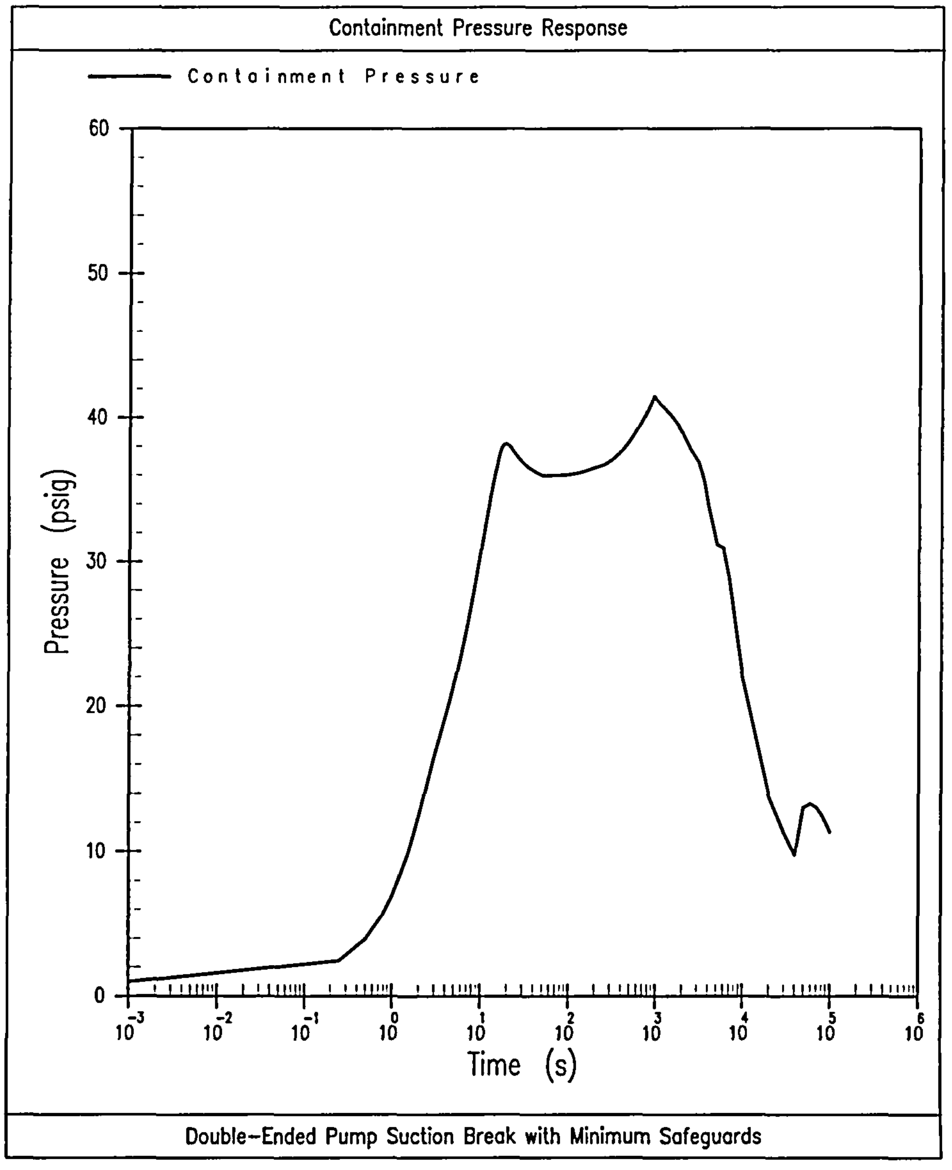

Figure 1 Double-Ended Pump Suction Break with Minimum Safeguards - Pressure

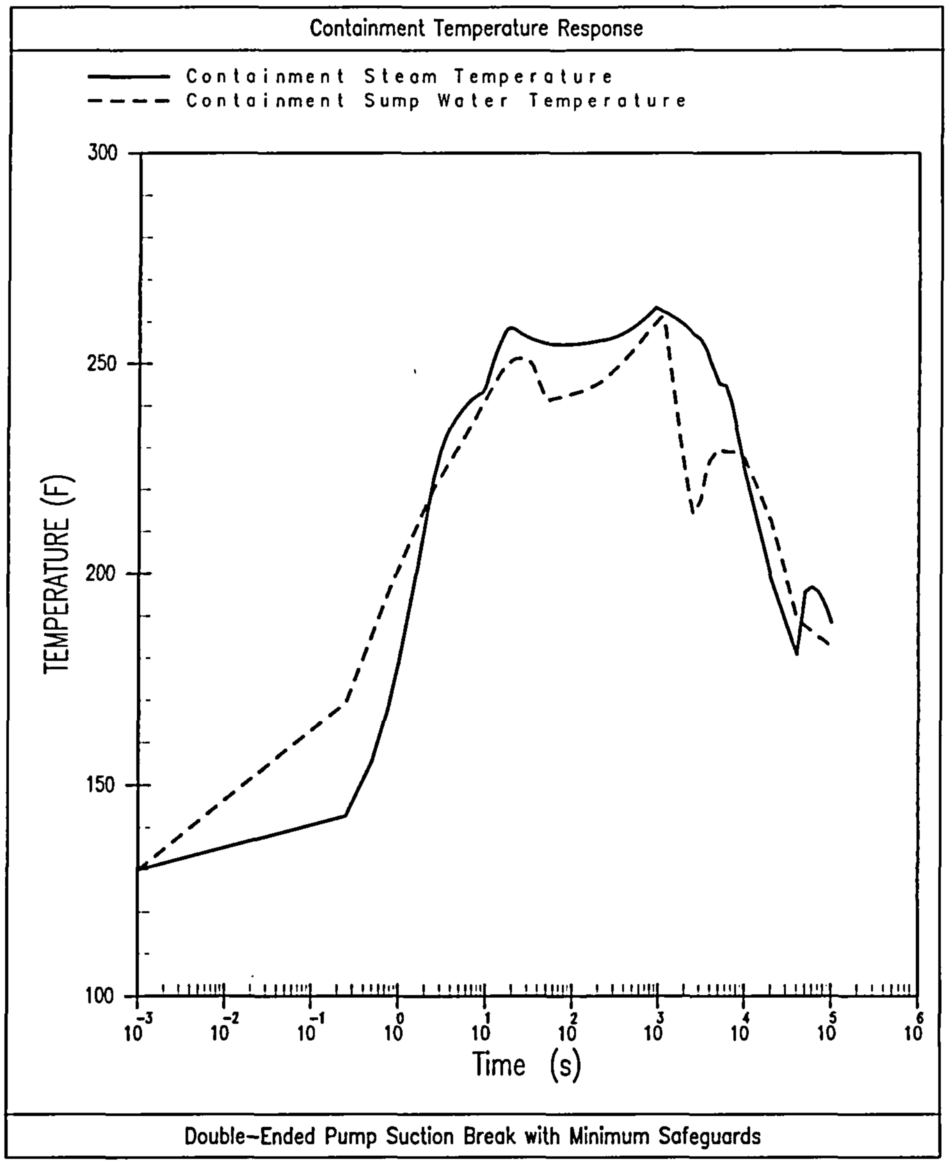

Figure 2 Double-Ended Pump Suction Break with Minimum Safeguards - Steam and Sump Water Temperature

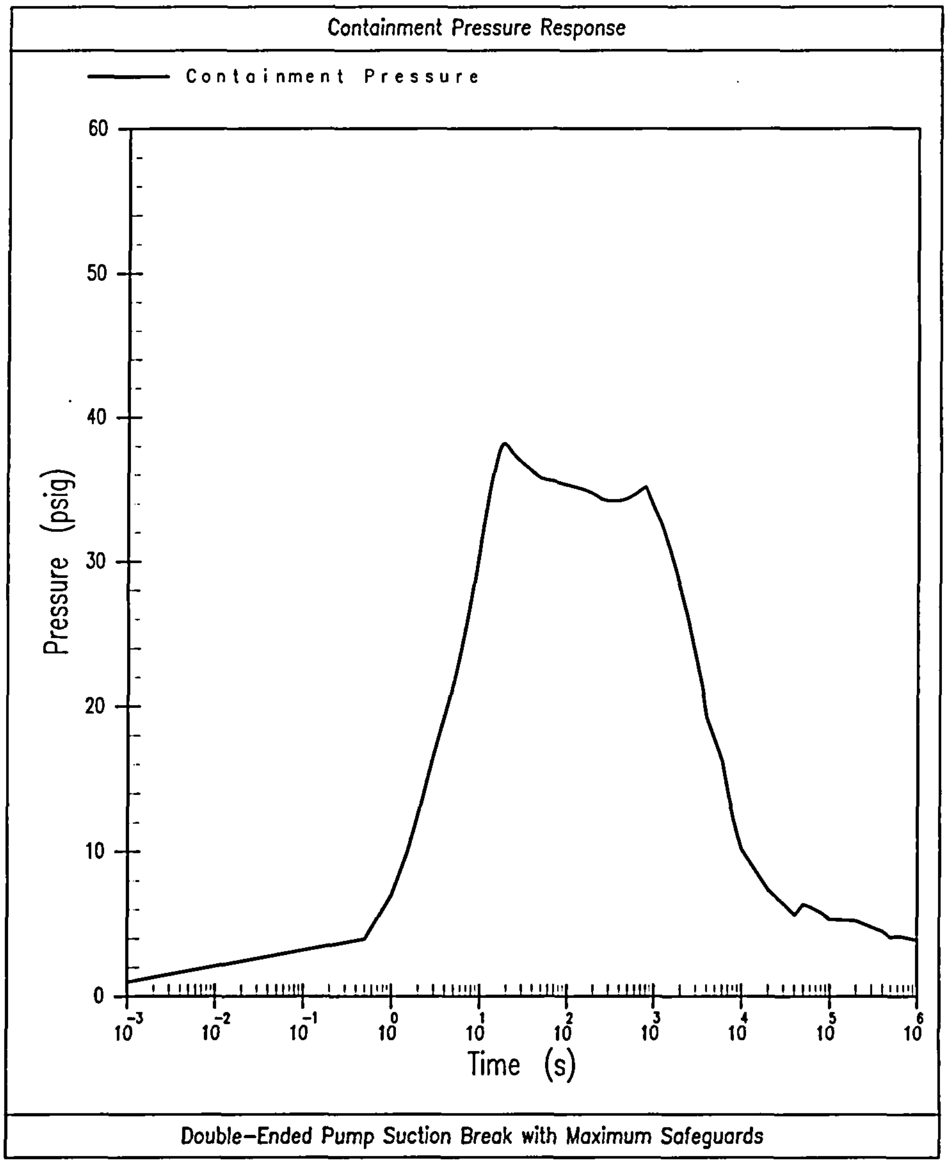

Figure 3 Double-Ended Pump Suction Break with Maximum Safeguards - Pressure

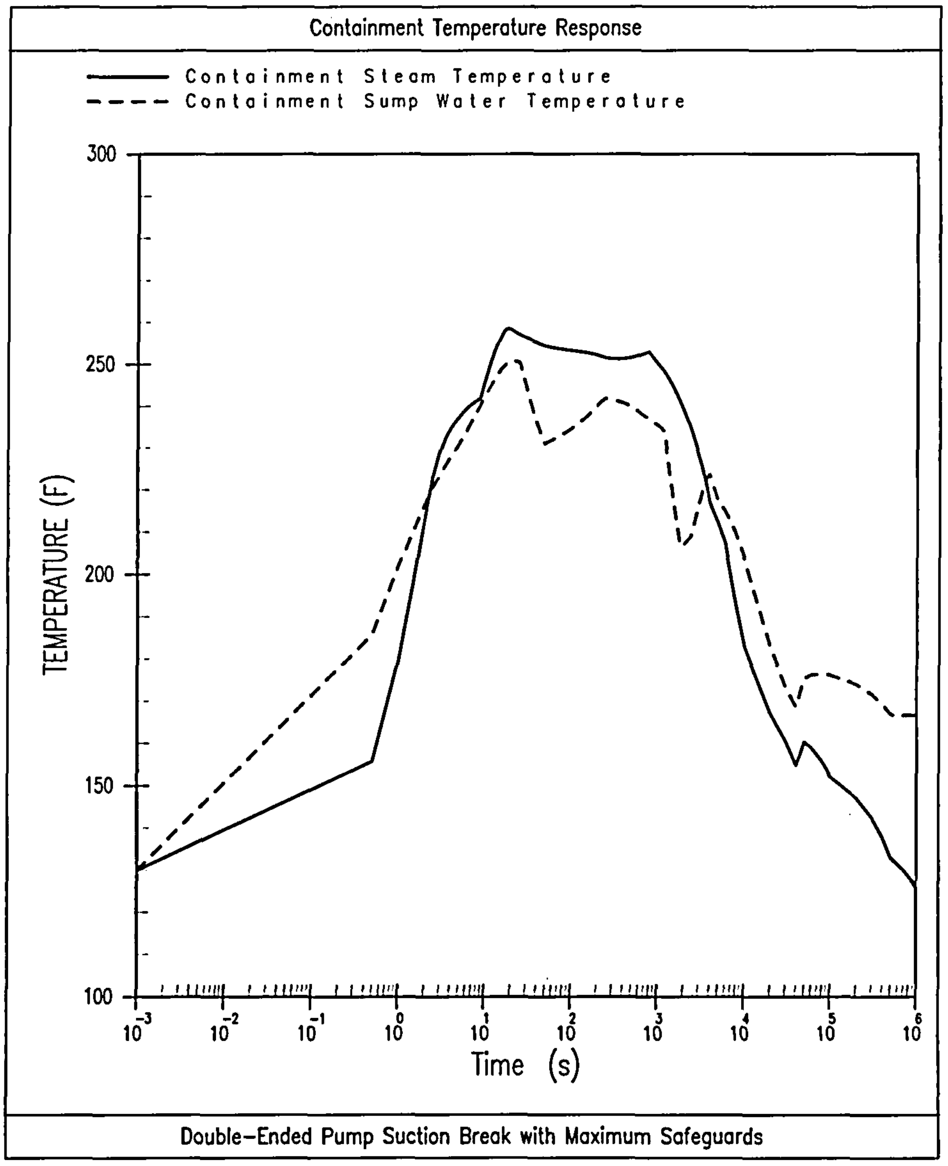

Figure 4 Double-Ended Pump Suction Break with Maximum Safeguards - Steam and Sump Water Temperature

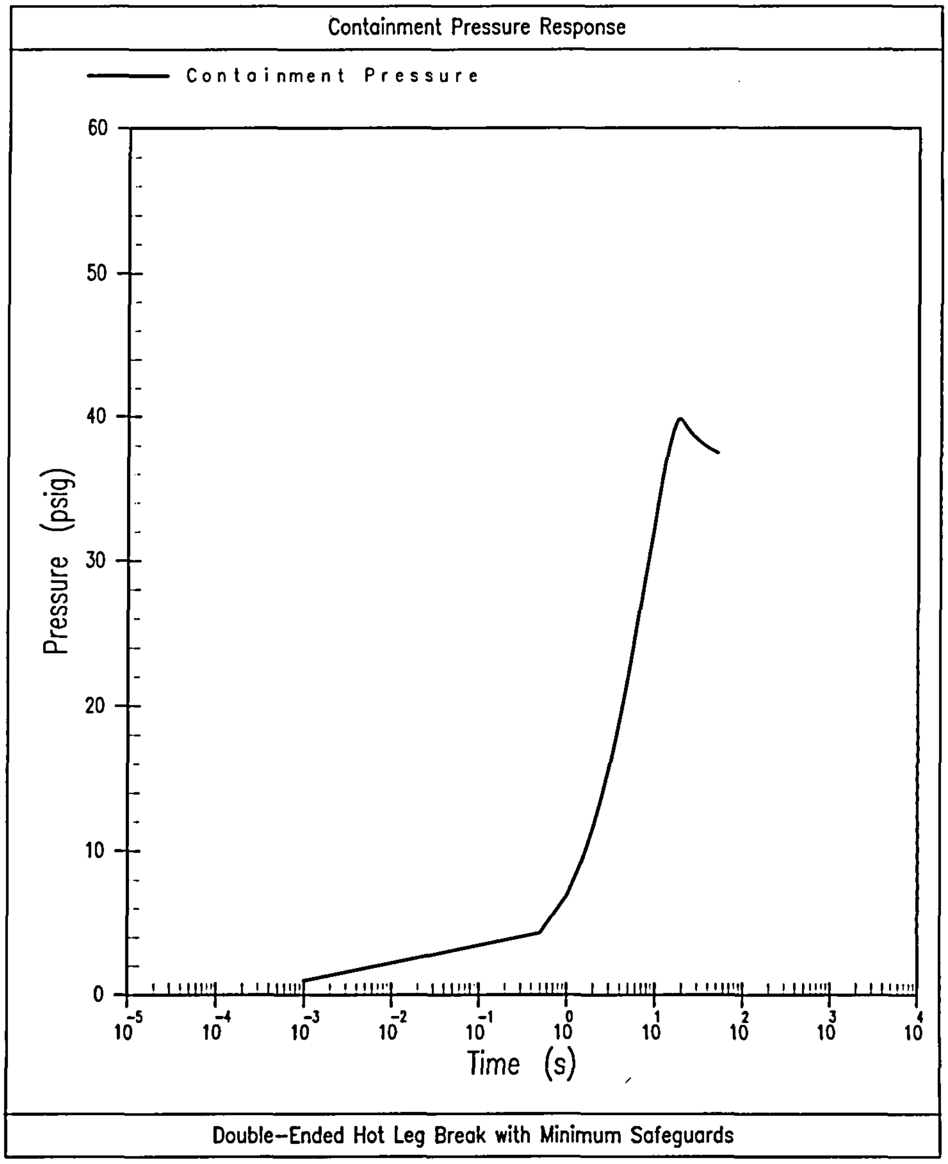

Figure 5 Double-Ended Hot Leg Break with Minimum Safeguards - Pressure

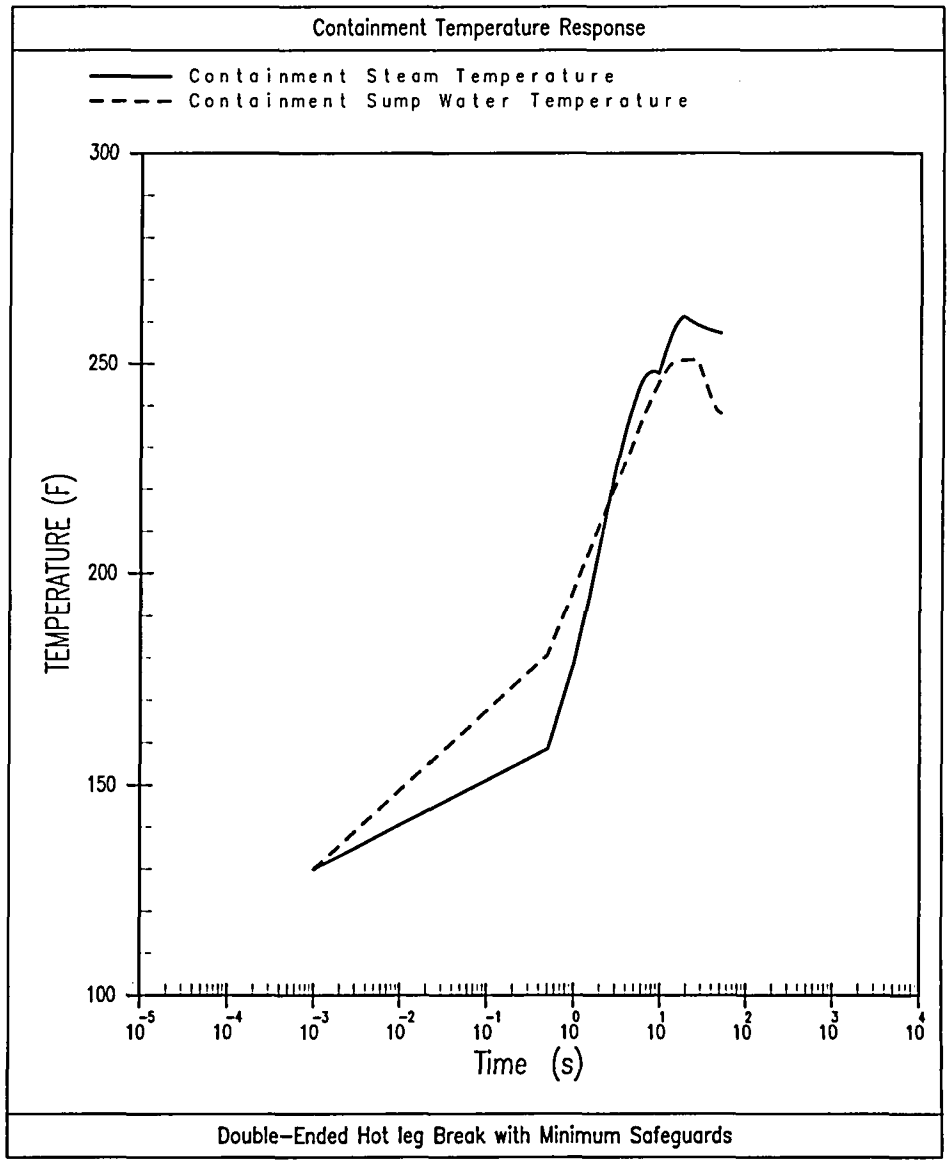

Figure 6 Double-Ended Hot Leg Break with Minimum Safeguards - Steam and Sump Water Temperature

References

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